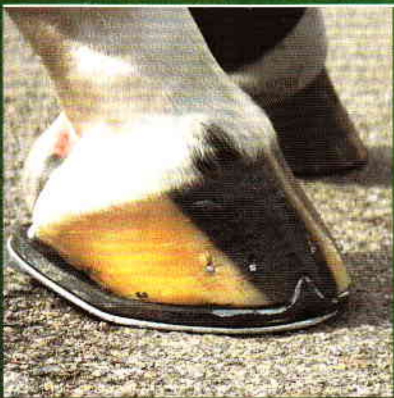
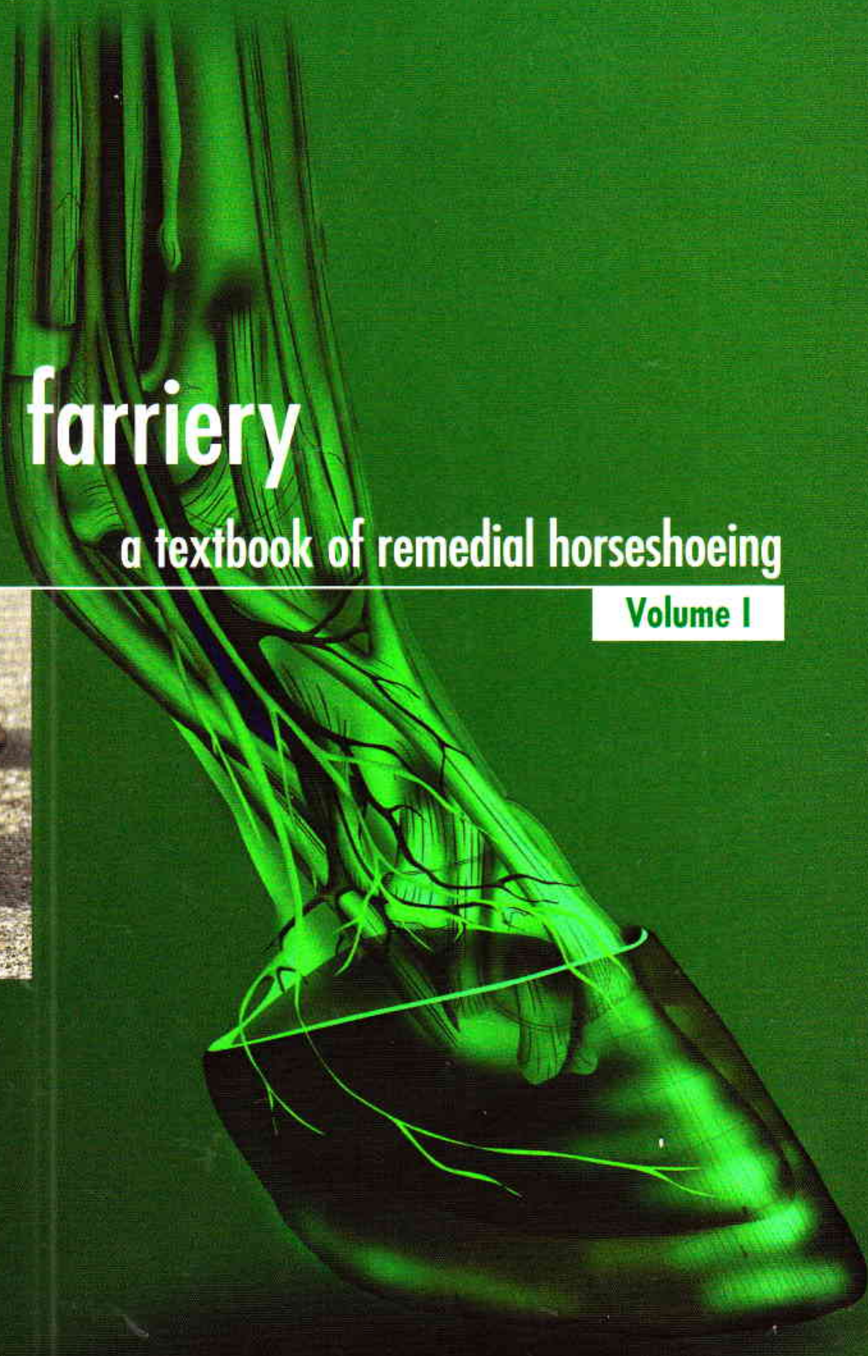
Corrective farriery

a textbook of remedial horseshoeing

Volume I





Edited by Simon Curtis

Corrective farriery

a textbook of remedial horseshoeing

Volume I

Edited by Simon Curtis

Copyright

c/o R&W Publications (Newmarket) Ltd,

Suites 3 & 4, 8 Kings Court, Willie Snaith Road, Newmarket, Suffolk CB8 7SG, UK

First published 2002

ISBN 1 899772 10 3

Published by Newmarket Farrier Consultancy

Typeset and Design by
R & W Publications (Newmarket) Ltd

Printed in Great Britain by
Quality Print Services (Anglia) Ltd, Ipswich, Suffolk

Acknowledgements

A book of this scale requires the work and assistance of many people, not the least the authors who have submitted their work and accepted the editorial amendments necessary to make each chapter conform to the format and ethos of the book. There was a great deal of collaboration across chapters and sections and many authors whole-heartedly allowed their pictures to be used unrecognised by fellow authors. Only those illustrations supplied by non-authors have been accorded credit. I must, however, give special thanks to Josie Meehan who researched many of the radiographs used throughout the book.

As editor, I take ultimate responsibility for the final result; nevertheless I owe a great deal to 3 others who checked the text: Jan Wade, David Ellis and Russell Brownrigg who read the text and checked for literary, veterinary and farriery accuracy. Doug Butler, who has been my friend and mentor for many years, was kind enough to write the Foreword. Louise Holder at R & W Publications once more designed and formatted the layout and Lorraine and Stephen Penney produced the graphic illustrations and the cover design.

Finally, I thank my brother and business partner, Mark, for once more holding the fort while I devoted most of my time to this project.

Foreword

Horseshoeing has come a long way since 1356 AD, when the Worshipful Company of Farriers of London was established. Even in my short lifetime, there have been tremendous changes throughout the world of farriery. Much of these have been due to the increased interaction between the UK and the US as a result of horseshoeing competitions and apprentice exchanges over the last 2 decades. Previously we were on 2 separate paths with our own ideas and traditions. Now, by coming together, we have both progressed further than either of us could have alone.

My first experience with farriery in the British Isles was when I went as a competitor with the 1980 North American Horseshoeing Team to the Dublin Show. Even the spectators seemed to know more about the high standards expected than many of us visiting as competitors. I have come to appreciate how the UK has preserved and elevated the craft of farriery to 'The Master Craft'.

I first met Simon Curtis when he and the Newmarket farriers hosted the 1986 North American Horseshoeing Team. I immediately felt a very strong kinship with him. I was most impressed with his hunger to learn and his desire to help others learn our craft. He was proud of his heritage and yet he wanted to expand to new horizons. His enthusiasm encouraged me to obtain permission to take all of the British farriery exams and thus improve my understanding of an established training system. Simon has taken the lead in bringing about positive changes in farriery. I am delighted to see the progress he has made as a craftsman, author, speaker, veterinary liaison and now Master of the Worshipful Company of Farriers.

His first book, *Farriery - Foal to Racehorse,* documents what he has learned in his own practice as a racehorse farrier. This second book, *Corrective Farriery,* clearly reflects a desire to learn and cooperate with other professionals. He has succeeded in getting both the farriery and the veterinary communities to present their views on horse foot issues. He has demonstrated that new technology has a place in farriery – a field that is frequently criticised for its stubborn adherence to tradition – while at the same time advocating mastery of traditional skills. It becomes apparent that farriers must expand their vocabulary to include medical terms, and veterinary surgeons must expand their view of therapy to include mechanical as well as medical treatment. It is also clear, that the tried and true solutions of traditional farriery should not be overlooked when administering professional horse foot care.

Corrective Farriery also reveals a frustration that all of us concerned with the health of the horse have shared. It is a compilation of the views of many authors rather than an attempt to align or synchronise the principles in a progressive and pedagogical sequence. It becomes the reader's responsibility to study and sort out the stellar principles that merit application. The fact that few practitioners appear to agree on a standard course of treatment for the various foot problems makes it difficult for future generations of farriers (as well as clients) to have confidence in the present generation.

Granted, each horse is an individual, but to be credible we must have agreed standards with the consistency and simplicity expected from a well-established craft and a respected profession. One wonders if this can be accounted for by differences in perception or if they are due to a selfishness that accompanies the pride of independent thought. This book certainly confirms that we live in yet another transitional time in the history of farriery and foot science. It reminds us of our need to resolve the divisions between us and among us.

I continue to admire Simon Curtis for having the courage to be an agent of change, helping farriers and veterinarians come together and understand the horse's foot. He has worked hard and paid the price to gain his knowledge and standing in the trade; yet he admits he is still growing. In addition, he is a devoted family man that has set an example worthy of emulation for all that aspire to master their craft and be successful in life.

Both farriers and veterinarians will be become better students of the foot by studying this book. Perhaps we will catch the vision of what corrective farriery could be. Then, we will come that much closer to achieving our mission of caring for the foundation of our noble friend, the horse.

Doug Butler PhD CJF FWCF

Preface

Farriery has come a long way yet stayed much the same. For 2,000 years, farriers have trimmed the hoof and attached (usually by nailing) a horseshoe (usually metal) to the foot. Nevertheless for much of that time it has been recognised that the way the foot is prepared and the type and style of fit affects the horse's gait and soundness.

Corrective Farriery – a textbook of remedial horseshoeing has been produced to cover the grey area between the art of farriery and science of the veterinary profession. It is not written in the expectation that farriers will take x-rays or that veterinary surgeons will make bar shoes, although both happen. Its main function is to promote a broader understanding between farriers and veterinary surgeons so that it is easier for both to work within the 'grey area'.

This book has other aims, not least assisting farriers to achieve better skills and understanding in the area of remedial shoeing. The Worshipful Company of Farriers recognised as long ago as 1907 that there was a need to encourage and examine farriers above and beyond just shoeing horses for protection and grip. The Associate examination (AWCF) expects farriers to understand and, where necessary, be able to shoe for all conditions and diseases of the foot and lower leg. One of my main criteria in planning and editing *Corrective Farriery – a textbook of remedial horseshoeing* was satisfying the needs of AWCF students.

What is corrective farriery? Many farriers have a saying that "there is no such thing as corrective farriery – only correct farriery". It trips nicely off the tongue but is incorrect. One would hope that all farriery is carried out correctly, ie feet are properly prepared (balanced) and the appropriate shoes applied soundly. Corrective farriery is more than that; it is taking farriery skills and using them to improve a recognised condition, eg applying a mediolateral extension shoe to a foal with an angular limb deformity. In this context the word corrective means to put right by changing. The word 'remedial' is used in the title where its meaning is synonymous with therapeutic. Any farriery technique that is used to aid the recovery of a horse from a condition is a therapy or remedy, eg fitting a fishtail shoe to a horse with a severed flexor tendon. The one adjective that I will not use is 'surgical'. The term 'surgical farrier' has been used for many years. It is incorrect and brings to mind visions of a farrier operating on the foot. Blood is something that farriers do not like to see!

It became apparent early on in the planning stage that this had to be a multi-authored work of more than one volume. In total more than 23 authors have been involved in this first volume; from 6 countries. Where there are varying views between authors, eg in the laminitis chapter, I have been content to allow each to have their say so that the reader can reach their own informed opinion. It is quite possible that, in some cases, there is no one correct answer. All the authors are practical people and so although the intention was not to produce a manual, many chapters have clearly laid out 'how to' sections.

Once it became obvious that *Corrective Farriery* needed to be a 2 volume book, the only question was which chapters and subjects should be in I or II. There are some chapters that were always destined for this volume: Anatomy of the Equine Leg, The Diagnosis of Lameness, Imaging the Foot and Leg and Development of the Leg and Foot are such. However, I did not want the volumes to be strictly divided into fundamental chapters and chapters devoted to conditions of the foot and leg and their treatment. So a slightly eclectic view has been taken and I hope that both volumes will almost stand alone and each will have balance. Some of the chapters do not have a strict technical relevance to farriery in the modern world but nonetheless contain interesting information and help us to raise our eyes above the coronary band.

Editing this book has impressed upon me the necessity to maintain traditional skills, whether as a veterinary surgeon or farrier, but also to have the self discipline and motivation not to be left behind with regard to technical advances. Veterinary surgeons have to look at the whole horse and palpate legs; farriers still need to trim feet and apply steel shoes accurately. We both need to make use of modern scanning techniques and new repair materials. My hope is that this book both records and promotes the skills and knowledge of the equine veterinary surgeon and the farrier.

Simon Curtis FWCF HonAssocRCVS

Contents

This book is dedicated to

the Worshipful Company of Farriers

Chapter 1: Anatomy of the equine leg

Rachel Murray

The distal limb of the horse is adapted to locomotion, with a reduced number of digits compared to the typical pentadactyl limb pattern seen in the dog. This reduction is observed distal to the carpus (forelimb) and tarsus (hindlimb). At this level muscles are represented principally by their tendons, leading to little soft tissue coverage of bone (Figure 1). Although this adaptation to locomotion may maximise efficiency at speed, it also leads to a relative susceptibility to external trauma of the more vital structures of the limb.

This chapter will discuss the anatomy of the distal limb by describing the structures comprising the limb in separate sections. The way in which these structures fit together is demonstrated in Figures 2 to 9 which show a parasagittal section of the forelimb (Figure 2), and sequential (ascending) transverse sections of the limb (Figures 3 to 9).

Skeleton

The distal forelimb skeleton comprises the metacarpal bones, proximal sesamoid bones, first, second and third phalanges and the distal sesamoid or navicular bone. In the hind limb, the metacarpals are replaced by the metatarsals, but the other bones remain the same. The joints of the distal limb comprise the metacarpo-(or metatarso-) phalangeal (fetlock) joint, the proximal interphalangeal (pastern) and distal interphalangeal (coffin) joints.

Bones

Distal to the carpus and tarsus the horse has 3 digits represented: the third metacarpal (forelimb) or metatarsal (hindlimb), commonly known as the cannon bone, flanked by the second metacarpal/metatarsal (medial splint bone) and fourth metacarpal/metatarsal (lateral splint bone). Only the third metacarpal/metatarsal bone is fully developed, and the second and fourth are reduced, ending in a button at approximately three quarters of the length of the third metacarpal/metatarsal. Distal to the metacarpus, 3 phalanges are present, continuing from the third metacarpal bone (Figure 10).

Forelimb

The third metacarpal bone is the principal weight-bearing bone in the metacarpal region. It is a long bone carried vertically, with thick cortices. It is relatively cylindrical but becomes wider and flattened distally. There is a nutrient foramen located approximately one third of the distance from the proximal end. The proximal surface is relatively flat and is shaped to articulate with the distal row of carpal bones. The distal articular surface is composed of a sagittal ridge with 2 condyles.

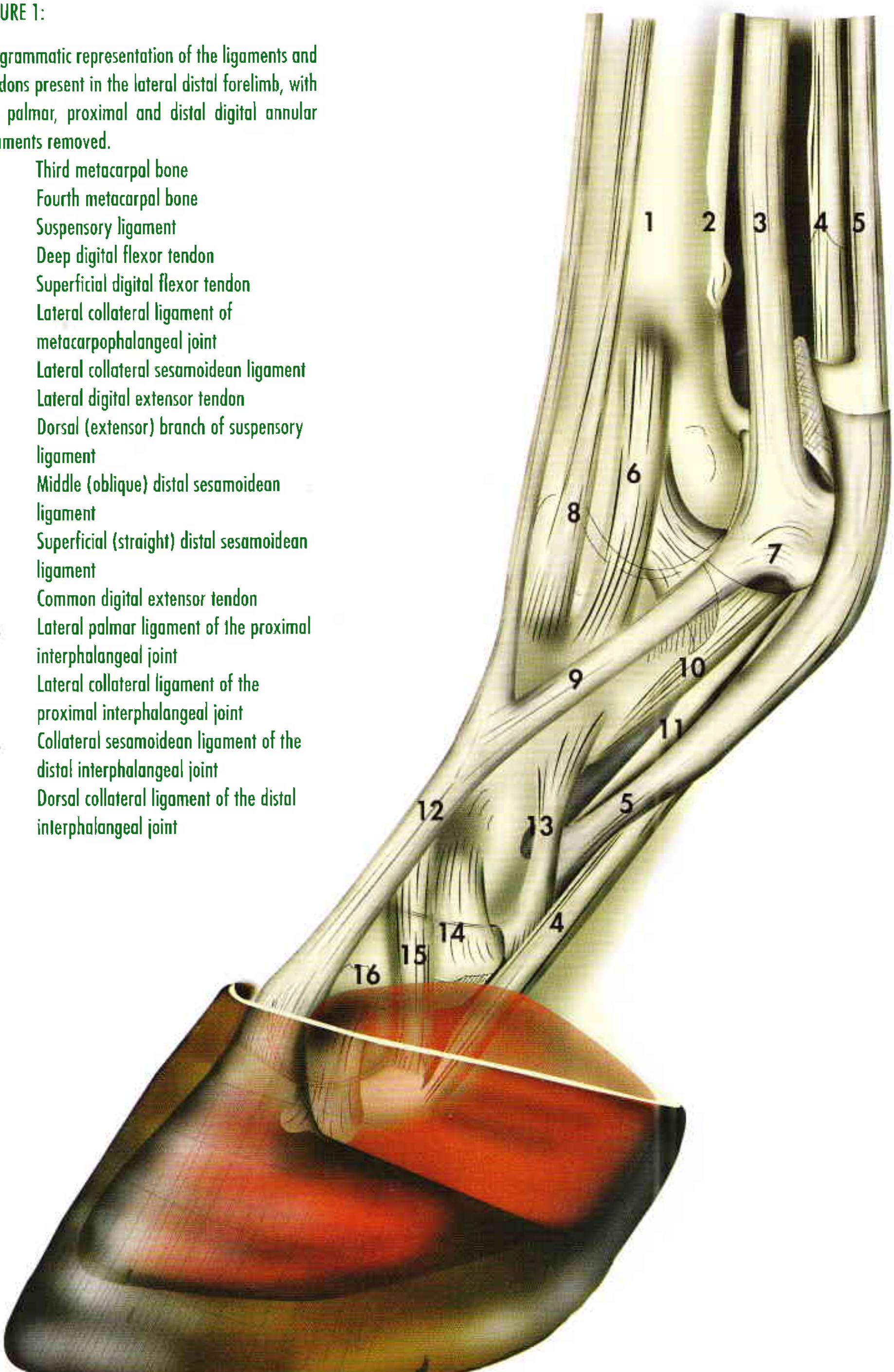
The second metacarpal (medial splint bone) and fourth metacarpal (lateral splint bone) are both large proximally and taper distally terminating in a rounded button. The proximal extent forms a part of the carpometacarpal joint, whereas the distal end finishes in the distal quarter of the third metacarpal. They can be of a variable relative length.

In the standing horse, the phalanges are angled at approximately 55° to the ground. The proximal (first) phalanx is a long bone that is wider with a relatively round cross-sectional shape (Figure 11). The dorsal

FIGURE 1:

Diagrammatic representation of the ligaments and tendons present in the lateral distal forelimb, with the palmar, proximal and distal digital annular ligaments removed.

1. Third metacarpal bone
2. Fourth metacarpal bone
3. Suspensory ligament
4. Deep digital flexor tendon
5. Superficial digital flexor tendon
6. Lateral collateral ligament of metacarpophalangeal joint
7. Lateral collateral sesamoidean ligament
8. Lateral digital extensor tendon
9. Dorsal (extensor) branch of suspensory ligament
10. Middle (oblique) distal sesamoidean ligament
11. Superficial (straight) distal sesamoidean ligament
12. Common digital extensor tendon
13. Lateral palmar ligament of the proximal interphalangeal joint
14. Lateral collateral ligament of the proximal interphalangeal joint
15. Collateral sesamoidean ligament of the distal interphalangeal joint
16. Dorsal collateral ligament of the distal interphalangeal joint



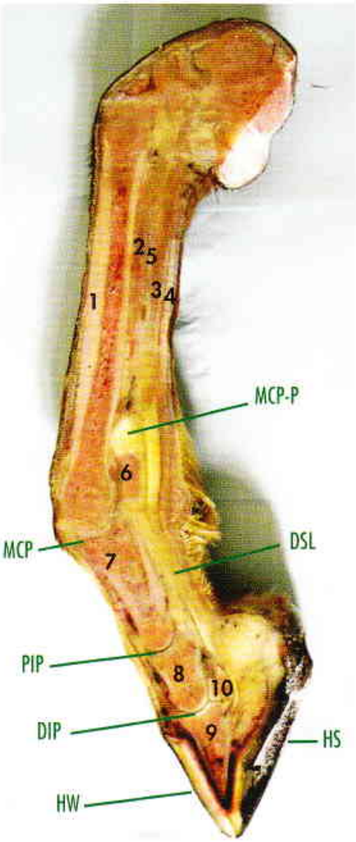


FIGURE 2:

Parasagittal section through the equine distal forelimb showing the anatomy of this region.

1. Dorsal cortex third metacarpal bone
2. Suspensory ligament
3. Deep digital flexor tendon
4. Superficial digital flexor tendon
5. Accessory (check) ligament of the deep digital flexor tendon
6. Proximal sesamoid bone
7. First phalanx
8. Second phalanx
9. Third phalanx
10. Navicular bone

MCP Metacarpophalangeal joint
MCP-P Palmar pouch of metacarpophalangeal joint
PIP Proximal interphalangeal joint
DIP Distal interphalangeal joint
DSL Straight distal sesamoidean ligament
HW Hoof wall
HS Sole of hoof

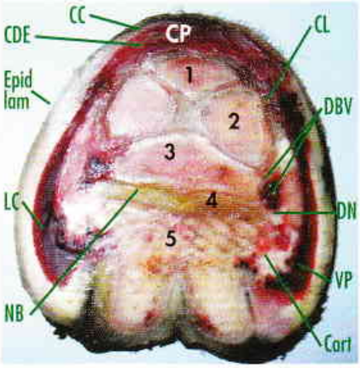


FIGURE 3:

Transverse section through the foot.

1. Extensor process of third phalanx
2. Second phalanx
3. Navicular bone
4. Deep digital flexor tendon
5. Digital/bulbar cushion

CDE Common digital extensor tendon
CC Coronary corium
CP Coronary venous plexus
Epid lam Epidermal laminae
LC Laminar corium
NB Navicular bursa
Cart Collateral cartilage
VP Venous plexus
DN Palmar digital nerve
DBV Palmar digital artery and vein
CL Collateral ligament of the distal interphalangeal joint

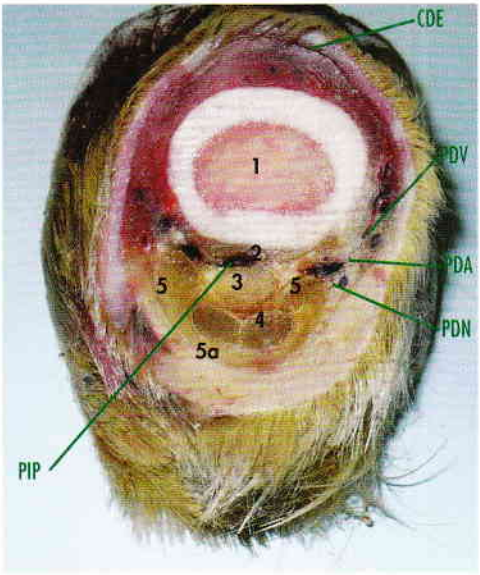


FIGURE 4:

Transverse section through pastern

1. First phalanx
2. Oblique distal sesamoidean ligament
3. Straight distal sesamoidean ligament
4. Deep digital flexor tendon
5. Superficial digital flexor tendon

5a. Sagittal part of superficial digital flexor tendon

CDE common digital extensor tendon
PIP proximal interphalangeal joint
PDN palmar digital nerve
PDA palmar digital artery
PDV palmar digital vein

surface is generally more convex and the palmar surface more flattened. The middle (second) phalanx is greater in width than in length, and flattened in a dorsal-palmar direction (Figure 12). Like the proximal phalanx, the dorsal surface tends to be convex and the palmar more flattened. The distal (third) phalanx is placed within the hoof, and is hoof-shaped. On the dorsal aspect is a parietal groove and many foraminae, which accommodate blood vessels. Dorsally there is a proximal extensor process, acting as the insertion site for the common digital extensor tendon. The bone possesses medial and lateral palmar processes and a concave solar surface. The articular surface is also concave, shaped to articulate with the distal condyles of the middle phalanx (Figures 13 and 14).

There are 2 sets of sesamoid bones: the proximal sesamoid bones and the distal sesamoid (navicular bone). The 2 proximal sesamoid bones (medial and lateral) form the palmar surface of the metacarpophalangeal joint. They are pyramidal in shape with 3 sides. The proximal pointed end is known as the apex and the wider distal end is described as the base. Generally the medial sesamoid bone is slightly larger and more rounded. The articular surface articulates with the distal third metacarpal and proximal phalanx. The palmar flexor surface forms the groove for the deep digital flexor tendon, and the abaxial surface provides the suspensory ligament insertion site. The distal sesamoidean ligaments originate from the base of the sesamoid bones.

The distal sesamoid (navicular) bone is a flattened bone with its long axis placed transversely in the limb (Figures 14 and 15). The articular surface forms the palmar aspect of the distal interphalangeal joint. The flexor surface is closely apposed to the dorsal surface of the deep digital flexor tendon. The proximal surface provides the insertion for the navicular suspensory ligaments and the distal border for the origin of the distal sesamoidean impar ligament.

Hind limb

In general, the pattern of bones in the hind limb is similar to that of the forelimb. They differ purely in some small details. The metatarsal bones tend to be longer than the relative metacarpals and the third metatarsal is usually more circular in cross-section than the third metacarpal with the nutrient foramen positioned relatively more proximally. The fourth metatarsal is very large proximally, and the second metatarsal is relatively small. The phalanges tend to be more

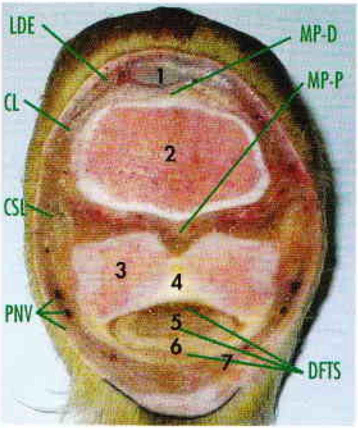


FIGURE 5:

Transverse section through the fetlock.

1. Common digital extensor tendon
2. Third metacarpal bone
3. Lateral proximal sesamoid bone
4. Intersesamoidean ligament
5. Deep digital flexor tendon
6. Superficial digital flexor tendon
7. Palmar annular ligament

LDE	Lateral digital extensor tendon
CL	Collateral ligament of the metacarpophalangeal joint
CSL	Collateral sesamoidean ligament
PNV	Palmar nerve, artery and vein
MP-D	Dorsal pouch of metacarpophalangeal joint
MP-P	Palmar pouch of metacarpophalangeal joint
DFTS	Digital flexor tendon sheath

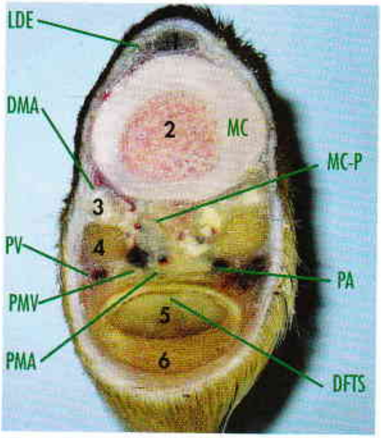


FIGURE 6:

Transverse section through distal metacarpus.

1. Common digital extensor tendon
2. Third metacarpal bone
3. Lateral splint bone (fourth metacarpal)
4. Lateral branch of suspensory ligament
5. Deep digital flexor tendon
6. Superficial digital flexor tendon

LDE Lateral digital extensor tendon
DMA Dorsal metacarpal artery
PV Palmar vein
PMV Palmar metacarpal vein
PMA Palmar metacarpal artery
DFTS Digital flexor tendon sheath
PA Palmar artery
MC-P Palmar pouch of metacarpophalangeal joint
MC Cortex of third metacarpal

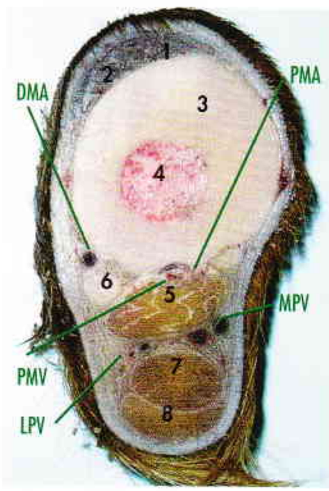


FIGURE 7:

Transverse section through the mid metacarpus.

1. Common digital extensor tendon
2. Lateral digital extensor tendon
3. Cortex of third metacarpal
4. Medulla of third metacarpal
5. Suspensory ligament
6. Lateral splint bone (fourth metacarpal)
7. Deep digital flexor tendon
8. Superficial digital flexor tendon

MPV Medial palmar vein, artery, nerve
LPV Lateral palmar vein, artery, nerve
DMA Dorsal metacarpal artery
PMV Palmar metacarpal vein
PMA Palmar metacarpal artery

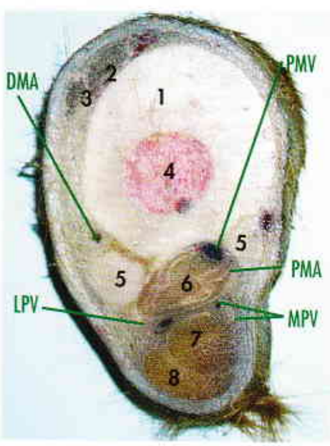


FIGURE 8:

Transverse section through the proximal metacarpus.

1. Cortex of third metacarpal bone
2. Common digital extensor tendon
3. Lateral digital extensor tendon
4. Medulla of third metacarpal
5. Second and fourth metacarpals
6. Suspensory ligament
7. Deep digital flexor tendon
8. Superficial digital flexor tendon

DMA Dorsal metacarpal artery
PMA Palmar metacarpal artery
PMV Palmar metacarpal vein
MPV Medial palmar vein, artery, nerve
LPV Lateral palmar vein, artery, nerve

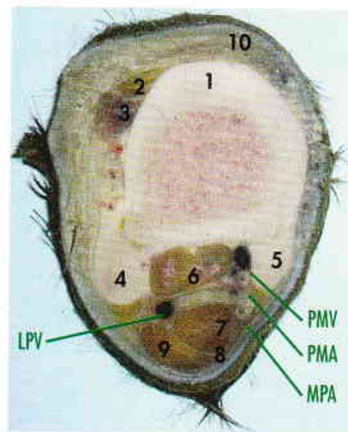


FIGURE 9:

Transverse section through the top of the metacarpus.

1. Cortex of third metacarpal bone
2. Common digital extensor tendon
3. Lateral digital extensor tendon
4. Fourth metacarpal
5. Second metacarpal
6. Suspensory ligament
7. Accessory ligament of deep digital flexor tendon
8. Deep digital flexor tendon
9. Superficial digital flexor tendon
10. Extensor carpi radialis tendon insertion

PMA Palmar metacarpal artery
PMV Palmar metacarpal vein
MPA Medial palmar artery
LPV Lateral palmar vein

upright relative to the ground than the forelimb. Relatively the hind first phalanx is usually shorter, the second narrower and longer and the third phalanx narrower than in the forelimb. The proximal sesamoid bones tend to be smaller than those in the forelimb, and the distal sesamoid (navicular bone) tends to be narrower and shorter.

FIGURE 10:

Bones of the right distal hindlimb.
1. Third metatarsal
2. Fourth metatarsal
3. First phalanx
4. Second phalanx
5. Third phalanx

Joints

Synovial joints comprise a collection of tissues that function together to provide movement and withstand the forces of weight-bearing and exercise. Tissues composing a joint include the synovium, fibrous joint capsule, peri-articular and intra-articular ligaments and the tissues forming the articular surface: the cartilage and underlying bone.

NB: In the rest of this section, 'metacarpal' will be used to represent either metacarpal or metatarsal unless otherwise specified.

Metacarpophalangeal (fetlock joint)

The metacarpophalangeal joint includes the proximal third metacarpal, first phalanx and the proximal sesamoid bones. The 2 condyles of the distal metacarpal are divided by a sagittal ridge, which fits into a corresponding sagittal groove formed in the proximal first phalanx. In the forelimb the medial condyle on both articular surfaces is larger than the lateral side. The proximal sesamoid bones sit either side of this sagittal ridge and are joined by the intersesamoidean ligament, which in turn possesses a sagittal groove (Figure 16).

On the palmar aspect, the joint capsule extends proximally between the third metacarpal bone and the suspensory ligament, extending to approximately the level where the suspensory ligament divides.

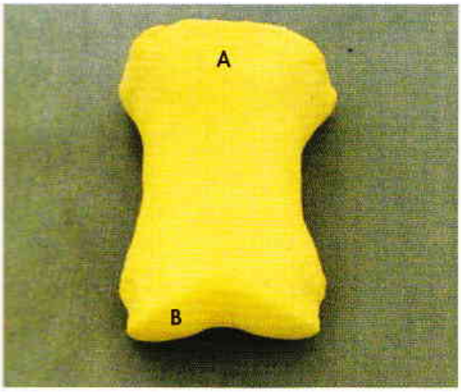


FIGURE 11:

Dorsal view of the first phalanx.
A. Proximal articular surface
B. Condyle on distal articular surface

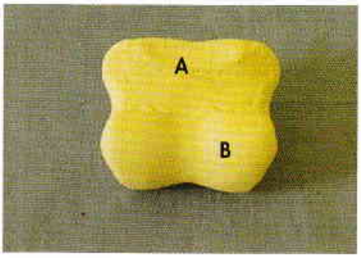


FIGURE 12:

Second phalanx, palmar view.
A. Proximal articular surface
B. Condyle on distal articular surface

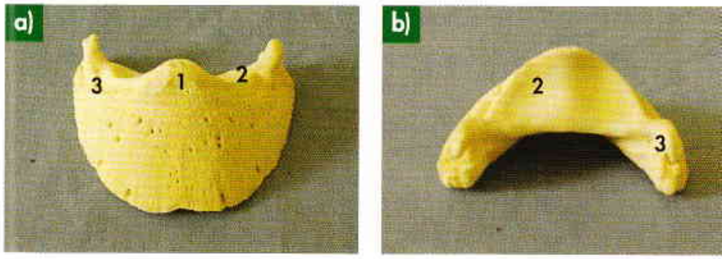


FIGURE 13:

Third phalanx. a) Dorsal view; b) Palmar view.
1. Extensor process; 2. Articular surface; 3. Palmar process.

On the dorsal aspect the joint capsule extends under the commo (forelimb) or long (hind limb) digital flexor tendon.

The lateral and medial collateral ligaments extend from the lateral an medial portions of the third metacarpal bone. Each collateral ligamen divides into 2 portions: the superficial portion attaches to the proxima first phalanx adjacent to the articular surface; the deeper portio inserts on the abaxial face of the closer proximal sesamoid bone an the proximal first phalanx (the lateral/medial collateral sesamoidea ligament).

The joint moves primarily in a sagittal plane, with a wide movemen arc. A very limited degree of lateral/medial and rotational movemen is possible during flexion. The joint is supported by the suspensor apparatus, which prevents hyperextension and flexion is limited by th heels contacting the metacarpus.

The suspensory apparatus: The fetlock joint is supported largely by th suspensory apparatus. This consists of the suspensory ligament proximal sesamoid bones and sesamoidean ligaments. The suspensor ligament refers to the interosseous muscle, which in the horse ha developed into a tendinous band with little muscle content. I originates from the proximal palmar metacarpus and distal row o carpal bones as a wide band and divides into 2 branches in the mid-metacarpus before inserting on the abaxial aspects of the 2 proxima sesamoid bones. On each side, a branch runs dorsally and distall from the level of the proximal sesamoid bones to join the digita extensor tendon in the mid-pastern region. These dorsal branche primarily limits hyperflexion of the interphalangeal joints, wherea the remainder of the suspensory ligament functions to preven

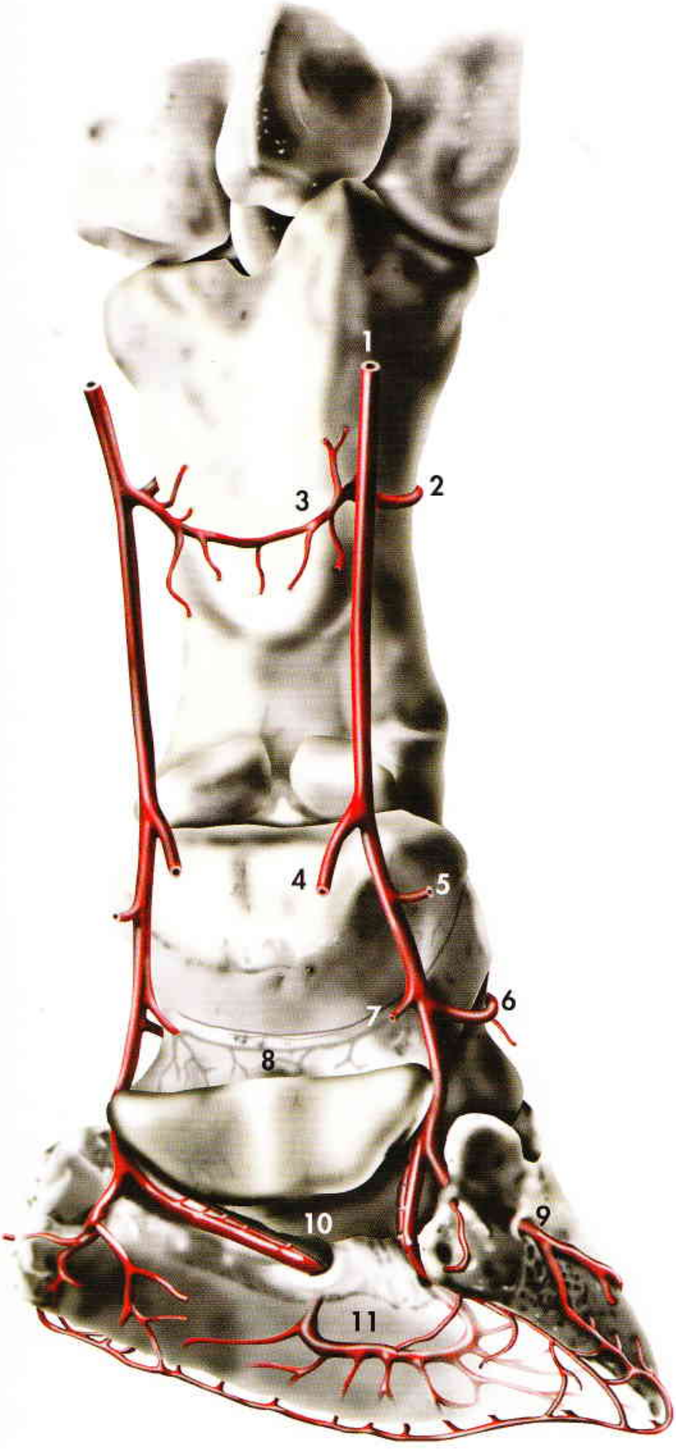


FIGURE 14:

Diagrammatic representation of the arteries of the palmar aspect of the distal right forelimb.

1. Lateral digital artery
2. Dorsal branch of proximal phalanx
3. Palmar branch of proximal phalanx
4. Bulbar artery
5. Coronal artery
6. Dorsal artery of middle phalanx
7. Palmar artery of middle phalanx
8. Proximal navicular plexus
9. Dorsal artery of distal phalanx
10. Distal navicular plexus
11. Terminal arch

Adapted from Adams' Lameness in Horses, 4th Edition, Lea & Febiger

FIGURE 15:

The distal sesamoid (navicular) bone: a) Proximal view; b) Distal view.

FIGURE 16:

Surfaces forming part of the metacarpophalangeal joint.
1. Proximal sesamoid bone
2. Proximal articular surface of the first phalanx

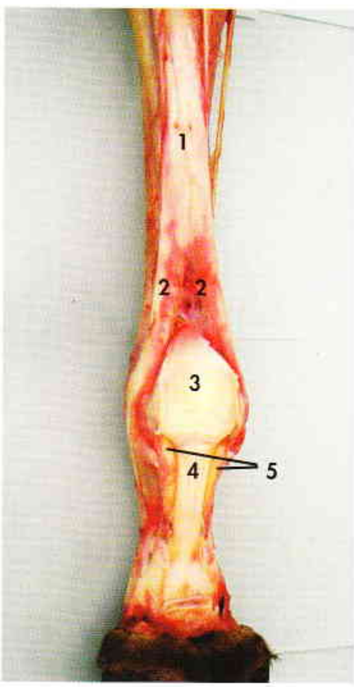


FIGURE 17:

The suspensory apparatus.
1. The wide band of the suspensory ligament
2. Branches of the suspensory ligament
3. Flexor surface of the proximal sesamoid bones
4. Straight distal sesamoidean ligament
5. Oblique distal sesamoidean ligament

excessive extension of the fetlock joint during weight-bearin (Figures 16 and 17).

Distal to the sesamoids, the suspensory apparatus continues as 3 set of distal sesamoidean ligaments originating from the base of th proximal sesamoid bones. The superficial or straight distal sesamoi ligament is the most superficial. It consists of a flat band that insert on the proximal, palmar second phalanx fibrocartilage. The middle o oblique distal sesamoidean ligament inserts on the palmar and slightl abaxial surface of the first phalanx. The deep or cruciate dista sesamoidean ligaments cross over and insert on the palmar firs phalanx on the eminence opposite the side from which eacl originates.

Proximal interphalangeal (pastern) joint

The proximal interphalangeal joint forms the articulation between th first (proximal) phalanx and second (middle) phalanx. The proxima articular surface comprises 2 convex condyles (the medial being larger which articulate with corresponding concave areas on the dista articular surface (Figure 18). On the distal surface, a palmar plate o fibrocartilage extends the articular surface.

The joint capsule extends proximally under the digital extenso tendon on the dorsal aspect, and deep to the straight dista sesamoidean ligament and branches of the superficial digital flexo tendon. There are short medial and lateral collateral ligaments originating in the depressions on the sides of the distal first phalan and inserting on the eminences each side of the proximal seconc phalanx. On the palmar aspect, there are 4 ligaments: 2 adjacent to th midline (central), a medial and a lateral which originate on the middle (central ligaments) and distal first phalanx, and insert on the palmar fibrocartilage and second phalanx.

This joint has only a small movement range, which is primarily limited to the sagittal plane. Limited lateral/medial motion can be induced during flexion.

Distal interphalangeal (coffin) joint

The distal interphalangeal joint forms the articulation between the second (middle) phalanx, third (distal) phalanx and distal sesamoid (navicular) bone (Figure 19).

The palmar aspect of the joint capsule extends proximally to the middle of the second phalanx and abaxially reaches the collateral cartilages. Dorsally the joint capsule extends under the common (forelimb) and long (hind limb) digital extensor tendon, being compressed into abaxial pouches.

The joint has short medial and lateral collateral ligaments which run from the middle to distal phalanx and collateral cartilages. The navicular suspensory (or collateral sesamoidean) ligaments suspend the navicular bone. These are wide bands that originate on the distal abaxial surfaces of the proximal phalanx, along the collateral ligaments of the proximal interphalangeal joint, and insert on the abaxial and proximal surfaces of the navicular bone. A branch also inserts into the

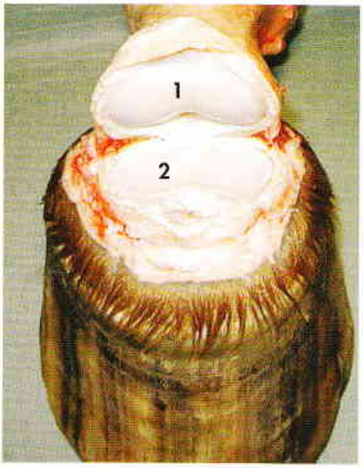


FIGURE 18:

The proximal interphalangeal joint.
1. Condyle on distal articular surface of first phalanx
2. Proximal articular surface of second phalanx

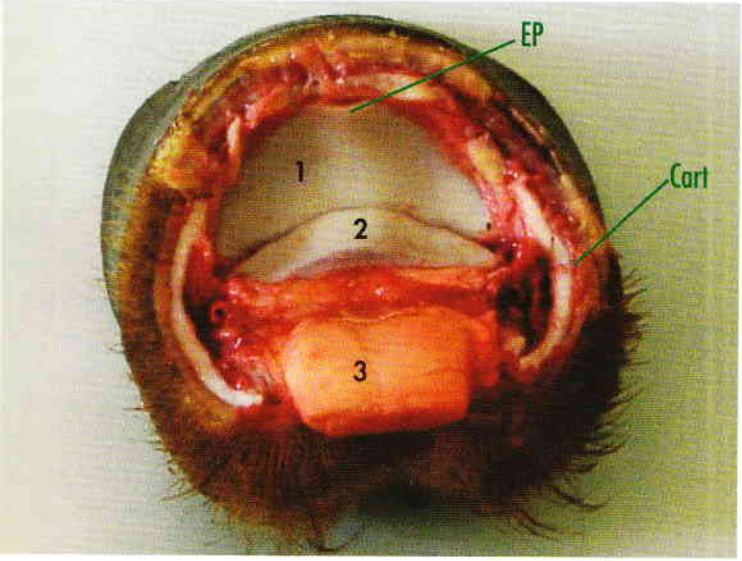


FIGURE 19:

The distal interphalangeal joint.
1. Articular surface of third phalanx
2. Articular surface of navicular bone
3. Deep digital flexor tendon
EP Extensor process of third phalanx
Cart Collateral cartilage (cartilage of distal phalanx)

collateral cartilages. Originating from the distal border of the navicula bone is the distal sesamoid impar ligament. This inserts on the flexo surface of the distal phalanx and supports the distal joint capsule.

The distal interphalangeal joint has a low range of motion that i largely restricted to flexion and extension in the sagittal plane although restricted rotation and medial/lateral motion can b produced during flexion. Extension is limited by the deep digita flexor tendon.

Collateral cartilages (cartilages of the distal phalanx)

These are cartilages associated with the third phalanx. They have convex shape on the abaxial surface, are concave axially and curve i towards the heel. Distally they are thicker and attach to the palma processes of the third phalanx. They are held in place by ligaments One runs from the navicular bone (a band extending from th suspensory ligaments to the axial cartilage); a second from th proximal phalanx to the proximal cartilage; a third from the abaxia middle phalanx to the dorsal cartilage and a fourth from the cartilag distal border to the angle of the distal phalanx.

Integument

Skin

The distal limb is covered by skin. This contains sweat and sebaceou glands, although their number and size are less than in some othe areas. There are hairs produced throughout the region.

Ergot

This is a small mass of horn situated on the palmar extent of th fetlock. The ligament of the ergot runs dorsodistally from the dista surface of the ergot, passes superficial to the palmar digita neurovascular bundle and inserts into the digital fascia. It is considere to be a vestige of the second and fourth digits.

The foot

Most of the distal limb has a covering of skin, fascia and subcutaneou tissue. However, the foot possesses a very specialised form of dermi and epidermis that is adapted to weight-bearing and locomotion.

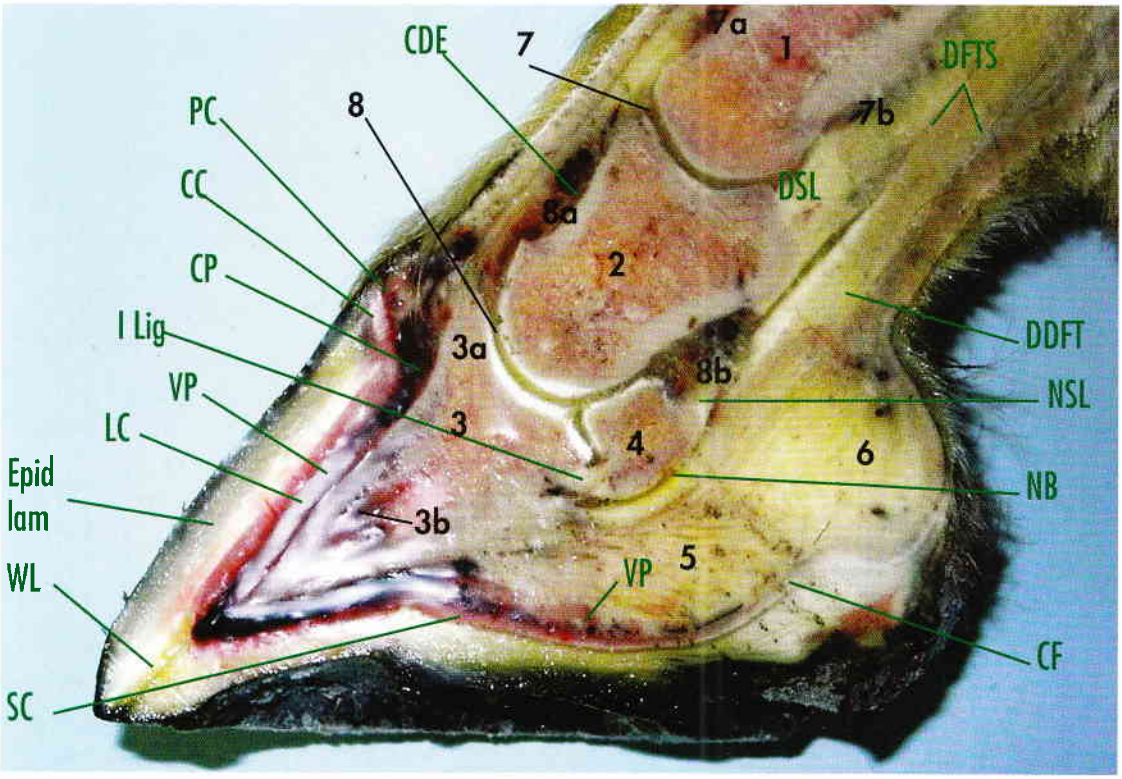


FIGURE 20:

Sagittal section through an equine foot showing the structures contained.

1. First phalanx; 2. Second phalanx; 3. Third phalanx; 3a. Extensor process; 3b. Semilunar/solar canal containing terminal arch 4. Navicular bone; 5. Digital cushion; 6. Bulbar portion of digital cushion; 7. Proximal interphalangeal joint; 7a. Dorsal pouch; 7b. Palmar pouch; 8. Distal interphalangeal joint; 8a. Dorsal pouch; 8b Palmar pouch.

CDE: common digital extensor tendon; PC: perioplic corium; CC coronary corium; CP: coronary venous plexus; I lig – distal sesamoidean impar ligament; VP: venous plexus (dorsal and palmar); LC: laminar corium; Epid Lam: epidermal laminae; WL: white line; SC: solar corium; CF: corium of frog; NB: navicular bursa; NSL: navicular suspensory ligament; DDFT: deep digital flexor tendon; DFTS: digital flexor tendon sheath.

Hoof

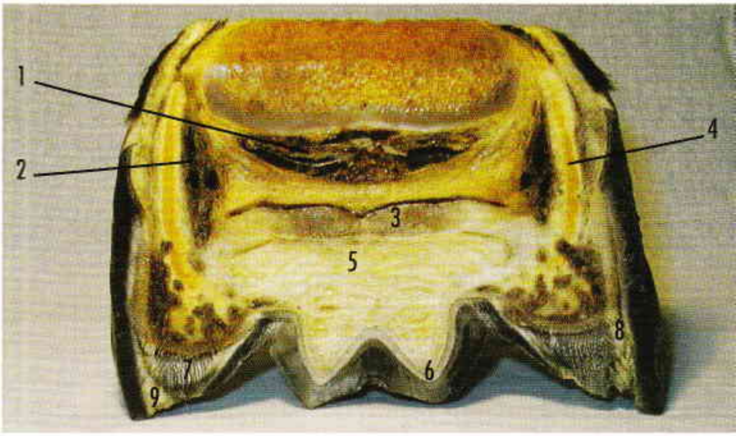
The hoof is a highly keratinised epidermis without blood vessels or nerves. It receives its nutrition from the underlying corium. In contrast to skin it has no stratum lucidum and no stratum granulosum. It is has a very thin stratum germinativum which produces the thick stratum corneum (Figures 3 and 20).

The wall

This is divided into regions described as the toe, heel and quarters (medial and lateral). The proximal extent is the coronary band, and the coronet forms the junction between the wall and adjacent skin. The wall is thickest at the toes, which is the region of greatest friction, and thinnest at the heels. The youngest, most elastic horn is present at the heels because hoof wall grows evenly from proximal to distal. As the toe is relatively longer than the heel, the older less elastic horn remains at the toe. The wall is reflected inwards to form bars at the heels, separated from the frog by paracuneal grooves.

FIGURE 21:

Dorsal plane section through the palmar foot.
1. Distal sesamoid (navicular bone)
2. Palmar process of the distal phalanx
3. Deep digital flexor tendon
4. Collateral cartilage
5. Digital cushion
6. Frog corium
7. Solar corium
8. Laminar corium
9. White line



In the hoof wall, keratinised cells are arranged in tubules extending from the proximal to the distal border. In healthy horn, approximately 25% of the wall is composed of water. There are 3 layers to the hoof wall:

a) Stratum externum (external layer)

This is a thin covering forming the surface of the wall. The proximal and distal portions of the stratum externum are different:

i) Periople: this covers the proximal wall and over the heels. It is non-pigmented and relatively soft;

ii) Stratum tectorium: this covers the rest of the wall. It is smooth and glossy and appears to reduce water loss from the hoof wall.

b) Stratum medium (middle layer)

This is made up of thick, hard tubular and intertubular horn. The tubules run parallel from proximal to distal. In a dark coloured hoof, this layer is pigmented.

c) Stratum internum (internal layer)

This is a non-pigmented layer that has 2 parts:

i) Proximally, there is a coronary groove;

ii) Distal to this are keratinised primary and non-keratinised secondary laminae that interdigitate with the primary and secondary laminae of the laminar corium.

The sole

The sole is usually slightly concave, and has a hard, flaky surface. It consists of vertical horn tubules that run parallel to those of the wall with intertubular horn. The sole contains approximately 33% water (Figure 21).

The frog

The frog is a relatively soft, wedge-shaped structure with a central groove and an apex placed dorsally. It is continuous with the heel bulbs and sits between 2 paracuneal grooves. The frog's rubbery nature is due to its composition of wavy horn tubules that are incompletely keratinised, along with intertubular horn. It also has a higher water content than the wall and sole, containing approximately 50% water.

Corium (dermis)

The corium is a highly vascular, sensitive structure that provides nutrition for the hoof. It can be divided into 5 parts:

Perioplic corium

The perioplic corium provides nutrition for the periople. It is placed deep to the periople at the coronet, blends with the corium of the skin proximally and with the frog corium over the heels. The coronary groove separates it from the coronary corium. On the outer surface, papillae fit into indentations on the inner surface of the periople.

Coronary corium

The coronary corium provides nutrition to most of the hoof wall. It is thick and generally pigmented. The coronary corium lies in the coronary groove immediately distal to the perioplic corium, and blends with the corium of the frog near the heels. The deep surface attaches to the common digital extensor and collateral cartilages and is associated with the coronary venous plexus. Papillae on the superficial surface fit into holes inside the coronary groove. The stratum germinativum overlying the coronary corium produces the stratum medium of the wall. The cells covering the papillae produce tubular horn, and the cells lying between the papillae produce intertubular horn.

Laminar corium

The laminar corium provides nutrition for the horny laminae and the interlaminar horn of the white line. Except for a small portion of the white line, overlying germinal cells do not produce the overlyin horn, which is produced by the stratum germinativum overlying th coronary corium. It is composed of primary and secondary laminae which are non-pigmented and interdigitate with the laminae of th hoof walls and bars. The deep surface of the laminar corium blend with the periosteum of the third phalanx and is closely apposed to th collateral cartilages distally, being attached by a subcutis containing venous plexus. By suspending the third phalanx in this way, mos pressure from the limb is taken by the wall, and not the solar surface The laminae become wider distally, and the distal laminae also contai papillae.

Solar corium

The solar corium provides nutrition for the horny sole and is ofte pigmented. It contains many papillae of varying size that fit int perforations in the sole. Adjacent to the frog, it blends with the coriu of the frog. The deep surface of the solar corium attaches to the palma third phalanx through a periosteal and subcutaneous layer containin the solar venous plexus. The stratum germinativum overlying the sola corium produces the solar horn.

Frog corium

The frog corium is generally pigmented with many small papillae tha fit into perforations in the frog. The deep surface is apposed to th digital cushion. The stratum germinativum overlying the frog coriu produces the horn of the frog.

White line

The white line is composed of thin, soft lighter-coloured horn at th junction of the wall and sole. It contains both pigmented and non pigmented horn. The non-pigmented horn is the deep layer of th stratum medium and distal parts of the keratinised laminae. Th pigmented horn is produced by the germinal cells which overlie th distal papillae of the laminar corium. This pigmented horn fills th spaces around the non-pigmented horn of the laminae.

Digital cushion

The digital cushion is a wedge of collagen and elastic subcutaneou tissue lying deep to the solar and frog coriums it is important in shoc absorption. Its deep surface is connected to the distal fibrous sheath of the deep digital flexor tendon, and abaxial surfaces to the collateral cartilages and associated venous plexus. Over the heel bulbs, it may be termed the bulbar cushion. The digital cushion contains collagen and elastic fibres, cartilage islands, fat and modified skin glands, but has poor vascular supply. The gland ducts exit through the frog corium and horn. The digital cushion is denser towards the toe, and the structure become looser and contains a greater proportion of fat towards the heels.

Coronary cushion

The coronary cushion is the thickened layer of elastic stratum germinativum tissues deep to the coronary corium. It attaches the coronary corium to the common digital extensor tendon and the collateral cartilages. It is highly vascular and contains the coronary venous plexus.

The anatomy of the foot is looked at in greater detail in Volume II.

Tendons

Tendons form the link between muscle and bone, at both the origin and insertion of the muscle. In the horse, the distal limb has virtually no muscle content and at this level muscles are represented by their tendons. Tendons are comprised of bundles of collagen fibres lying in a complex matrix, and show both elasticity and considerable tensile strength. At points where tendons pass over joints or around sharp bends, they are often surrounded by a fluid filled sheath or pass over a fluid-filled bursa (Figures 1–9).

In the distal limb, the tendons can be divided into the extensors and flexors of the metacarpophalangeal and interphalangeal joints. The extensor tendons include the common digital extensor (replaced by the long digital extensor in the hind limb) and lateral digital extensor. The flexor tendons include the superficial and deep digital flexors.

The common digital extensor muscle originates from the humerus, radius and ulna. It inserts via its tendon on the extensor process of the third phalanx, and on the dorsal surface of the proximal phalanx and middle phalanx (Figure 22). This tendon runs from lateral to the midline at the carpus, into the midline over the phalanges. A synovial sheath is present dorsal to the carpus, and a bursa occurs between the

FIGURE 22:

Dissection of the dorsal aspect of the distal limb showing the digital extensor tendons.

1. Common digital extensor tendon
2. Lateral digital extensor tendon
3. Dorsal branch of suspensory ligament

FIGURE 23:

Dissection of distal forelimb showing flexor tendons
1. Superficial digital flexor tendon
2. Deep digital flexor tendon
3. Accessory (check) ligament of deep digital flexor tendon
4. Palmar annular ligament

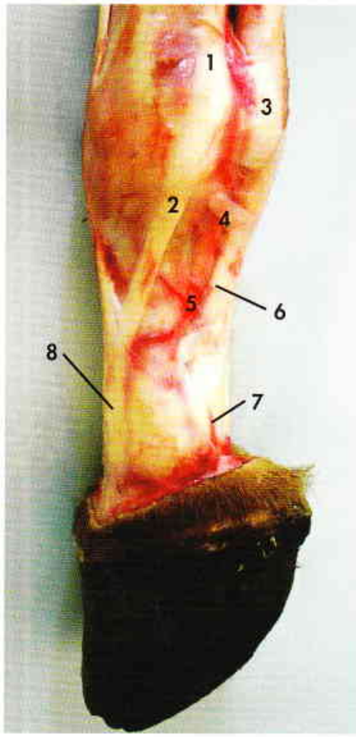


FIGURE 24:

Dissection of medial aspect of the digit.
1. Medial branch of suspensory ligament
2. Dorsal branch of suspensory ligament
3. Palmar annular ligament
4. Proximal digital annular ligament
5. Distal digital annular ligament
6. Superficial digital flexor tendon
7. Deep digital flexor tendon
8. Common digital extensor tendon

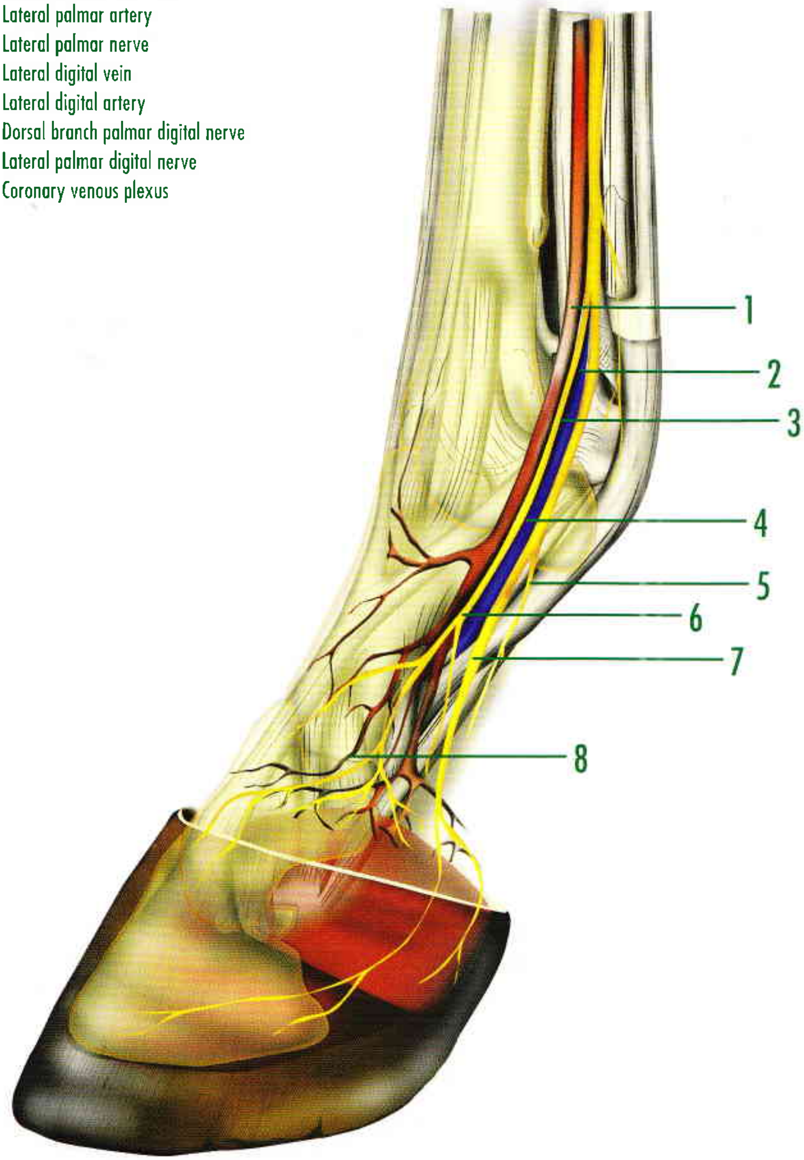
tendon and joint capsule of the fetlock joint. The lateral digital extensor muscle originates from the radius and ulna and inserts on the dorsal proximal first phalanx. A synovial sheath and bursa similar to those in the common digital extensor are present.

The superficial digital flexor muscle originates from the humerus, with a fibrous band (the proximal check ligament, or accessory ligament of the superficial digital flexor) originating from the medial aspect of the distal radius. The tendon is within a synovial sheath as it passes through the carpal canal. A second synovial sheath is present over the palmar aspect of the fetlock joint, extending distally from the distal quarter of the metacarpus to the distal second phalanx. The tendon inserts abaxially on the distal first phalanx and proximal second phalanx, immediately palmar to the collateral ligaments. The deep digital flexor muscle originates from the medial humerus, ulna and radius, with a fibrous band (the distal check ligament, or accessory ligament of the deep digital flexor) originating from the palmar carpal ligament. The latter joins the tendon in the proximal to mid-third of the metacarpus (Figure 23). The tendon passes through a synovial sheath common to the superficial digital flexor both within the carpal

FIGURE 25:

Diagrammatic representation of arteries, veins and nerves of the lateral aspect of the distal limb.

1. Lateral palmar vein
2. Lateral palmar artery
3. Lateral palmar nerve
4. Lateral digital vein
5. Lateral digital artery
6. Dorsal branch palmar digital nerve
7. Lateral palmar digital nerve
8. Coronary venous plexus



canal and palmar to the fetlock. Distally a bursa, the navicular bursa, is placed between the tendon and the navicular bone. Insertion of the deep digital flexor is on the palmar third phalanx and adjacent cartilage. The superficial and deep digital flexor tendons are closely related as they course distally on the palmar aspect of the metacarpus and phalanges (Figure 24). Adjacent to the fetlock joint, the superficial digital flexor tendon forms a ring around the deep digital flexor tendon, until dividing into abaxial branches near its insertion. Both tendons are enclosed by the palmar annular ligament at the level of fetlock and a proximal digital annular ligament distal to the fetlock. Distally, the deep digital flexor tendon is enclosed by the distal digital annular ligament.

In the hind limb, the common digital extensor is replaced by the long digital extensor which originates from the femur. Distal to the tarsus, the tendon is positioned and acts in a similar pattern to that in the forelimb. The lateral digital extensor muscle originates from the stifle collateral ligament, tibia and fibula. It inserts on the long digital extensor muscle in the mid-metatarsus. It acts to assist the long digital extensor. The superficial digital flexor muscle originates from the femur with no accessory ligament, and inserts on the distal first phalanx and proximal second phalanx, similar to the forelimb, but with a fibrous band to the calcaneus. The deep digital flexor originates from the tibia and inserts as in the forelimb. The distal check or accessory ligament is generally thinner and longer than in the forelimb, and may be absent. The relationships of the superficial and deep digital flexors distal to the tarsus are similar to those in the forelimb.

Vasculature

The blood supply to the distal limb is supplied in muscular, thick-walled arteries and returned in thin-walled veins (Figures 2 to 9 and 25).

Forelimb

Arterial supply: The arterial supply of the forelimb is derived from the median and ulnar arteries on the palmar aspect, and the transverse cubital artery on the dorsal aspect.

Dorsally, there are medial and lateral dorsal metacarpal arteries, which run between the third metacarpal bone and each splint bone. These small arteries originate from the dorsal carpal rete.

Most of the arterial supply for the distal limb runs on the medial, lateral and palmar aspects of the limb. The large medial palmar artery (common digital artery) runs on the palmaromedial aspect, along with the associated vein and nerve. It runs between the digital flexor tendons and the suspensory ligament. The small lateral palmar artery runs with the lateral palmar vein and nerve on the opposite side of the limb. Distally, the medial palmar artery divides into the medial and lateral digital arteries (Figure 26).

On the palmar aspect, the palmar metacarpal arteries originate from the proximal deep palmar arch. This arch is formed from the large radial artery anastomosing to the small lateral palmar artery, with contribution from a branch of the medial palmar artery that joins the radial and medial metacarpal arteries. This arch lies superficial to the suspensory ligament and deep to the distal check ligament (accessory ligament of the deep digital flexor tendon), with a smaller branch lying between the suspensory ligament and the third metacarpal bone. The medial and lateral palmar metacarpal arteries continue distally, along with the associated palmar metacarpal vein and nerve. Branches of these arteries join the relevant dorsal metacarpal arteries. The nutrient artery for the third metacarpal bone derives from the medial metacarpal artery, and a middle palmar metacarpal artery may branch off at this point. The distal deep palmar arch is formed from the medial and lateral palmar metacarpal arteries, which join in the distal portion of the metacarpus. A branch from these arteries joins the lateral digital artery and forms the superficial palmar arch.

From the level of the fetlock, the arterial supply is primarily derived from the medial palmar artery, which divides into the medial and lateral digital arteries. These run superficially from the level of the fetlock and provide a blood supply to the fetlock joint, tendons and digital flexor tendon sheath, ligaments, skin and fascia. The superficial palmar arch provides branches to the fetlock joint.

Branches of palmar digital arteries:

a) Palmar branch of proximal phalanx: In the proximal pastern region, a palmar branch from the digital artery provides palmar supply by branches joining between contralateral palmar branches, which run between the straight and oblique distal sesamoidean ligaments. Near its origin, this palmar branch gives off a dorsal branch, which supplies the dorsal aspect and anatomoses with the contralateral dorsal branch deep to the digital extensor tendon.

FIGURE 26:

Superficial dissection of the medial aspect of the distal forelimb.

1. Medial palmar artery, vein and nerve.
2. Medial digital neurovascular bundle (digital artery, vein and nerve)

b) The bulbar artery supplies the digital cushion, skin, frog and heels.

c) The coronal artery supplies the heel and perioplic corium.

d) The dorsal arteries of middle phalanx: These anastomose dorsally deep to the digital extensor tendon. They supply the coffin joint, common digital extensor tendon, perioplic and coronary corium, fascia and skin.

e) The palmar arteries of middle phalanx: These anastomose in the navicular suspensory ligament to form the proximal navicular plexus. They supply the proximal third of the navicular bone.

f) The dorsal branch of distal phalanx: This passes through a foramen in the palmar process of the distal phalanx and exits dorsally to supply the laminar corium (toe – one branch, heel and quarters – other branch). Prior to passing through the foramen, it branches into the palmar branch of the distal phalanx which supplies the digital cushion and frog corium.

g) The branches to the distal sesamoid: These originate from the digital artery immediately distal to the navicular bone.

h) The branch to distal navicular plexus: This runs in the impar ligament. It supplies the distal border of the navicular bone.

i) The terminal arch: Digital arteries enter foramina in the sole of the distal phalanx, and then join the contralateral artery within the semilunar canal to form the terminal arch. This supplies adjacent bone, laminar coriums, the marginal artery of the sole and interconnecting network of arteries.

Venous return (foot): There are 3 interconnected venous plexuses in the foot

1. The dorsal plexus in the laminar corium;
2. The coronary plexus in the coronary corium, connected with palmar plexus through holes in cartilages;
3. The palmar plexus: solar corium, frog corium, digital cushion and cartilages.

Palmar digital veins provide drainage from the 3 converged plexuses. In addition, 2 veins run in the semilunar canal and drain into the palmar digital veins after emerging from the solar foramina. The venous return continues proximally, associated with the matching arterial supply, being joined by venous branches corresponding to the arterial branches.

Hind limb

The arterial supply originates from the femoral artery (continued as the popliteal artery). Distal to the fetlock, the digital supply is similar to that observed in the forelimb.

From the dorsal pedal artery:

1. Dorsal metatarsal artery (femoral): This runs first dorsally, then gradually laterally until it runs in the groove between metatarsals 3 and 4. It then passes between them distally (the distal perforating branch) before dividing into the medial and lateral plantar digital arteries. They are joined by the plantar metatarsal arteries and plantar arteries near their terminal end to form the superficial plantar arch. The dorsal metatarsal artery is not usually accompanied by a vein.

2. Medial and lateral plantar digital arteries

From the saphenous artery:

1. Medial and lateral plantar arteries:

    a) Medial plantar artery: A deep branch passes under the deep digital flexor tendon and forms the proximal deep plantar arch, along with the lateral plantar artery and the proximal perforating branch. A superficial branch runs along the border of the digital flexor tendons until the distal metatarsus where it joins the plantar arteries in the superficial plantar arch, and continues as the plantar digital arteries.

    b) Lateral plantar artery: A deep branch passes deep to the deep digital flexor tendon and forms part of the proximal deep plantar arch. This supplies the deep digital flexor tendon, the plantar ligament and the plantar tarsus. A superficial branch runs along the border of the digital flexor tendons to the distal metatarsus where it joins the plantar arteries in the superficial plantar arch and continues as the plantar digital arteries.

2. Medial and lateral plantar metatarsal arteries:

    These originate from the proximal deep plantar arch and supply the suspensory ligament. They join the distal perforating branch of the dorsal metatarsal artery to form the distal deep plantar arch.

Nerves

Peripheral nerves are composed of bundles of axons with associated Schwann cells and connective tissue. Nerves are frequently found in close proximity to associated arteries and veins, in a relationshi referred to as a neurovascular bundle (Figures 1 to 8).

Forelimb

All the nerves of the distal forelimb originate from the median, ulna and musculocutaneous nerves. There is little motor component t muscles required in the distal limb as it is largely devoid c musculature. The following nerves are located within the distal limb:

1. Medial cutaneous antebrachial nerve:

   This nerve is a branch of the musculocutaneous nerve and supplie the skin of the dorsomedial carpus and metacarpus.

2. Dorsal branch of the ulnar nerve:

   This nerve supplies the skin of the dorsolateral carpus an metacarpus.

3. Palmar branch of the ulnar nerve:

   This nerve supplies sensation to the suspensory ligament, part c the carpal joint and the distal check ligament (accessory ligamen of the deep digital flexor tendon), and terminates as the medial an lateral palmar metacarpal nerves.

4. Medial and lateral palmar metacarpal nerves:

   These nerves run along the edges of the suspensory ligament an supply the fetlock joint capsule and skin in the fetlock and paster regions.

5. Medial and lateral palmar nerves (Figure 25 and 26):

   These arise from the median nerve and run in the groove betwee the suspensory ligament and deep digital flexor tendon, along wit the associated vein and artery. In the proximal portion, the latera palmar nerve runs with the palmar branch of the ulnar nerve. I the mid-metacarpus a communicating branch runs distally fron the medial to lateral nerves across the superficial surface of th superficial digital flexor tendon. The palmar nerves supply th palmar aspect of the fetlock joint, then continue abaxial to th proximal sesamoid bones as the medial and lateral digital nerves terminating within the foot.

6. Medial and lateral digital nerves (Figure 25 and 26):

   Immediately distal to the fetlock, each digital nerve divides to giv off a dorsal branch or branches, and continues as the palmar digita nerves. The exact number, path and interrelationship of the nerves in the distal limb may vary between individuals. Anastomotic branches between the dorsal branch and palmar digital nerve occasionally occur. The presence of aberrant branches has been estimated to occur in 35–50% of horses.

Dorsal branch: This innervates the skin of the fetlock, a portion of the fetlock joint, the dorsal aspect of the pastern and coffin joints and the dorsal hoof (including the collateral cartilages, coronary and perioplic corium).

Medial and lateral palmar digital nerves: These run distally immediately palmar to the associated vein and artery. The neurovascular bundle is situated immediately dorsolateral or dorsomedial to the deep digital flexor tendon and sheath at the level of the first and second phalanges. Distally the nerve divides into multiple branches supplying the structures of the foot and heel region. They innervate the skin on the palmar pastern region, the palmar pastern and coffin joints, the navicular bursa, the digital cushion and the solar and laminar corium.

Hind limb

The nerves of the distal hind limb originate from the peroneal and tibial nerves. As with the forelimb, there is little motor component. The following nerves are located within the distal limb:

1. Superficial peroneal nerve:

   This divides into 2 dorsal branches which run on either side of the extensor tendons. They supply the sensory innervation to the skin on the lateral and dorsal metatarsus.

2. Deep peroneal nerve:

   This supplies the joint capsule of the tarsus, then splits into the medial and lateral dorsal metatarsal nerves.

3. Medial and lateral dorsal metatarsal nerves:

   These supply the dorsal and medial skin of the pastern region, the dorsal pastern and coffin joint capsules and dorsal hoof wall.

4. Medial and lateral plantar nerves:

   These originate from the tibial nerve and run between the suspensory ligament and the deep digital flexor tendon. The lateral plantar nerve divides in the proximal metatarsus and gives off a deep branch, which turns into the medial and lateral plantar metatarsal nerves. They supply sensory innervation of the media and lateral fetlock and pastern regions. Distal to the fetlock, these nerves become the medial and lateral plantar digital nerves.

5. Medial and lateral plantar metatarsal nerves:

   These originate from the lateral plantar nerve and run on the axia aspect of the splint bones. They supply the plantar fetlock joint. They supply sensory innervation of the medial and lateral fetlock and pastern regions.

6. Medial and lateral digital nerves:

   The anatomy at this level is almost identical to the forefoot, excep that in the hind foot a contribution from the dorsal metatarsa nerves also exists.

Chapter 2: The diagnosis of lameness

Marcus Head and Rob Pilsworth

Accurate treatment must be preceded by accurate diagnosis. Time is often wasted by attempts to embark on 'trial by treatment'. Although the experienced farrier or veterinarian may be able to identify a large number of diseases and conditions with only a cursory look at the animal, it should always be borne in mind that our patients sometimes seem to be trying to confound us. Experience, after all, is the name one gives to one's mistakes, although doing something incorrectly for many years is sometimes also mistaken for experience! The aim of this chapter is to enable the reader to minimise the amount of time spent in reflection murmuring "if only I'd....".

In the UK, the Veterinary Surgeons Act does not allow anyone other than a registered veterinary surgeon to diagnose lameness. Similar laws exist in many other countries. Therefore, this chapter is included not to encourage diagnosis by farriers but to serve as a guide to veterinary surgeons and as an explanation of the process of lameness diagnosis to promote understanding and co-operation between veterinary surgeons and farriers.

With the ever-increasing number of diagnostic tools available to the equine clinician, it is always tempting to resort to technology to investigate a problem. However, a thorough clinical examination will always be rewarding. Every farrier and veterinarian will employ the basic examination, to a greater or lesser degree, whenever they cast their eyes over a horse. Many do this so often that the basics of this examination have become ingrained and taken for granted. As experience is gained it is always a useful exercise to 'go back to basics' and, from time to time, examine precisely what we are doing each time we look at a limb or pick up a foot. Much of the following may appear rather obvious to those who deal with horses every day of their lives but it is an undeniable fact that 'you miss more by not looking than you do by not knowing'.

The general appraisal

This part of the examination is, with experience, done almost without consciously thinking about it, but it is important that certain points are noted. Even before the horse is encountered, much can often be learnt from the conditions in which it is kept and the attitude and initial impression given by the owner or guardian. The general condition of the horse should be assessed, particularly with regard to bodyweight. It will be assumed from this point that the horse is lame and that the ensuing examination is aimed at determining the cause.

Lameness, particularly if long term (chronic) or severe, will result in wastage (atrophy) of the muscles that would be used to move the affected limb. The general symmetry of the musculature should, therefore, be assessed. This may help to identify the lame limb, or conversely, to indicate that the limb requiring the most immediate attention is not the one that has been the cause of the long term problem, eg in the case of overload laminitis.

Determining which limb is affected by the lameness

If not immediately obvious, the next step is to ascertain the limb that the lameness is affecting. This is best done by trotting the horse on a loose rein, in a straight line (Figures 1 and 2). It should always be borne in mind that the horse adjusts its body movements, when lame, to avoid transferring weight through the affected leg. There are many people who claim to be able to identify the source of lameness by simply looking at the way the horse moves. Although this is possible

FIGURE 1:

The horse is trotted in a straight line towards the examiner on a level, hard surface. Note that the handler maintains a loose rein, thereby not restricting the movement of the horse's head.

FIGURE 2:

The horse is trotted away from the examiner. Again, the handler holds the horse on a loose rein to allow natural head movement, but the observer should concentrate principally on the hind limbs, particularly the vertical displacement of the pelvis.

in a few cases, eg laminitics generally place the heel of the foot to the floor before the toe, it is always safer to assume that the only fact that can be confidently predicted from watching a horse trot is which limb is the lame one.

Lameness occurs most frequently as a result of pain arising from one, or more, of the structures within that limb. Occasionally, lameness occurs because of a mechanical restriction to movement, or from neurological disease (where there is an inability to move the leg in a normal way, because the messages from the brain cannot be conducted along the pathways to the muscles, or from the joints and muscles back to the brain to provide feedback). Whilst these cases should be borne in mind, the isolation of the source of pain should always be the primary objective.

The trot is the gait in which lameness is most easily recognised. This is because it is an even, 2 beat gait. The terms 'unlevel' and 'stiff' should, generally, be avoided as they tend to cloud the fact that the horse is actually lame in one or more limbs. Similarly, there is no such thing as a horse that is sound at the walk/canter/gallop but 'only lame at the trot'. These individuals are lame at all gaits but it is very difficult, unless the lameness is severe, to identify it in gaits other than the trot.

FIGURE 3:

In forelimb lameness the horse uses its head as a large counterbalance to relieve the pain. As the lame limb hits the ground, the horse attempts to move its centre of gravity backward by lifting its head.

Forelimb lameness results in the horse using the head as a large counterbalance (Figure 3). As the lame limb hits the floor, the horse attempts to move its centre of gravity backward by lifting the head upwards. This is often described as the horse 'nodding on the sound leg'. With hindlimb lameness, the easiest method is to focus the eye on one point on the pelvis, for example the tuber coxa or 'point of the hip'. This point on the lame limb will undergo a greater vertical displacement during the stride than that of the sound, or less lame limb. In other words, the horse will appear to 'drop the hip' on the lame leg (Figure 4). Some horses, usually those with a moderate to severe hindlimb lameness, will also demonstrate a head nod. In most cases, a hindlimb lameness will make the horse appear to nod on the contralateral forelimb (ie the forelimb on the opposite side of the horse to the lame hindlimb). The horse, therefore, appears lame on the ipsilateral (same side) forelimb. Unfortunately, this is not a hard and fast rule but, generally speaking, attention should be paid to the limb showing most lameness first. There are a number of other parameters used in the assessment of the gait which are highly useful but probably beyond the scope of this chapter. For example, changes in the phases of the stride and amount of sinking of the fetlock joint on weight bearing are often useful parameters. Subtle lamenesses are not always obvious when the horse is trotted in a straight line. In these cases lunging the horse in a small circle on a hard surface is a stiff test that may exacerbate the lameness (Figure 5).

FIGURE 4:

To assess which hindlimb is lame, it is easiest to focus on one point of the pelvis, eg the tubar coxa. This point will appear to drop further on the lame limb than the sound side.

Further examination

From this point, the initial step is to rule in, or out, the foot as the cause of the lameness. This is not just the farrier's approach, but any individual involved in assessing the lame horse must focus their attention initially on the distal limb. The shape of the hoof capsule is assessed, with particular attention to symmetry between left and right. A horse with a smaller and more upright hoof capsule in one limb may have a long term lameness problem that has resulted in less weight being applied through this leg, or may have acquired this foot shape early in life, eg low grade club foot, with or without adverse long term effects. The growth rings may give some indication as to the history of the horse. So-called 'hardship lines' occur when significant changes in management occur and appear as prominent ridges in the hoof wall. They are rarely of significance when examining the lame individual but provide interesting and often relevant information as to a horse's

FIGURE 5:

The horse is lunged on both reins within a small diameter circle on a hard, level surface. This is a particularly stiff test for soundness and will often exacerbate a subtle lameness which is not obvious when the horse is trotted in straight lines.

history. Divergence of the growth rings occurs specifically in laminitis. Because the growth of the hoof is retarded at the front of the hoof, the rings are set wider apart at the heels. Divergent hoof rings are almost invariably encountered in horses or ponies presented for acute (sudden onset) laminitis and indicate that the individual has been living with sub-clinical disease for some time prior to presentation.

The feet should be viewed from in front and from behind the horse. This will enable the observer to assess the symmetry and balance of the feet. When viewed from the side, the dorsopalmar balance of the feet can be ascertained and the hoof-pastern axis (HPA) can be evaluated. Long toes and low, under-run, heels are a very common finding in the Thoroughbred, and result in a broken back HPA. The dorsal wall of the hoof capsule should be at the same angle as that of the dorsal pastern, relative to the ground. In other words, it should be possible to draw a perfectly straight line from the toe to the fetlock along the front of the foot and pastern. If this line is 'bent' with the kink forward, the horse is said to have a broken forward HPA. This is typical of club footed horses. Conversely, if the kink is backwards then the HPA is broken backwards. Although in itself, the HPA is not a cause of lameness, it will have a significant influence on the way weight is transferred through the foot and the structures within it. When viewed from behind, the shape of the heels and the relationship between medial and lateral should be assessed. A common finding is that the medial heel is displaced proximally (upwards) relative to the lateral heel. This occurs because of mediolateral imbalance and the fact that the lateral heel strikes the ground first. This eventually causes the medial heel to be pushed upwards. If this becomes a long-standing problem, sheared heels may result. An in depth description of hoof balance and assessment can be found in Chapter 6: The Principles of Foot Balance.

FIGURE 6:

Palpation to detect the amplitude of the pulse within the palmar digital arteries. The neurovascular bundles can be felt on the inside and outside of the fetlock over the back of the proximal sesamoids. In this illustration, the left thumb is on the lateral artery and the first finger is on the medial artery.

A brief examination of the whole limb, as the hands are run down towards the foot, will help avoid missing anything obvious higher up the leg, and a potentially unrewarding exploration of the foot. The initial inspection should involve an assessment of the surface temperature of the hoof capsule. This should always be compared to the opposite foot, as the temperature of the feet will vary during the day. Using the less dominant hand, ie the left hand in right handed people, will give a greater sensitivity to temperature.

Palpation of the digital arteries is easiest at the back of the fetlock joint, where they pass over the proximal sesamoids (Figure 6). The neurovascular bundles are medial and lateral, at the back of the fetlock joint and they can be felt, rather like thin pieces of string. Each bundle consists of the palmar artery, vein and nerve. As with other superficial arteries, a pulse can be felt, corresponding to each contraction of the heart. Time should be spent learning where these arteries lie and the normal amplitude of the pulse that can be felt. With careful palpation, a pulse can be felt even in normal horses with no abnormalities. As with all aspects of the examination, the pulse should be compared with the opposite limb. An increase in the amplitude of the digital pulse merely signifies an increase in pressure of the blood flow to the foot. However, it is a highly significant and useful clinical sign, as it generally indicates inflammation within the foot. Many farriers and veterinarians use this simple check, almost without thinking. Conditions as varied as subsolar abscess ('pus in the foot'), solar bruising, distal phalanx fractures, laminitis and distal interphalangeal joint synovitis all result in an 'increased digital pulse' so this clinical finding is by no means specific for a particular condition, but it is a highly useful finding when trying to localise the site of lameness.

Unfortunately, because the structures within the foot are enclosed within a semi-rigid capsule, further palpation of the vital areas is limited. The distal interphalangeal joint ('coffin joint') can be felt on the dorsal aspect of the foot when distended. Careful palpation just above the coronary band on the front of the foot will reveal a fluid like swelling. This feels fluctuant when pressure is applied. Enlargement of the structures around the proximal interphalangeal joint ('pastern joint') can also be palpated.

The distal intersesamoidean ligaments, the branches of the superficial digital flexor tendon (SDFT) and the deep digital flexor tendon (DDFT) can also be palpated on the palmar aspect of the foot/pastern region. Sepsis of the navicular bursa often results in a pain response from the horse when firm pressure is applied to the region between the bulbs of the heels. Infections of the foot, ranging from relatively straightforward subsolar abscesses to life threatening sepsis of the distal interphalangeal joint or navicular bursa may produce oedema of the distal limb ('filled leg' or 'humour'). A fluid swelling may sometimes be felt on the palmar aspect of the pastern associated with the digital sheath. This tube-like structure envelopes the flexor tendons from above the fetlock joint to the foot. Filled with synovial fluid, it allows the tendons to glide easily over the back of the fetlock, and is sometimes referred to as a 'tendinous windgall' (Figure 7). It is important that this is recognised as damage to the tendons within this structure may also result in an increase in the amplitude of the digital pulse.

FIGURE 7:

Medial view of the right fore fetlock joint. The digital sheath is distended ('tendinous windgall'). This can be seen both above and below the fetlock (arrows).

At this point the leg should be picked up and palpated further. All of the structures mentioned above should be re-assessed and the distal limb should be flexed firmly to try and elicit a painful response from the horse and ensure that there is a normal range of movement in the distal joints. The mediolateral balance should again be assessed. For the forefoot the limb should be held, flexed, with the observer facing the back of the horse. For the left forelimb ('near fore') the left hand should hold the cannon bone loosely, with the arm inside the knee and forearm of the horse. Holding the cannon with the operator's arm outside the forearm and inside the knee will result in the limb not being held straight and distorts the anatomy from the viewer's eye (see Chapter 6 for a more detailed assessment of foot balance).

Hoof testers

Probably the most important piece of diagnostic equipment in the armoury of equine clinicians is the hoof tester. Used every day, and on every lame horse examined, this relatively inexpensive tool is vital. There are a number of different designs of hoof tester available, some of which are capable of exerting enormous pressure when operated even by the weakest of users. Some of the older versions come with very long handles and even elaborate hinge systems that amplify the force applied from the operator's hands to the foot. The simple rule, as with all equipment, is to buy a well made instrument to which you will become accustomed easily and that will stay the distance.

The principle of using hoof testers is simple. When they are applied to the foot and pressure is exerted by closing the handles, the horse will exhibit a withdrawal reflex if the act produces pain. The examination

FIGURE 8:

Poor use of hoof testers often leads to excessive searching of the hoof. The white line has been almost entirely debrided and large cavities opened at both heels.

should be systematic, although there is no hard and fast rule as to the 'correct' method.

One method is to begin at the heel and slowly work around to the other heel. Should there be any pain reflex, the hoof testers are moved to the furthest point on the foot and worked back towards the point of pain. This improves the accuracy in pinpointing the source of pain and reduces the often seen 'trench method' of abscess searching (Figure 8).

The initial application of the hoof testers should not be with too much pressure. It is better to go around several times increasing the pressure incrementally than to immediately cause a widespread pain response which often increases the sensitivity to all further pressure.

The foot should be placed between the knees for a front limb and over the knee for a hindlimb, as if the shoe were being removed. This will allow the leg to be held securely and safely should the horse resent the examination, and the hoof testers to be used with both hands. Holding the foot with one hand and operating the hoof testers with the other will lead to inconclusive results and puts the operator at potential risk should the horse move the limb suddenly or attempt to kick. Pressure is applied around the hoof capsule, paying particular attention to the positions of the nails, and the common sites of bruising or subsolar abscessation, such as at the toe and the seat of corn (Figures 9, 10 and 11). Many texts state that applying pressure across the heels and from one frog cleft to the hoof wall (Figure 12) may indicate pain arising from deeper structures, such as the distal sesamoid, but these authors have never found this to be a useful test for such conditions.

When taking other clinical signs into account such as an increase in the amplitude of the digital pulses and an increase in the surface temperature of the hoof capsule, a positive response on examination with hoof testers represents a highly significant finding. The most common conditions diagnosed in this way are solar bruising (including corns), laminitis and subsolar abscesses ('pus in the foot'). Occasionally fractures of the distal phalanx or distal sesamoid will also be encountered. As mentioned previously, cases of navicular disease, distal interphalangeal joint synovitis, DDFT pathology and other conditions affecting the deeper structures within the foot cannot be diagnosed reliably with hoof testers.

A positive response on application of the hoof testers does not provide a diagnosis, but does at least identify the region of the limb from which the lameness is likely to be arising. Some horses, particularly racing

FIGURE 9:

Pressure is applied at the toe of the hoof with the hoof tester. The examiner should hold the foot firmly between the knees and operate the hoof testers with both hands.

FIGURE 10:

The hoof testers are placed so that they exert pressure on a single nail. This is repeated around the foot so that all nails are assessed.

FIGURE 11:

Pressure is applied from the medial wall across to the medial 'seat of corn' (between the bars and the wall). Many horses react to pressure applied here and it is important to compare the lame limb to the sound limb as examination of the lame leg only may be misleading. This is a common site of lameness and extra time should be spent examining this area, and in particular, comparing it to the opposite limb. If in doubt, the shoe should be removed and the area explored further.

FIGURE 12:

The hoof testers are positioned from the wall of the hoof to the frog. Some authors advise positioning of the hoof testers from heel to heel, as a method of diagnosing 'navicular syndrome'. The present authors have not found this to be useful.

Thoroughbreds, seem particularly sensitive to pressure applied to the feet in the way described above, even if the source of the lameness does not originate in the foot. The contralateral foot should therefore be examined if there is any doubt, and this will become a routine part of the assessment for those involved in the care of such animals. Whether or not the hoof testers indicate a site of focal pain, the foot should be trimmed clean and explored further if there is any chance at all of the problem being within the foot.

Regional anaesthesia ('nerve blocks')

A very dramatic response can often be seen on the faces of horse owners and trainers when 'blocking' the foot abolishes 'shoulder lameness'. Diagnostic nerve blocks are the mainstay of lameness diagnosis in the horse despite the advent of far more technologically advanced methods such as scintigraphy. Once again, the principle is simple. If the nerves that supply a particular area of the limb are anaesthetised ('blocked' or 'frozen'), the horse cannot feel it. If the source of the pain is in that area, then the lameness will not be evident when the horse is trotted subsequent to the block. By this means, the region responsible for the lameness can be identified. However, as with all procedures relating to the horse, things may not be quite that straightforward. Nevertheless, the use of nerve blocks is a rewarding, relatively simple and inexpensive method of narrowing down the options. The main use of regional anaesthesia is for the diagnosis of lameness, but is should also be borne in mind that it can play a very useful role during treatment and management.

If we concentrate on the use of regional anaesthesia as an adjunct to lameness diagnosis then the following protocol will illustrate how it is used. Whilst it might seem obvious, a prerequisite to nerve blocking is a lame horse. Generally speaking a positive response is said to have been seen when at least a 50% improvement in the degree of lameness occurs subsequent to the block. It is, therefore, pointless to nerve block a horse with such a subtle lameness that a 50% improvement cannot be appreciated. Most equine clinicians grade lameness as a method of recording their observations objectively and allowing comparisons between examinations. There are several systems, but the 2 most commonly employed grade the degree of lameness between 1 and 10 or 1 and 5. In both systems, zero represents soundness, and the higher number represents non-weightbearing.

The present authors favour the 1 to 5 system as it seems the easiest to apply objectively. It should be borne in mind that, rather like the pH scale relating to acididity/alkalinity there is a somewhat logarithmic character to the scale. In other words, the difference between Grades 3 and 5 is far greater than the difference between Grades 1 and 3.

The '1 to 10' system appears to offer more options but is, in our opinion, a less satisfactory scale.

Lameness grades

Grade 1: the subtlest lameness that can be seen, ie slight;

Grade 2: mild;

Grade 3: moderate;

Grade 4: severe;

Grade 5: non-weightbearing.

It is important that a baseline lameness is established before nerve blocks are attempted. In the horse that has an obvious lameness at the trot, this will not be difficult. A thorough evaluation, including flexion tests and trotting on the lunge on hard and soft surfaces should always be considered, although the interpretation of flexion tests is a contentious issue in itself and, if an obvious lameness presents itself when the horse is trotted in straight lines, lunging may not be necessary. Individual cases must be judged on their own merits.

Fortunately, the nerve supply to the distal limb of the horse is relatively simple. Owing to the evolutionary adaptations that have occurred, the horse walks, trots and gallops on only 2 'fingers' and 2 'toes'. This has not simplified the dynamics of these athletes, but it does make nerve blocking considerably easier. Generally speaking the process should be started at the bottom of the limb (distal), working upwards (proximal). This is because the most common causes of lameness occur in the distal limb, and also because if the initial block is proximal it is then not possible to block distally until the nerve block has worn off (2–3 h).

Broadly speaking, regional anaesthesia can be divided into 2 categories. Perineural anaesthesia involves injecting small amounts of local anaesthetic beneath the skin, as close as possible to the nerves that are to be 'blocked' (Figures 13 and 14). Intra-articular anaesthesia requires the anaesthetic to be injected directly into joints (Figure 15). This latter procedure improves the specificity as, in theory, only one structure is blocked out. In practice, however, even intra-articular

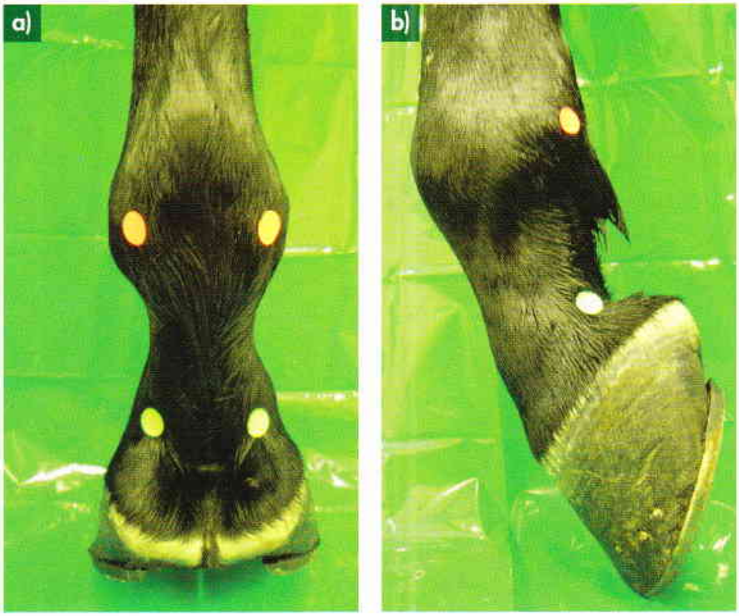


FIGURE 13:

a) Palmar view of the fetlock/pastern, indicating the positions at which local anaesthetic should be injected for anaesthesia of the palmar digital nerves, medially and laterally. Orange dots: 'abaxial sesamoid nerve block'; Yellow dots: 'palmar digital nerve block'

b) Lateral view of the fetlock/pastern, indicating the positions at which local anaesthetic should be injected for anaesthesia of the palmar digital nerves, medially and laterally. Orange dots: 'abaxial sesamoid nerve block'; Yellow dots: 'palmar digital nerve block'.

FIGURE 14:

Regional anaesthesia: The limb is held up whilst local anaesthetic is injected around the lateral palmar nerve of the right forelimb. Approximately 2 ml of solution should be injected around each nerve.

anaesthesia may influence structures outside the joint. Usually, perineural anaesthesia is used to isolate the source of the lameness to a general area, and intra-articular anaesthesia is used subsequently to refine the search area. Once again, it should be noted that regional anaesthesia only determines the region of the limb where the source of the pain lies; it does not provide a diagnosis. Imaging techniques such as radiography (x-rays), scintigraphy (bone scanning) and ultrasonography provide the visual information to permit a diagnosis (see Chapter 3: Imaging the Foot and Leg).

Once the initial lameness assessment has been made, the first nerve block is performed. The following description applies to the forelimb, but is equally applicable to the hindlimb. Anatomically, the back of the forelimb from the carpus distally is referred to as palmar. In the hindlimb, the same region is said to be plantar. These terms are interchangeable from forelimb to hindlimb in the following text.

From the perspective of identifying the foot as the cause of the lameness, the first block used will either be the 'palmar digital' block or the 'abaxial sesamoid' block. A palmar digital block involves anaesthesia of the medial and lateral palmar digital nerves just above the collateral cartilages of the foot (Figure 14). The abaxial sesamoid block anaesthetises the palmar nerves on the palmar aspect of the fetlock (or on the abaxial aspect of each sesamoid, Figure 13). The procedure is similar for both, and indeed, all nerve blocks, but the location of the needle placement obviously varies.

The foot is picked up and the operator places a short, fine needle subcutaneously in the correct position to lie close to the nerve (medial or lateral). Once in position, a syringe is attached to the needle and 1–2 ml of local anaesthetic is instilled over the nerve (Figure 14). Frequently, if the needle is close to the correct position, blood will be seen in the needle hub, or will flow from the needle. This is not a cause for concern but indicates that the needle is very close to the nerve, as the artery, vein and nerve run together in a neurovascular bundle. The needle should be repositioned slightly, by retracting the point and then repositioning in a slightly more palmar position. The injection of local anaesthetic should be subcutaneous and, if done correctly, an obvious 'bleb' should rise during injection. This should be easily dispersed by digital pressure subsequently. The procedure is then repeated for the opposite nerve.

FIGURE 15:

Intra-articular anaesthesia: Local anaesthetic is injected into the dorsal pouch of the distal interphalangeal joint (DIPJ/'coffin joint'). Note that the limb has been clipped and scrubbed and that the operator wears sterile gloves to avoid introducing infection.

After 10–20 min the horse should be trotted up again. Some clinicians prefer to have the horse walked in order to enhance diffusion of the local anaesthetic and hence increase the chances that the nerves will have been blocked. Others prefer to allow the horse to stand in a box, believing that increased diffusion will reduce the specificity of the block. The present authors usually compromise and have the horse walked for 1–2 mins before being placed back in the box. If the horse trots up sound after the injection of local anaesthetic, then it has had an effect. This is a positive response. If the horse is still as lame (and some horses actually trot up more lame after blocking the foot, if the source of pain is not in this area), then this is a negative response. In the latter case it can be assumed that that the cause of the lameness is not within the area affected by the nerve block. Problems arise if the block has not anaesthetised the nerves fully or the nerves are anaesthetised fully but the block has only been partially successful in abolishing the lameness.

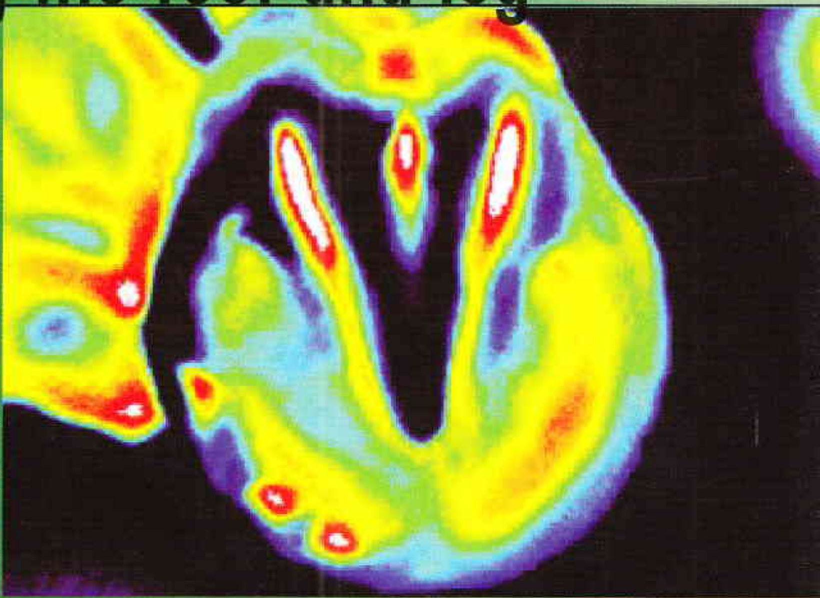
In the first instance, the block should be repeated, and incomplete anaesthesia should be assumed in the second instance until proven otherwise. Proving this can be difficult. Skin sensation, or lack of, is the most commonly used method of assessing the effect of the nerve block. Although this is generally applicable, there are cases in which skin sensation remains despite the lameness having been abolished. The degree of lameness seen after the block is the most reliable guide to its effectiveness. Local anaesthetics work in a complex way. Each nerve is a bundle of fibres contained within a lining, analogous to a bunch of electric wires contained inside a pipe. Each wire is connected with a different site, is of a different size and conveys different information along its path. When local anaesthetic is injected on or close to the outside of the 'pipe' (the nerve), it has to move inside and interact with the 'wires' (the neurons). The time taken to affect each neuron depends on the type and thickness of the pipe and the role of each individual neuron. Therefore, neurons that transmit the sensation of pain may be anaesthetised whilst those that convey the feeling of pressure may remain functional. As always, a fairly simple procedure is more complicated when considered in more detail.

If anaesthesia of the palmar digital nerves at the level of the collateral cartilages does not alter the lameness, the next step is to move slightly proximal and perform the same procedure on the palmar nerves on the palmar aspect of the fetlock ('abaxial sesamoid nerve block'). Numerous texts have been written on the precise areas that each block desensitises and a whole chapter could be devoted to this one point. However, if blocking the foot abolishes the lameness, then at least further investigations can be directed more precisely.

There are occasions when pain arising from the foot is not abolished by either the palmar digital or abaxial sesamoid nerve blocks. This is particularly true if the condition is causing severe pain. Some septic conditions such as subsolar abscesses or chronic distal interphalangeal joint sepsis may not respond to regional anaesthesia, as has also been the case with fractures of the distal phalanx. The reasons for this are complex and, as yet, not fully understood.

Further efforts to determine the source of pain usually involve intra-articular anaesthesia. Injection of local anaesthetic, under strict aseptic conditions, into the distal interphalangeal joint and navicular bursa may help to elucidate the cause of the lameness. From this point, once a precise anatomical location is identified, imaging techniques such as radiology, ultrasonography, scintigraphy and in some cases magnetic resonance imaging may be necessary to provide the diagnosis.

Chapter 3:
Imaging the foot and leg



Marcus Head, Josie Meehan,
Rachel Murray, Richard Payne,
Rob Pilsworth and Mike Shepherd

Radiography is a method of taking images of a structure enabling us to see, for example, the tissues inside the hoof or limb. The object of radiography is to produce optimal quality x-ray images of the correct views at standard angles to the foot. This enables a radiologist to make a diagnosis of abnormality.

RADIOGRAPHY

Josie Meehan

Equipment

X-ray machine

This generates a cloud of electrons which are focused and accelerated against a target within the 'tube'. The collision of these electrons with the target, usually made of the metal Tungsten, produces x-rays. The power of the x-ray beam is controlled by the operator and depends on the number of electrons generated and the speed at which they hit the target (Figure 1).

X-ray film

This is a sheet of plastic which is coated on one or both sides with x-ray sensitive chemicals, based on silver salts and similar to those used in photography. When this has been exposed, the film needs to be developed chemically to allow the human eye to see the resulting image, which is essentially black and white.

X-ray cassettes

The function of the cassette is to protect the film from light exposure and to keep the film perfectly flat. Modern cassettes also contain 'screens' which amplify the effect of each x-ray hitting them by producing tiny flashes of light, allowing a reduction in the radioactive dose needed to produce a diagnostic image.

FIGURE 1:

Taking an upright navicular view. Note the use of gloves and protective clothing and the groom standing as far away as possible.

Methods of development

After exposure, the film needs to be processed in order to see the image. This involves a development stage where the image becomes visible and a fixing stage which will keep the image permanently on the film. This may be carried out by hand in tanks or by an automatic processor.

Positioning aids

Various blocks are used to hold the foot at the required angles to allow diagnostic views to be taken. Cassette holders ensure the correct positioning of the plates.

Safety

Radiosafety is an important issue for the health and welfare of the horse and all the people who are involved in the radiographic process. Exposure of human and animal tissue to x-rays is harmful and adequate protection is essential. Most, if not all, countries have radiosafety legislation which must be followed. Detailed legislation varies internationally but basic principles are:

- Radiographs should only be taken when clinically justified.
- The minimum number of exposures should be taken to allow a clinical diagnosis to be made.
- Radiographic exposures should only be made in specially controlled areas, with adequate environmental and personal protection and standard operating procedures.

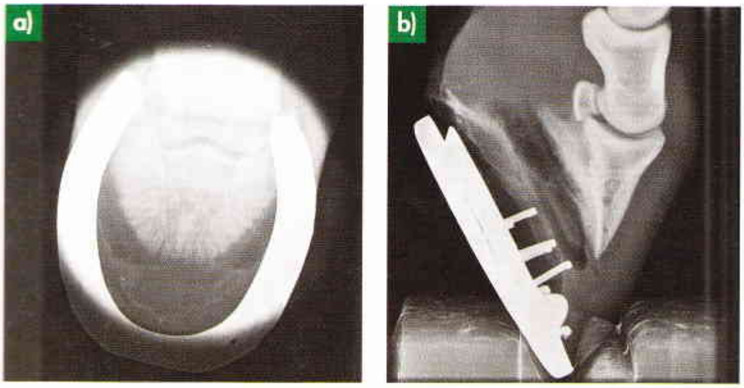


FIGURE 2:

a) Dorsopalmar and b) Lateromedial views of the same foot. The darker area around the distal margin of the pedal bone (a) and between the sole and pedal bone (b) is pus.

FIGURE 3:

To produce clear images, the sole and frog are trimmed and the sulci are filled with a modelling clay (Play-Doh).

- Modern machine, screen and film technology should be used to minimise exposure times.
- The height and width of the x-ray beam must be controlled by collimation to minimise scatter and to keep the edges of the field of view inside the border of the cassette.
- Only the minimum number of people needed to restrain the horse and manage the machine and cassettes should be within the controlled area.
- Only the specific area to be imaged, and no personnel or their appendages, should be positioned in the direct line of the x-ray beam.
- All personnel who are required to be involved with the radiographic exposure must wear fully-functional radiosafety clothing, eg lead aprons, and must also be dose monitored.
- X-ray cassettes should be positioned, ideally in the blocks, or held remotely in cassette holders by personnel wearing protective gloves.
- Personnel who are regularly involved with radiographic examinations must be monitored for their level of exposure.

Image quality

The quality of the image depends on several important factors:

- The strength of the x-ray beam.
- The distance from the x-ray source to the cassette and film.
- The variable ability of the x-rays to penetrate the different tissues in the path of the beam.
- The chemical development process of the film.

The areas of film exposed to the unobstructed x-rays will, after development, be black, whereas those that are obstructed by solid objects will be relatively underexposed and will appear white. Bone is a solid tissue which absorbs x-rays and therefore produces a white x-ray image. Less dense tissue, such as tendons and ligaments, produce various shades of grey. Fat and gas are the least dense tissues, producing almost black images. A 'pocket' of gas or pus in an infected foot will appear as a discrete black area (Figure 2).

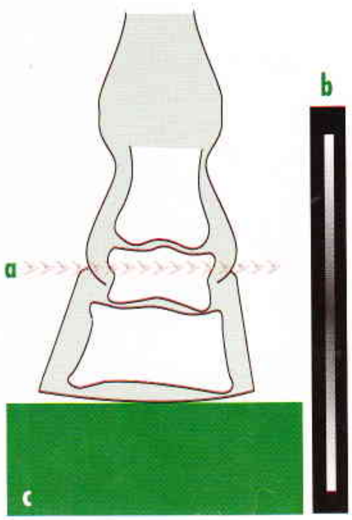


FIGURE 4:

Standing lateromedial foot: a) Direction of beam; b) Cassette and film; and c) Wooden block.

Modern radiographic exposure times for feet are very short but movement of the patient during an exposure will result in a blurred image. The horse must co-operate with the radiographic process by

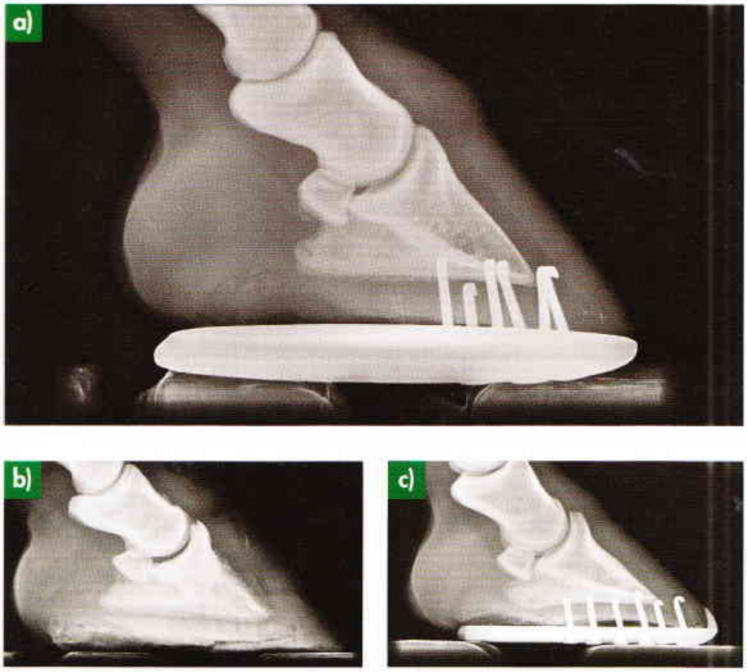


FIGURE 5:

Lateromedial views show both changes to bone and its position within the hoof capsule.

a) Relatively good dorsopalmar balance;

b) Changes to the parietal surface of the pedal bone caused by infection;

c) Low collapsed heels and a broken back hoof-pastern axis with toe length.

standing still, with its foot in the position required. Chemical tranquillisers should be used where the horse does not co-operate.

Standard views

Experience has established standard views of the foot that allow the majority of abnormal conditions to be imaged. Nevertheless, clinicians will occasionally take different views at different angles and exposures and with different kinds of film to highlight certain areas. The following is a brief description of the standard radiographic view of the foot.

Preparation of the foot and limb

Adequate preparation must be carried out first to ensure a diagnostic result. The foot may have the shoe removed, although it may be useful to have lateromedial foot pictures with the shoe on. This allows assessment of dorsopalmar foot balance. The foot should be cleaned out thoroughly and the frog and horn pared of any loose tissue. The whole area should be cleaned with a stiff brush, washed and dried thoroughly. The ergot, if excessively long, may be trimmed. It may be useful to bandage feathers up away from the back of the fetlock.

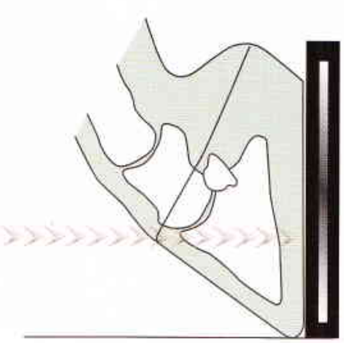


FIGURE 6:

Foot position for upright pedal view (dorsopalmar), correctly called a dorsoproximal-palmarodistal oblique view.


FIGURE 7:

Dorsopalmar view. a) Upright dorsopalmar showing sagittal fracture of PIII; b) Upright navicular view.

The frog sulci will need to be packed for views of the navicular bone to be acquired without artefacts. Playdoh, soft soap or Vaseline may all be utilised for this purpose (Figure 3). The limb should be examined thoroughly for mud etc and the coat brushed to remove all debris.

Lateromedial view

This is the 'side' view which is used to examine the pedal bone and its relationships to the hoof wall, ie in cases of laminitis. The horse stands on a wooden block. The x-ray machine is positioned on the outside of the limb and the beam is directed across the foot towards the film positioned on the inside of the limb (Figures 4 and 5 a,b,c).

Dorsopalmar view ('upright pedal' and 'upright navicular')

This is the 'front to back' view. The machine is placed in front of the horse and the foot is held on a block with the toe pointing towards the floor. The film is placed against the sole of the foot. Strictly speaking this is called the dorsoproximal-palmarodistal oblique view (DPPaDO; Figure 6).

This view is used to produce 2 separate images, one of the distal phalanx (Figure 7a) and after a slight change in angle of the foot another of the distal sesamoid (Figure 7b).

In a true or standing dorsopalmar view the foot is placed in a normal weightbearing position and the x-rays aimed at the front of the foot with the film at the back of the foot (Figures 8 a,b).

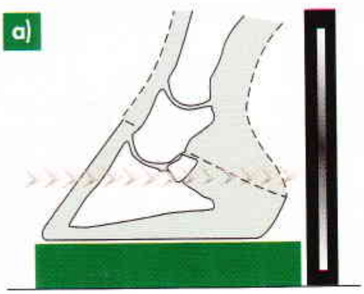



FIGURE 8:

A true dorsopalmar image will show a mediolateral imbalance. The limb balance of this pony is shown in Chapter 6: The Principles of Foot Balance.

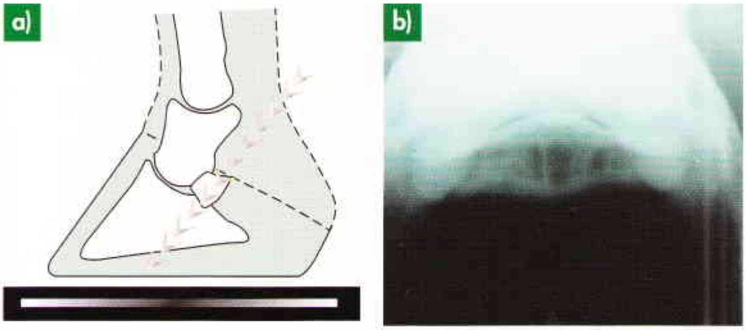


FIGURE 9:

a) Showing positioning for flexor view; b) Resultant image showing the distal sesamoid with evidence of changes.

Palmaroproximal-palmarodistal oblique view ('flexor' or 'California' view)

This is very useful for looking at the distal sesamoid. It also highlights the wings of the pedal bone. Unfortunately, the horse has to place the foot as far back underneath the body as possible and stand on a special cassette tunnel that contains the film. The machine has to be manoeuvred underneath the belly of the horse to aim the x-ray beam down at the heel bulbs. This is not a comfortable position for most horses and many require sedation to obtain the best images (Figures 9 a,b and 10).

Contrast radiography

A radio-opaque substance (Conray) is injected aseptically into the navicular bursa, usually in conjunction with a local anaesthetic. This enables the clinician to confirm that the anaesthetic is contained within the bursa. This technique can also be used to ascertain the extent of penetration injuries.

FIGURE 10:

Lateromedial radiograph of foot showing contrast which has been injected into the navicular bursa.

ULTRASONOGRAPHY

Mike Shepherd

Ultrasonography is an imaging technique used for the assessment of soft tissue structures within all species. Not only is it employed for orthopaedic imaging (tendons, ligaments and joints) it is also commonly used for assessment of heart, lungs, abdominal viscera and reproductive systems.

An image is created by a high frequency sound wave being transmitted through the soft tissues. When the sound wave reaches an interface between tissues of different density, a proportion of these waves is reflected back towards the transducer, received and the information is transferred to the machine to be processed. This raw information is converted into an image after calculating the time taken for the wave to be reflected back and hence the depth of the particular interface can be assessed.

Equipment

Different machines and more specifically transducers operate at different frequencies. A crystal present within the head oscillating at a certain frequency creates the ultrasound beam. Higher frequency probes have a higher resolution and hence better image quality. The downside of this is that the depth of penetration will decrease. Thus for superficial work, either 7.5 or 10 megahertz scanners are used. Should deeper body parts require imaging, a lower frequency probe will be utilised.

Technique

In order for successful and accurate imaging to be performed, a close 'coupling' of the transducer and the skin must be achieved. Hence, thorough cleaning and often clipping of the limb is necessary and the use of ultrasonographic gel is always required. It is also imperative that the transducer is placed at right angles to the tissue being examined. This ensures the majority of the reflected ultrasound beam is collected by the transducer in order to maximise the brightness of the image.

To interpret images accurately, a thorough knowledge of the normal anatomy of the region is essential. Also consideration needs to be given to potential artefacts and variations of normality.

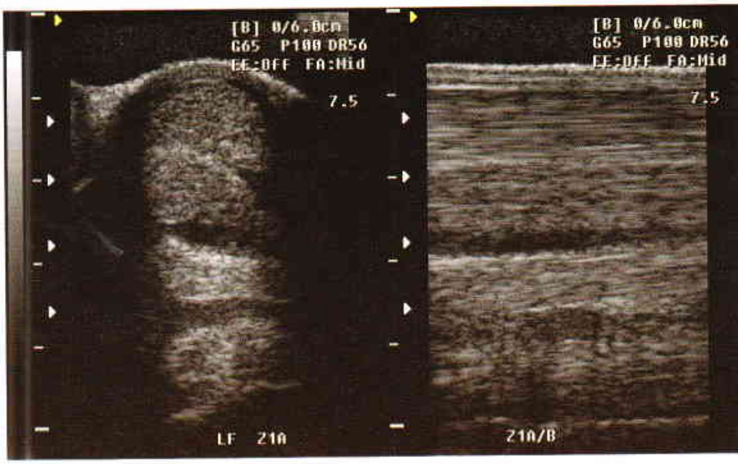


FIGURE 11:

This shows a transverse and longitudinal ultrasonographic image of the tendons and ligaments in the mid cannon region of a normal limb. Note the regular echogenicity and fibre pattern of each of these structures.

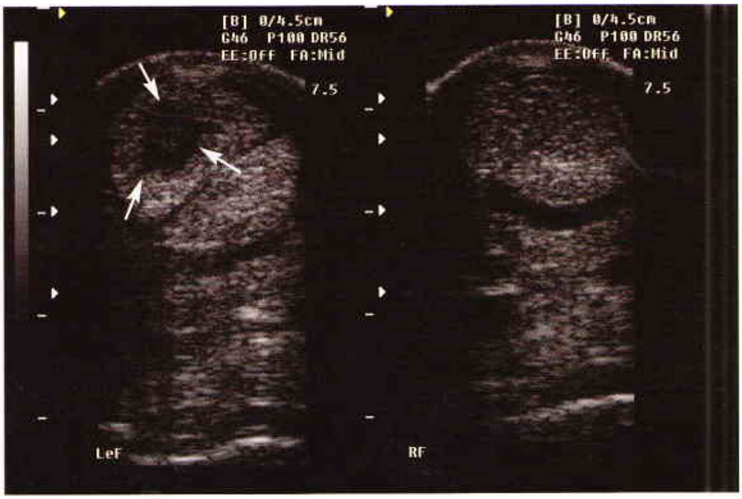


FIGURE 12:

A transverse image of an injured SDFT on the left hand side (arrowed) and a comparative normal image on the right.

Assessment of soft tissue structures in the cannon bone region

The superficial digital flexor tendon (SDFT) , the deep digital flexor tendon (DDFT), the inferior check ligament and the suspensory ligament are all lying behind and parallel to the cannon bone. These are very accessible to ultrasonographic examination and, due to their relatively regular layout, any subtle changes are detected readily (Figure 11). It is important to know the relative size and shape of each structure at different levels along the cannon bone in order to judge normal from abnormal. During examination of this region, it is also important to compare images of both limbs (Figure 12).

When a structure is damaged, an inflammatory process is set up. This results in an accumulation of fluid within the relevant tendon or ligament. This extra fluid shows up as a dark area (hypoechogenicity) on the scan. This comes about due to a lack of echo being created within this area. As well as the alteration in echogenicity, an injury will also result in an increase in cross sectional size and a loss of fibre pattern in longitudinal section (Figure 13).

Assessment of the soft tissues of the pastern region

Both the SDFT and DDFT continue their course through the pastern region. These tendons are accompanied by short, strong ligaments which originate from the bottom of both sesamoid bones and insert into the back of the pastern region. These short ligaments complete

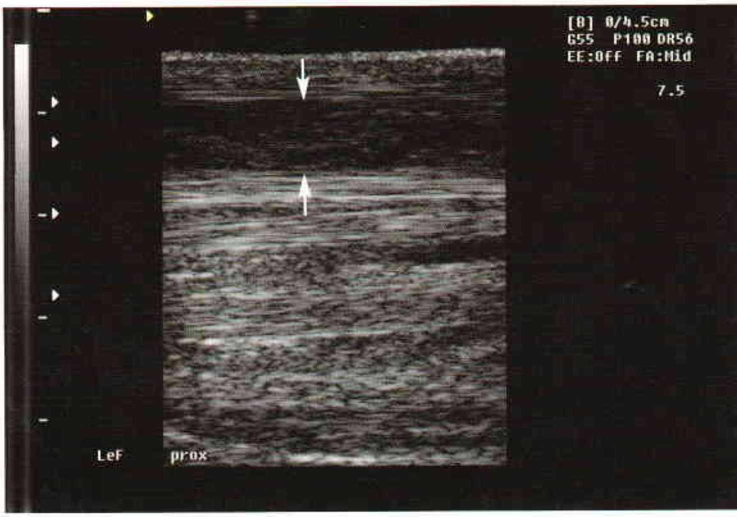


FIGURE 13:

This shows a longitudinal image of an injured SDFT. Note the central area of hypoechogenicity associated with a significant loss of fibre pattern (arrowed).

the suspensory apparatus lending support to the fetlock joint. The SDFT divides into outside and inside branches which insert at the level of the pastern joint. The DDFT continues its course distally, runs over the bottom of the navicular bone and inserts onto the pedal bone.

The pastern region is obviously more complicated than the cannon region. Although ultrasonographic examination is possible, but more care and attention to the varying sizes and shapes of individual tendons and ligaments needs to be employed.

Assessment of the foot region

Recent advances in ultrasonographic techniques have allowed some visualisation of the DDFT and the navicular bursa as it courses behind and underneath the navicular bone. This technique requires a specific transducer and careful preparation of the foot with significant trimming to the frog. Unfortunately the images obtained of the DDFT are limited in both the extent of the region imaged and the quality of the image obtained. Hence for accurate and sensitive images of these soft tissue structures, an MRI scan is best employed where possible.

MAGNETIC RESONANCE IMAGING

Rachel Murray

Equipment required for MRI

At present there are few MRI systems available for imaging in the live horse because of the constraints associated with creating a uniform magnetic field. The magnetic field strength is described in terms of Teslas (T). Most human clinical systems tend to be in the range of 0.5–1.5 T. Various types of system are available for use in man: 'closed' systems, dedicated extremity magnets and an 'open' configuration. Closed systems are the most commonly used and consist of a cylindrical, superconducting magnet into which a human or small animal patient can be placed. Obviously there are size constraints with this type of system so only the extremities of a horse could be fitted into the clinical systems in current hospital use. Extremity magnets have also been produced for the medical market, and use a lower field magnet to produce images of single extremities.

MRI is a non-invasive technique used widely in people, and increasingly in small animals for detection of pathology in a wide range of tissues. MRI has particular applications for orthopaedic injuries affecting bones, joints and soft tissues. It is non-invasive and requires the use of no ionising radiation, but is relatively expensive and can be time-consuming. It is very versatile in the ability to provide images sliced in many planes, and is capable of producing 3-dimensional images in a variety of orientations. MRI combines the ability to give detailed anatomical information with a physiological sensitivity.

The image is produced by exciting hydrogen nuclei in the body at their resonance frequency in the magnetic field, and then detecting the energy released as these nuclei relax. By using different sequences of excitation and relaxation, an image can be built up. The most abundant sources of hydrogen nuclei in the body are water and fat, and so most signal in MRI is derived from these.

FIGURE 14:

The 1.5 T GE Echospeed magnet at the Animal Health Trust, Newmarket which is used for magnetic resonance imaging in live horses. Located in the bore of the magnet is a radio frequency coil suitable for use on the equine distal limb. This is placed on a shaped pad to move it into the centre of the magnet. As both limbs are placed into the magnet bore at once, the shaping of the pad allows it to be placed over the limb that is not being imaged.

FIGURE 15:

An anaesthetised horse is placed in lateral recumbency on a non-ferrous table for MRI of the front fetlocks and feet.

Open magnets are more adaptable with regard to size although the problems with creating a uniform magnetic field in an open system means that the image quality tends to be inferior to that of a corresponding closed system. Within the magnet, use of field gradients and a radiofrequency coil around the body assist in building up an image of the tissues (Figure 14).

Practicalities of MRI in horses

For acquiring high quality images, the horse must be immobile and placed within the isocentre (imaging portion) of the magnet. At the present time, this means that MRI requires general anaesthesia of equine patients. Equipment used close to the MRI system needs to be non-ferrous and unaffected by the strong local magnetic field. Therefore, an MRI-compatible equine table, anaesthetic and monitoring equipment are required, and for most magnets the system has to be placed within a specially shielded building.

The size and shape of the individual horse determines partially what areas of the limbs may be imaged. In a closed magnet, it is only possible to image the limbs and the head in most adult horses. The distal limb is the most practical site to image easily in the live horse as this can be

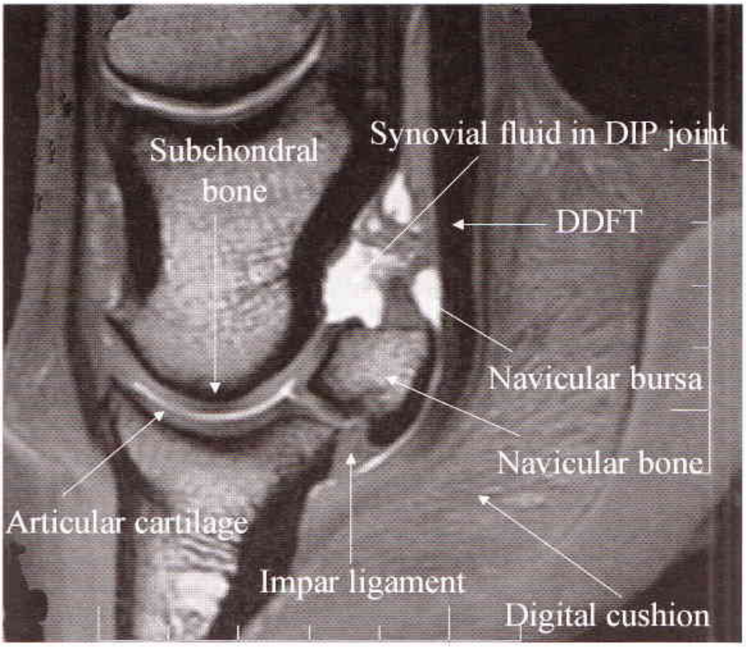


FIGURE 16:

Annotated T2 weighted (T2* gradient echo) sagittal image of an equine foot centred over the distal interphalangeal (DIP) joint.

placed into the magnet isocentre without too much difficulty with the horse in lateral recumbency. In order to minimise time under anaesthesia, sequences are used to optimise image acquisition in equine limbs in the shortest possible time for producing diagnostic quality images (Figure 15).

Image interpretation

Anatomical structures can be visualised in detail, including tendons, ligaments, articular cartilage, subchondral, cortical and cancellous bone. In addition, flow in vessels can be detected and spectroscopy can be used for looking at metabolite distribution.

Images produced depend on detection of T1 or T2 relaxation of hydrogen nuclei, and are referred to as T1 or T2-weighted images. On T1 weighted images, tissues with fast T1 relaxation, such as fat, show high signal intensity (bright). On T2 weighted images, tissues with slow T2 relaxation, such as water, show high signal intensity. The relative weighting of the image determines the signal intensity of, and contrast between, different tissues. In general, structures with a high water content are bright on T2-weighted images, and those with a high fat content are bright on T1 weighted images.

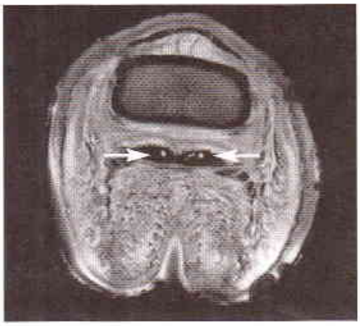


FIGURE 17:

T2 weighted tranverse image of the distal limb at the level of the middle phalanx showing lesions in both sides of the DDFT.

FIGURE 18:

T2* gradient echo dorsal image of the distal limb showing an avulsion fracture at the origin of the impar ligament on the navicular bone. This is seen as a focal area of low signal on the left side of the picture.

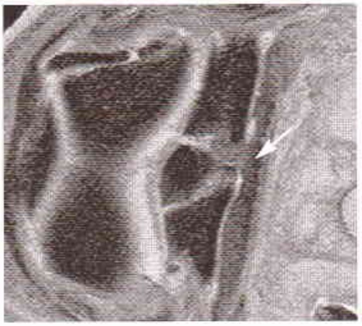


FIGURE 19:

T2* gradient echo transverse image of the distal limb showing a comminuted fracture of the navicular bone, a fracture of the second phalanx and laceration of the DDFT. The lacerated fibres from the DDFT are displaced into the fracture line.

Tendons and ligaments generally have low signal intensity on both T1 and T2 images (so appear nearly black), as does cortical bone or other areas of mineralised tissue. On T1 and T2 (to a lesser extent) weighted images, bone marrow shows a bright signal. Synovial fluid has low signal intensity on T1 and high on T2. Cartilage tends to have a low signal on T2 weighted images, although appears brighter on T1 in comparison with the low signal of the synovial fluid (Figure 16).

Many imaging sequences have been developed to show differences between tissues and highlight areas of pathology. These include the basic spin echo and fast spin echo sequences, gradient echo, spoiled gradient echo and magnetisation transfer. Specialist techniques are also used to improve visualisation of specific tissues and reduce artefact. Fat suppression techniques are commonly used in equine limb imaging to reduce interference from fat signal. This is particularly useful in bone where medullary bone has a high fat content and so bone pathology which has locally increased fluid content may be obscured by a high fat signal. Following fat suppression, on T2 weighted images bone pathology may be detectable as a high signal intensity in the bone.

Detection of pathology

Pathology that may be detectable using MRI, but difficult to image using other non-invasive modalities, includes ligament injuries (distal sesamoidean, impar, navicular suspensory and collateral), DDFT

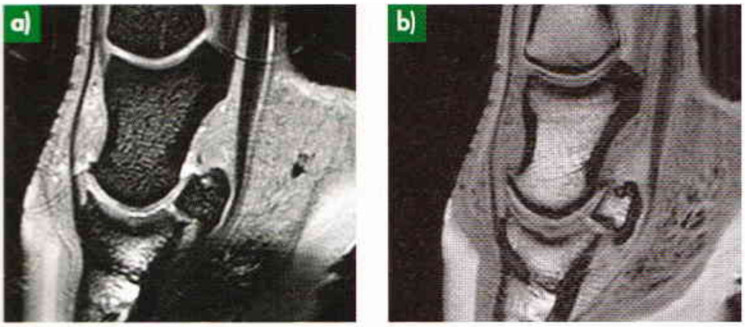


FIGURE 20a and b:

Osteoarthritis: sagittal image of articular cartilage and subchondral bone damage in the distal interphalangeal joint as seen on a T2 weighted image (a), where cartilage is low signal, subchondral bone very low signal and synovial fluid high signal. A T1 weighted (spoiled gradient echo) image of the same joint (b) shows cartilage with high signal and synovial fluid and subchondral bone with low signal. Note the heterogeneous cartilage signal in the T2-weighted image, and clearly irregular cartilage and subchondral bone margins on both T2 and T1-weighted images.

injuries (including the insertion), occult fractures, articular cartilage damage and subchondral bone remodelling.

In acute stages of tendon and ligament damage, focal pathology tends to appear as an area of bright signal on T1 and T2- weighted images with detectable local swelling. In the inflammatory phase, dark linear signal separated by areas of high signal may represent damaged fibres surrounded by cellular infiltration. During the later phases of healing and fibrosis, signal intensity tends to decrease but remain higher than that of normal tendon (Figure 17).

Severe bone pathology is detectable using either T1 or T2 weighted images. Fractures show as defects in the bone contour and structure. Subchondral bone irregularity and osteophytes are also detectable using MRI. MRI is unique, however, in its ability to show evidence of subtle damage within the medullary bone or marrow cavity when fat suppressed T2 weighted imaging is used. On these images, areas of bright signal may represent bone oedema, haemorrhage, trabecular damage or necrosis (Figures 18 and 19).

Articular cartilage pathology may be evident on T2 weighted images as altered signal intensity. In T2-weighted images the low signal of cartilage and high signal intensity of synovial fluid gives clear delineation of cartilage fluid interfaces so surface irregularities may be detected. Loss of collagen can lead to focal signal loss, while matrix damage may be indicated by increased signal intensity. For accurate cartilage morphological measurements and detection of surface defects, fat suppressed T1 weighted 3-D gradient echo imaging may be the technique of choice (Figures 20 a,b).

Gamma scintigraphy depends on the delivery of a labelled radio-pharmaceutical to the living tissues of the area under investigation. A variety of labels are available to target a variety of tissues. In equine scintigraphy, the most commonly used label is one which attaches itself to living bone, methylene-di-phosphonate. This label is attached to a radioactive molecule and injected into the bloodstream. It circulates in the blood and is available for uptake by all of the tissues. The only tissues which will selectively bind methylene-diphosphonate are those in which phosphorus exchange is active. This includes any calcified soft tissues, but primarily bone. The degree of uptake by bone is related to 2 factors. One is the delivery of isotope to that bone. The second is the intrinsic metabolic activity of the bone itself, ie if the bone is actively repairing or growing.

SCINTIGRAPHY

Rob Pilsworth

Equipment required for gamma scintigraphy

Images are formed using a piece of equipment called a gamma camera (Figure 21). This is a large radiation detector, which, by a complicated series of interfaces with a computer system, forms an image of the source of radiation (Figure 22). As the source of radiation in the horse is the bones, one ends up with an image of the skeleton of the horse. Areas of increased radio-pharmaceutical uptake appear brighter on this image (see Figure 23). The most common reasons for resorting to scintigraphic examination in investigating lameness attributable to the foot, is when a nerve block has localised lameness to the foot, but no abnormality has been found on a thorough radiographic survey of the area.

Imaging techniques

During the first few minutes following a bolus injection into the jugular vein, the distribution of the isotope within the foot mimics the distribution of normal blood flow. This is often called the 'soft tissue' or 'pool' phase image (Figure 22 a,b,c). This phase only lasts for a few minutes before isotope begins to be actively taken up by bone. 'Pool' phase images are useful in demonstrating areas of inflammation in the soft tissues not related to a bone lesion. In the equine foot, pool phase

FIGURE 21:

A gamma camera in use taking an image of the left fore-leg. A lead shield is placed between the legs to screen out the other leg on the picture.

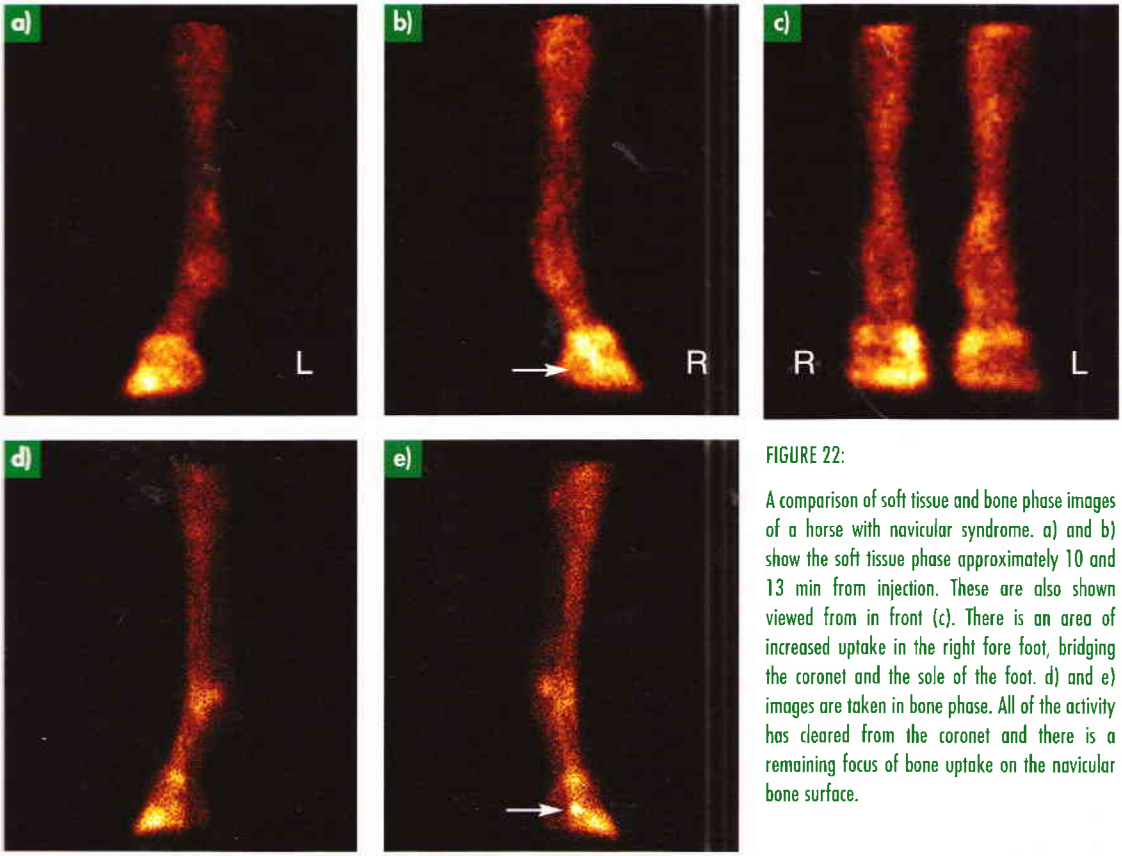


FIGURE 22:

A comparison of soft tissue and bone phase images of a horse with navicular syndrome. a) and b) show the soft tissue phase approximately 10 and 13 min from injection. These are also shown viewed from in front (c). There is an area of increased uptake in the right fore foot, bridging the coronet and the sole of the foot. d) and e) images are taken in bone phase. All of the activity has cleared from the coronet and there is a remaining focus of bone uptake on the navicular bone surface.

imaging is often useful in examination of the navicular bursa and deep flexor tendon region, particularly when combined with later bone phase images (Figures 22 a,b,c).

Normally 2–3 h are allowed to elapse between the injection of the bolus and imaging of the bones. During this time, isotope in the bloodstream and soft tissues is effectively and progressively cleared, and excreted by the kidney and the only isotope remaining in the horse is located within the bones (Figures 22 d,e).

Scintigraphy offers an alternative approach, in that an investigation both of inflammatory changes in the 'pool' phase, and possible disturbance of bone metabolism in the bone phase, is possible (Figures 22 d,e and 24). Pool phase images of the foot are particularly useful in assessing involvement of DDFT and navicular bursa in navicular syndrome. Bone phase images are useful in cases of fracture to the pedal bone, which sometimes cannot be visualised easily (Figure 25).

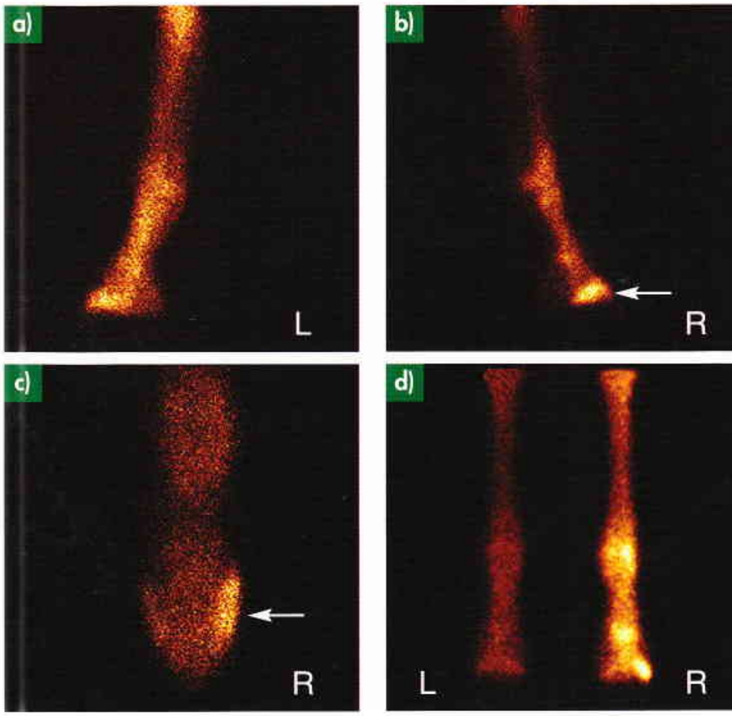


FIGURE 23:

A horse with a calcifying lateral cartilage imaged at bone phase. Note the intense focal increased uptake in the right hind limb on the area of the lateral cartilage, seen on the view taken from below the hoof (c). This may ***not*** be associated with lameness.

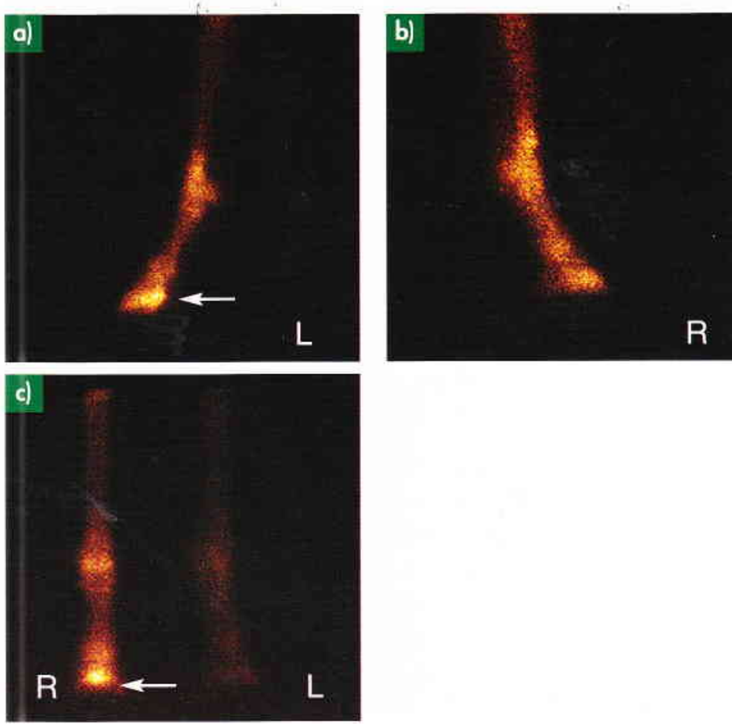


FIGURE 24:

A case of navicular bone fracture. There is a focal increased uptake in the region of the left navicular bone seen on both the dorsopalmar view (c) and the lateromedial view (a and b) of the left hind leg (arrow).

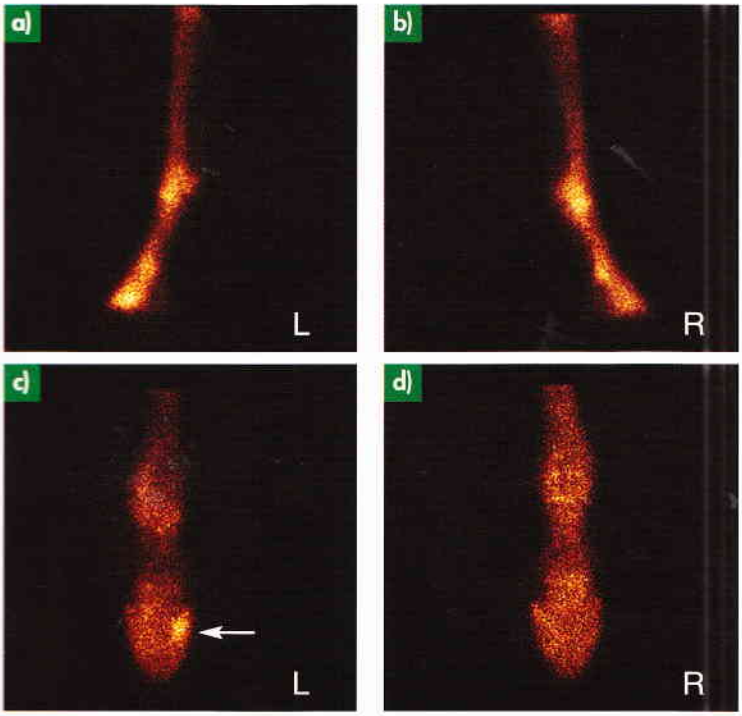


FIGURE 25:

A horse with a medial 'wing' fracture of the pedal bone. There is focal increased uptake visible on the medial wing of the pedal bone of the left hind leg, visualised best on the solar view (c).

Similarly, injury or inflammatory changes in the lateral cartilage can sometimes cause lameness during the period of calcification, and these show exquisitely on bone phase imaging of the foot long before the calcification is visible as a radiographic entity (Figure 23).

Scintigraphy is an expensive, time consuming procedure and should be reserved for cases in which no diagnosis is possible using conventional regional and intra-articular anaesthesia, in combination with radiography. However, in certain cases, it is extremely useful in helping to formulate a diagnosis and, more importantly, a prognosis for the more difficult cases of lameness attributable to the foot. It is important therefore that farriers and veterinary surgeons involved in investigating foot lameness are aware that the technique is available by referral, even if they do not have direct access to this technology.

Diagnostic imaging techniques fall broadly into 2 categories; anatomical and physiological imaging. Anatomical imaging, such as radiography, ultrasonography, computed tomography and magnetic resonance imaging will, with modern equipment and digitalisation, produce high quality, high detail images of what tissues actually look like. In the case of skeletal imaging, this information is frequently the cornerstone of diagnosis but, in some cases, may be of historical interest only, ie a record of what has happened in the past. Physiological imaging, on the other hand, allows the operator to 'see' the activity within specific tissues. Nuclear scintigraphy is commonly performed in horses, most frequently using intravenous technetium labelled methylene diphosphonate, in the diagnosis of bone injury. Thermography could, in theory, add another element of physiological imaging by allowing us to portray inflammation in a graphical manner, monitor its progression and/or resolution and detect early recurrence.

THERMOGRAPHY

Marcus Head

Thermography is the assessment of the surface temperature of a object. Medical imaging makes use of the fact that heat is one o the cardinal signs of inflammation. Therefore, an increase i surface temperature may indicate inflammation of structures close t that point. Objects dissipate heat by conduction, convection evaporation and radiation although the latter, under mos circumstances, is by far the most important. The temperature of an are of the body is a product of cell metabolism and local blood flow Increases in temperature are usually the result of an increase in thes factors, with changes in blood flow playing the major role. In som disease processes, there is a reduction in blood flow to the affecte tissues, and this also will result in alterations in surface temperature.

Equipment

Thermographic equipment was designed primarily for industrial an military applications and, until recently, was bulky and expensive t purchase. Additionally, there were legal restrictions on the amount o technology that was made available to the public domain for fear o the equipment falling into the wrong hands. Medical equipment ca be divided broadly into 2 categories; contact and non-contact devices Contact devices detect the temperature of the surface onto which the are placed. The simplest devices involve a direct reading, electri thermometer with a manual surface probe that is applied to the ski by gentle pressure. They involve laborious and time consumin application and are prone to error. The placement of an object agains the surface of the skin will, in itself, cause cooling or heating of th area. More complicated devices involve embedding liquid crystals int a latex base. The crystals change shape according to the temperatur that contacts them and, as they do so, they reflect a different colour o light. Therefore, the colour of the crystal represents a specifi temperature. Again these are cumbersome to operate and prone t error.

Both these types of device are all but obsolete as modern technolog has allowed non-contacting devices to evolve. Modern thermograph cameras detect infra-red radiation and recent advances have made th

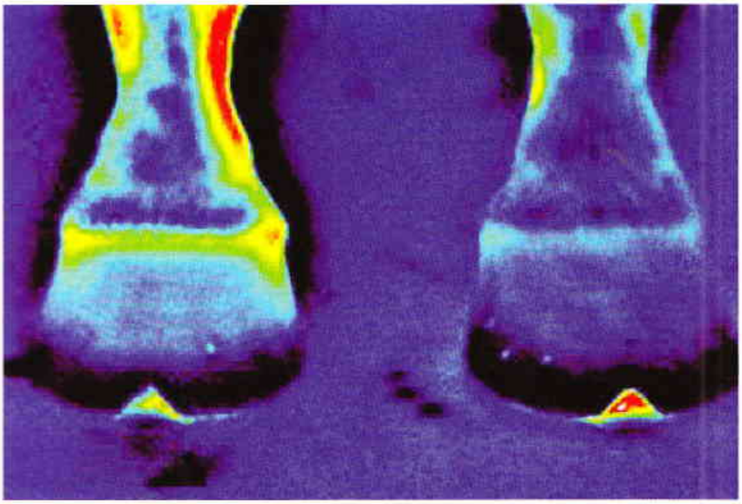


FIGURE 26:

Thermograph of the front feet of a normal horse taken from in front. There is a discrepancy in the surface temperature of the front hooves, a common finding frequently of no significance. Note that the coronary band is warmer than the rest of the foot; this is a normal finding.

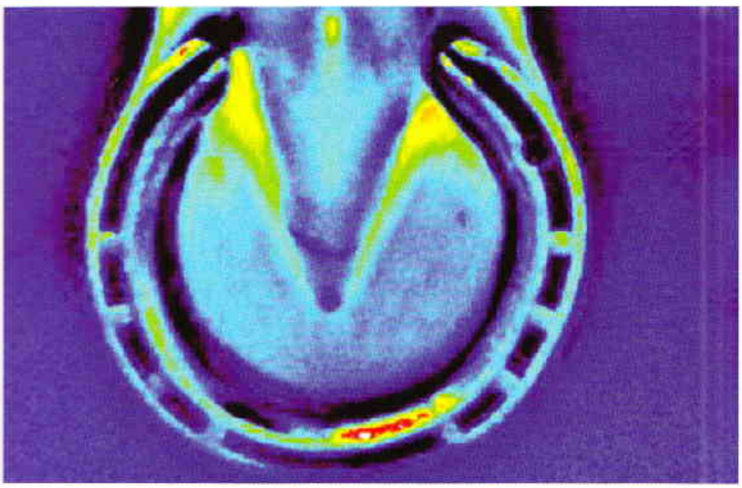


FIGURE 27:

Thermograph of the solar surface of a front foot from a normal horse. Impingement of a single nail on the sensitive laminae ('nail bind') may cause the offending nail to heat slightly, differentiating it from the other nails on this view.

modern thermography camera truly portable (most significantly because they do not require cooling). Thermography cameras are now manufactured and aimed specifically at the veterinary market.

Modern medical thermography cameras are lightweight, portable and require only a few moments following switching on before they are ready to use. The patient should be examined standing in a room or stable. The ambient temperature of this examination room is not important, so long as extremes are avoided and the temperature is not above 30°C, so that the horse does not sweat. The horse should be clean, dry and have had any bandages and rugs removed for at least 20 minutes before the examination.

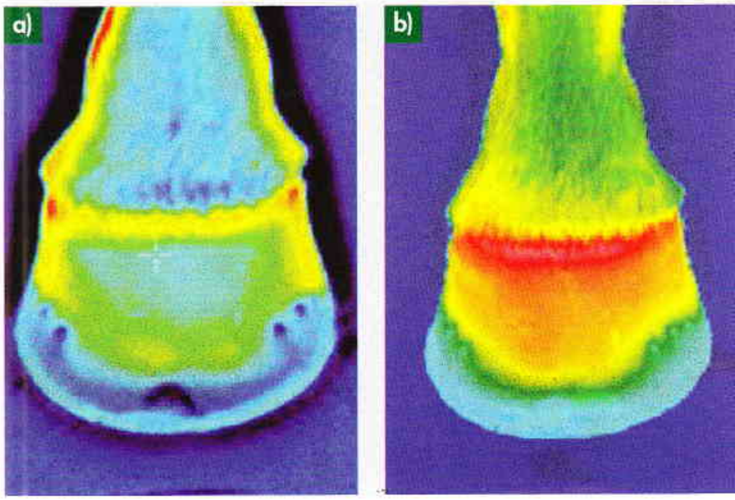


FIGURE 28:

Images of a normal foot (a and b). Both are of the same foot, taken one after the other but with different cameras. Differences exist in the basic thermograph between these 2 cameras due to different processing features of the equipment.

Sedation is best avoided as these drugs usually have some effect on the circulation, and may induce vasodilation and/or sweating. Areas of the coat that have been clipped or lost the hair cover for other reasons wet, debris and radiant heat from either natural or artificial sources wil introduce artefacts and make interpretation of the images difficult Specifically, the feet should be clean and dry and thoroughly pickec out with loose horn removed in advance of the examination. Exercise will alter the blood supply to the foot and is best avoided prior tc thermography. Some clinicians use the alterations in surface temperature that occur following exercise to aid in the diagnosis o palmar foot pain. The examination protocol varies slightly depending on whether a particular area of interest is being imaged or a whole body 'screen' is being conducted. Suffice to say that views are taker from at least 2 sides of the area being imaged, and comparison between contralateral limbs, which form an important part of the interpretation, are made. The feet, for example, will be assessed fron dorsal, lateral, palmar/plantar and solar views (Figures 26 and 27). Mos devices allow the 'gain' setting to be adjusted for each image, thereby optimising the information obtained by utilising the entire range o the colour palette. Each camera will have a different colour palette anc some cameras allow the operator to choose between several options depending on the preference of the operator. Most commonly, a 'rainbow' type is selected, and this usually involves the warmest area appearing white, and the cooler areas graded through yellow, red green, blue and black. Images can be viewed on a 'real time' screen or the camera and are simply frozen when the desired detail is obtained

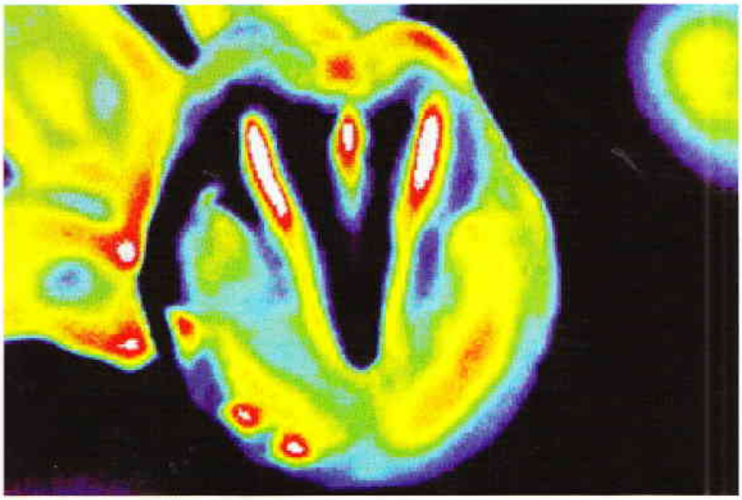


FIGURE 29:

This horse has had repeated hoof explorations, attempting to drain a subsolar abscess. There are a number of areas of variable surface temperature. Unfortunately, the biggest cause of this effect is the thickness of the sole and therefore the distance to the blood vessels beneath, rather than the proximity of the underlying abscess.

This image can then be stored (often onto a digital storage card inserted into the camera) or discarded. Modern digital storage media make transfer of information onto computers relatively straightforward, and from there data can be manipulated, communicated and stored permanently. Cameras can also be linked to video recorders for storage of moving images.

Thermography has always occupied a somewhat peripheral position in the diagnostic armament of the equine clinician. Revered by a few clinicians, it remains an enigmatic tool and has not gained full acceptance by the majority. The lack of published, peer reviewed, articles has not helped its cause; there has been no objective work published on reproducibility, both within individual cases and between animals of the same species that can provide a normal base line for other users to refer to (Figure 28).

Early publications diagnosed injuries that could not be confirmed by any means other than elimination of other orthopaedic injury, but failed to eliminate these other injuries in the diagnostic work up. The overall impression of this author is that the technique is not consistent or reproducible and that it frequently does not agree with more accepted diagnostic methods (Figure 29).

With particular reference to the foot, thermography is said to be useful in the management and diagnosis of a variety of conditions including laminitis, navicular syndrome, subsolar abscessation and nail bind. Indeed, if a condition induces an increase in blood supply to the foot, either generally or locally, then the thermograph obtained will vary

FIGURE 30:

This still image has been captured from a video recording of a horse on a high speed treadmill. It shows a marked focal increase in surface temperature of the medial hoof wall of the left fore foot as it impacts the surface. Rapid changes in temperature during weight bearing similar to this may be caused by hoof imbalances.

from normal. However, this information is rarely of any more use than confirming the clinical impression. Navicular syndrome is said to have a pattern characterised by reduced blood flow to the palmar foot. More recent work aimed at unravelling the syndrome of palmar foot pain would suggest that the disease has multiple causes and outcomes and it seems unlikely that all of these will cause the same, simple alteration in blood flow to the palmar foot. Impressive images have been obtained when feet are examined during exercise. Video recording of the changes in hoof capsule temperature during weight bearing may represent underlying imbalances, and this application warrants further investigation (see Figure 30).

Further work is required in order to clear the otherwise muddy waters surrounding the usefulness of thermography. There is still a considerable distance to cover before reaching the point where this technique is little more than an interesting adjunct, albeit one which the horse owning public seem keen to utilise.

Further reading

Turner, T. A. (1989) Hindlimb muscle strain as a cause of lameness in horses. *Proc. Am. Ass. equine Pract.* **35,** 281-290.

Turner, T.A. (1991) Thermography as an aid to the clinical lameness evaluation. *Vet. Clin. N. Am: equine Pract.* **7,** 311-338.

Webbon, P. M. (1978) Limb skin thermometry in racehorses. *Equine vet. J.* **10,** 180-184.

ARTHROSCOPY

Richard Payne

Arthroscopy is the technique of 'keyhole' surgery, which allows us to see inside a joint space or synovial cavity. By use of this technique the internal structures of these cavities (such as cartilage, ligaments, synovial membrane and tendon) can be assessed.

Within the horse's foot there are 2 cavities which can be examined by keyhole surgery. The coffin joint and the navicular bursa.

Within the lower leg the fetlock joint, pastern joint and digital flexor tendon sheath can also be examined by keyhole surgery.

Why use arthroscopy?

There are 2 reasons to use this technique: 1) to accomplish surgical treatment; for example to remove a chipped fragment of bone from the extensor process of the distal phalanx, where it has already been identified as the cause of lameness by other techniques; and 2) to try and achieve a diagnosis where other techniques have failed; for example we may be sure (from thorough examination) that a horse's fetlock joint is the site of a problem, and yet be unable to demonstrate this on radiographs. In this situation internal inspection of the joint, to look for evidence of cartilage wear and tear, may be useful to make a diagnosis, and to offer advice about treatment, management, and prognosis.

General requirements for arthroscopy

1. General anaesthesia of the patient, which carries a recognised risk in the horse.
2. A sterile operating theatre.
3. A skilled, experienced surgeon.
4. Specialised equipment (Figure 31).

FIGURE 31:

Anaesthetised horse undergoing keyhole surgery.

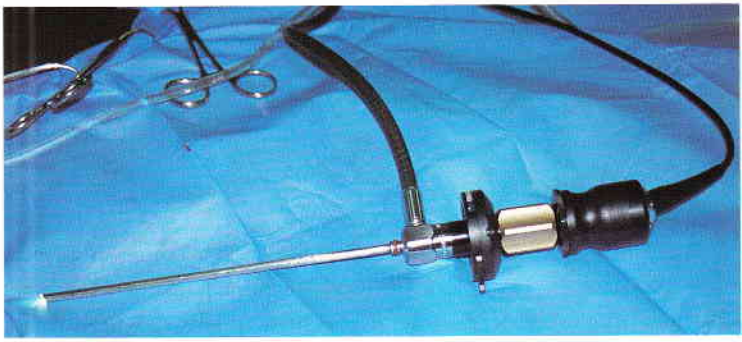


FIGURE 32:

An arthroscope.

Equipment

A rigid fibreoptic endoscope (usually 4 mm in diameter), is connected via a long flexible fibreoptic light cable to a powerful light source (eg xenon lamp), which illuminates the joint (Figure 32). The endoscope is coupled to a video camera and the image is displayed on a television monitor. This image can be recorded on videocassette, or on DVD.

A wide range of specialised surgical instruments are required for arthroscopic surgery. These incluce grasping forceps ('rongeurs'), probes, curettes, chisels and cutting blades. Some of these may be motorised instruments.

Surgical technique

After sterile preparation and draping of the appropriate part of the horse's leg, a needle is inserted into the joint and it is distended with sterile fluid (eg 'Hartmanns' solution), delivered by a mechanical pump. Once distended, a small 'stab' incision portal is made, and through this the arthroscope is introduced carefully into the joint (Figure 33). The joint is inspected, and further stab incision portals can be made, through which keyhole instruments can be inserted in order to accomplish a specific surgical task, eg removal of loose fragments of cartilage or bone.

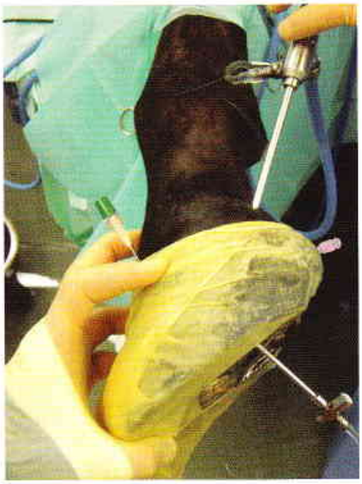


FIGURE 33:

Arthroscopic examination of a joint.

The arthroscope may be inserted at more than one site in the joint, in order to allow a thorough evaluation of the different compartments and pouches.

Throughout the surgical procedure the joint is continually distended with fluid. This is important both to prevent joint collapse (which would obstruct vision), and to enable any joint debris to be flushed out.

FIGURE 34:

Diagnostic arthroscopy of a joint reveals an area of cartilage damage.

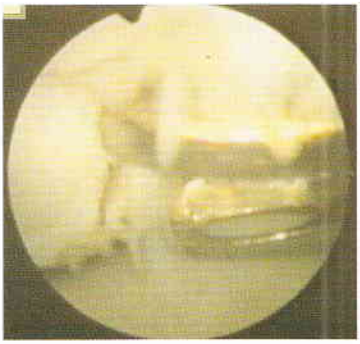


FIGURE 35:

View of a chipped fragment of bone which can be removed by keyhole surgery.

Indications for the use of arthroscopy in the horse's foot

Diagnostic examination of the coffin joint

The coffin joint is a common site for lameness problems in the horse, particularly in mid to older age when degenerative joint disease occurs. Such cases can be frustrating, as very often there is little to see on radiographs. This is no surprise, however, as in the early stages it is the cartilage which becomes damaged and cartilage is not visible on conventional radiographs (Figure 34).

In this situation arthroscopic examination may be of value to try and assess the degree of damage within a joint, and to assess the likely prognosis for the horse.

Surgical treatment of the coffin joint

The most common reason for surgery would be to remove a loose osteochondral fragment from the extensor process of the third phalanx (Figure 35).

Lavage (flushing) of a septic coffin joint

Infection in any synovial cavity is an extremely serious event. Infection of the coffin joint is most often the result of a puncture wound to the foot or coronary band. Immediate treatment by flushing the joint is required, and arthroscopy provides a useful method by which to accomplish this.

FIGURE 36:

Keyhole image of a torn DDFT, at navicular bursa level.

Diagnostic examination of the navicular bursa

In some cases lameness can be demonstrated quite specifically to relate to the navicular bursa. If other imaging techniques fail to reveal exactly what type of injury is present at this site, keyhole examination may be useful. Tears of the DDFT, and damage to the cartilage on the flexor surface of the navicular bone, may be diagnosed (Figure 36).

Lavage (flushing) of a septic navicular bursa

Infection of the navicular bursa, most often due to a penetrating injury to the foot, is a potentially life threatening event. Keyhole surgery has revolutionised our ability to access this synovial cavity (buried deep within the hoof) and to inspect and flush it.

Advantages and disadvantages of arthroscopy as an imaging technique

Advantages

1. It is the only imaging technique which gives a real image. To see is to believe!
2. Treatment (eg chip fragment removal) may be accomplished, as well as diagnosis, in some cases.
3. The ability to flush fluid, as well as to inspect, makes it an ideal technique for dealing with infected synovial cavities.
4. It is minimally invasive, with small wounds, which makes for quicker post operative recovery.

Disadvantages

1. The cost.
2. The requirement for general anaesthesia.
3. It requires specialist skill, equipment and an operating theatre.
4. In most joints there are some nooks and crannies which cannot be examined by arthroscopy.

Chapter 4:
Development of the leg and foot

David Ellis

In routine stud veterinary practice the mare's pregnancy is confirmed by ultrasound examinations at varying times from 13 days after ovulation. In checks at 40 days some parts of the skeleton are discernible and, by 65 days, the shape and structure of the limbs are clear. These observations confirm that the limbs develop very early in equine pregnancies. They can be observed as small buds or outgrowths on the embryo by about 30 days of gestation, the forelimbs appearing a few days before the hind limbs (Figure 1). Precursor cells within the buds multiply and change to form the components of the limb, which include the cartilage model, on which ossification builds the bones of the limb, the muscles, their tendons and the ligaments. The shapes of the limbs, joints and hooves are readily apparent in the embryo as early as 50 days even though they contain no bone. The period between 30 and 50 days of pregnancy is critical for correct development of the embryo.

Formation of bones and joints

The long bones of the limbs are derived from tubes of cartilage formed by the precursor connective tissue cells. The outer cuff is called the periosteum (Figure 2) and this layer of cells produces bone on its inner surface which gives it shape and rigidity. Repeated absorption of this inner layer of bone and further laying down by the gradually expanding periosteum increase the width of the bone shaft. In the centre of each model is a primary centre of ossification where cartilage is replaced by bone. At each end of the bone the cartilage develops secondary centres of ossification or epiphyses. Between the main shaft and the epiphysis is the area called the growth plate where the bone increases its length. This whole process is called endochondral ossification and development of the individual bone's shape is called modelling. The gross structure of a tube is mechanically the soundest that can withstand the forces of weight-bearing and propulsion. The shape of the bony tube, known as the cartilage model, is determined genetically but is also moulded by forces on it (movement and after birth, weight-bearing) and around it (muscle masses). Smaller bones, such as the cuboidal bones within knees or hocks, develop from cartilage models with single centres of ossification and no growth plates. The flat or plate-like bones, such as those making up the skull, do not develop from cartilage but from a matrix of connective tissue fibres (intramembranous ossification). Although their developments differ, the bone formed by endochondral and

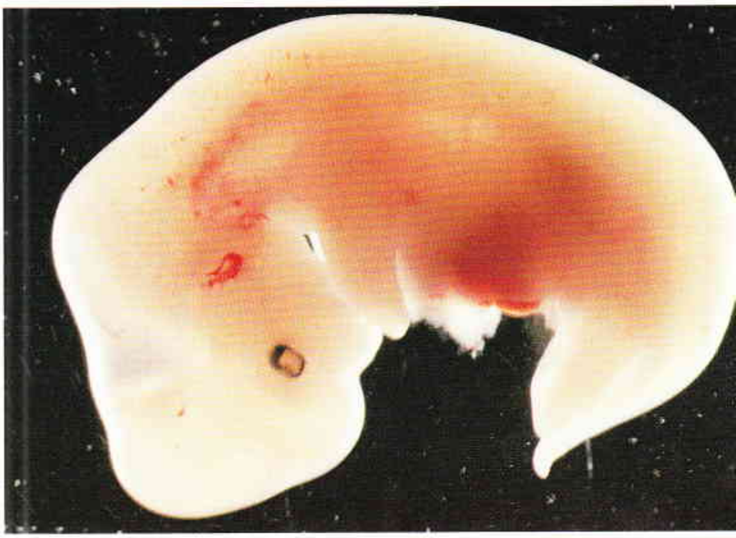


FIGURE 1:

Day 34 equine embryo. Note the buds of the forelegs.

Picture courtesy of Professor W. R. Allen, University of Cambridge.

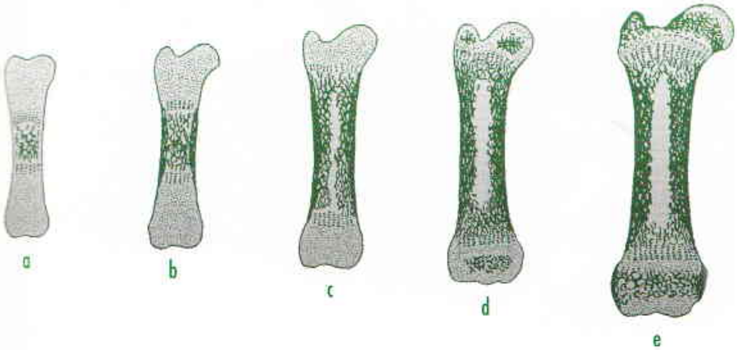


FIGURE 2:

Diagram of long bone development in the equine fetus. a) Cartilage model appears after 30 days; b) Outer cuff or periosteum appears on the diaphysis by 50 days; c) Enlargement of the diaphysis of the long bone by endochondral ossification during mid pregnancy; d) Ossification starts in the epiphyses at each end of the bone from 250 days onwards; e) The long bone with the clear shape of the adult bone near birth.

Ossified bone is shown in green.

intramembranous ossification ultimately has a similar structure, the shape and density of which is varied by the forces placed upon it.

Joints also develop very early in pregnancy. As a result of limb movement they appear as spaces between the cartilaginous epiphyses and they are enclosed by a joint capsule. Blood vessels invade the epiphyses each side of the joint in order to ensure adequate oxygen and nutrition for the cartilage and ultimately the bone cells. Cartilage cells enlarge and bone is laid down around them but the cartilage cells lining the joint surface flatten and become the smooth white articular surface on the firm bony plate.

Development of limbs in the embryo

The main ossification centre or diaphysis of the long bones of the upper limbs, such as the humerus and radius in the forelimb and the femur and tibia in the hind limb is the earliest to contain significant amounts of calcium and be recognisable on X-ray films. The scapula and ilium or front part of the pelvis are also apparent. Next, the cannons (metacarpals and metatarsals) appear by 65 days (Figures 3 a,b). The pastern and pedal bones (phalanges) then appear as

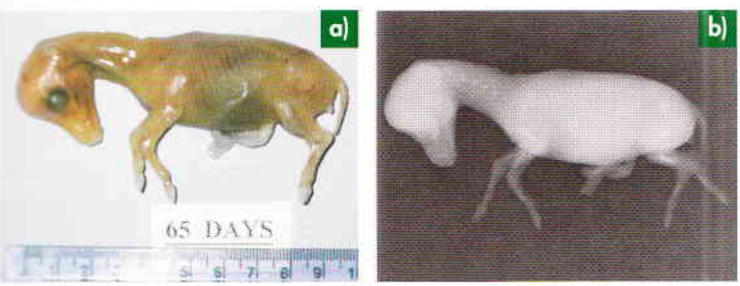


FIGURE 3:

a) Day 65 equine fetus. Note the distinct shapes of the limbs and hooves.

b) Radiograph of a Day 65 fetus. Note the white shadows of the bones in the skull, spine, pelvis and upper limbs indicating that ossification has started.

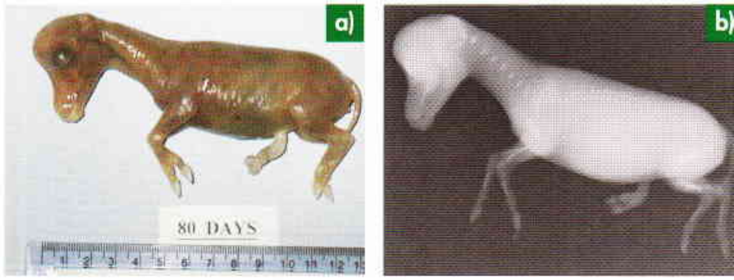


FIGURE 4:

a) Day 80 equine fetus.

b) Radiograph of Day 80 fetus. Note the appearance of bones in the lower limb or digits.

rudimentary marks, identifiable more by their position in relation tc the longer bones than by their shape (Figures 4 a,b). The epiphyses o: centres of ossification at the ends of each bone are slower to ossify anc only do so later in gestation (250 days onwards). During the last thirc of gestation the fetus will double in size. Some growth plates, such a that in the distal first phalanx (long pastern bone) close and ossify during the last month. The sesamoid bones at the back of the fetlock: are also very late to ossify.

Post natal development of bones

Compared with other species such as people, dogs or pigs, the newborn foal has a highly developed skeleton which allows it to stanc and run beside its dam within a few hours (Figure 5). The long bone: of the lower limb, such as the cannons, are little shorter than they are destined to be when the animal is mature. The cannon bones only grow 20% more in length after birth compared with a doubling ir length of the humerus or femur in the upper limb. The cannons have only one growth plate still apparent at birth and it is at their lower end just above the fetlock joint. This growth plate is one of the earliest tc close and it does so by 6–9 months of age. The long and short pasterr bones also have only one growth plate which is at their upper end anc closes at a similar age. In general, the growth plates lower in the limb close earlier in the animal's life than those in the upper limb (Figure: 6 a,b). Those at both ends of the forearm and gaskin (radius and tibia) close by 24–30 months old (Figures 7 a,b) and of the femur anc humerus later, but usually by 36 months. The growth plates at each enc of a long bone do not close at the same time. Thus the lower or dista humerus closes before the upper whereas the upper or proximal radius closes before the distal radius (the growth plate just above the knee). These timings can be varied by external factors. Physical factor: include excess pressure on a growth plate as a result of over weight or longstanding lameness. The administration of hormones such a

FIGURE 5:

Newborn foals should be able to stand within 2 h of birth.

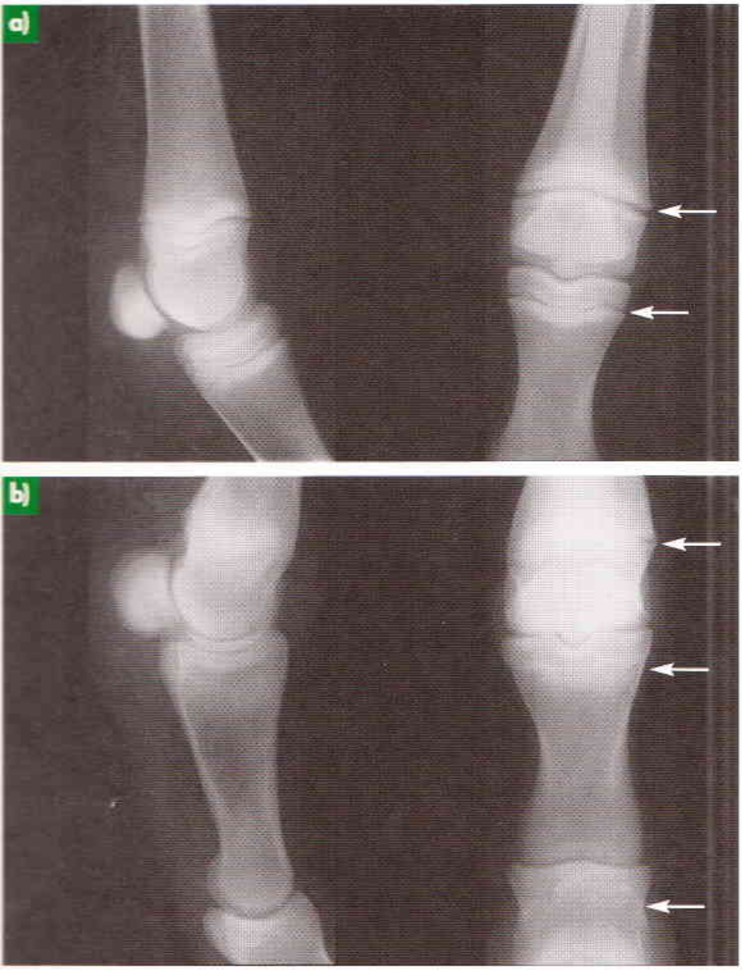


FIGURE 6:

a) Radiographs of the fetlock joint of a 10-day-old foal. Note the very open growth plates above and below the fetlock joint (arrowed) and the immaturity and incomplete ossification of the sesamoid bones.

b) Radiographs of the fetlock joint of a 7-month-old foal. Note that the growth plate in the upper long pastern bone is closing earlier than that in the lower cannon and that in the upper middle phalanx bone has closed completely (arrowed).

anabolic steroids, which by their nature have testosterone or male hormone effects, cause the growth plates to close earlier. Conversely, gelding will delay closure hence the tendency for some Thoroughbred store horses to grow tall, lean and leggy. After closure of the growth plates the bone can grow no longer but, in response to exercise, it can change its shape and strength.

Development of muscles and tendons

The precursor cells in the limb buds of the embryo also start to organise and change into muscle and tendon early in pregnancy. By 50 days they are probably present and contain nerve fibres which have invaded the limb bud and are essential to muscle development and

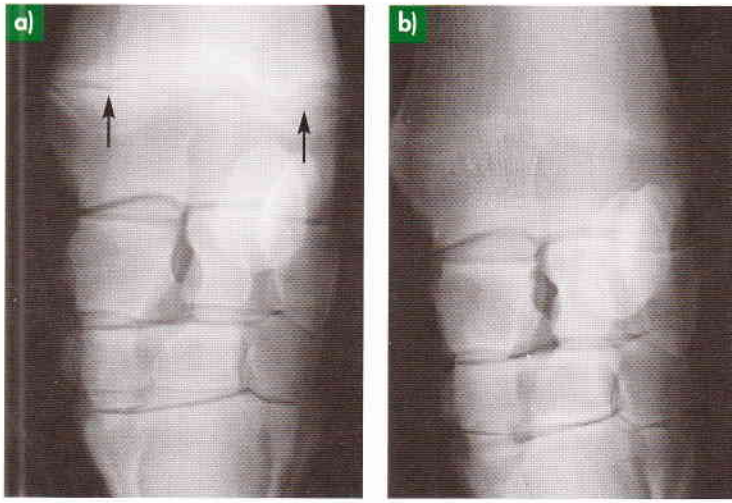


FIGURE 7:

a) Radiograph of the carpus and distal radial epiphysis of a yearling (arrowed).

b) Radiograph of the carpus and closed distal radial growth plate of a 3-year-old.

function. Fetal movement is quite marked and easily seen during ultrasound examinations at 60 days. Incidentally, fetal movement starts much later in human pregnancy, at almost mid term. Fetal muscle fibres grow in length by the addition of new muscle cells and in girth by an increase in myofibrils within the cells.

Tendons and ligaments develop from the same versatile precursor cells which produced muscle and bone in the limb buds. They turn into cells called fibroblasts and produce specialised fibres which form the connection between muscle and bone (tendon) or stabilise the joints (ligament). Their fibres develop great tensile strength and have some elasticity. The basic component of the fibres is collagen, which is laid in a crimp or zigzag pattern that allows them some elasticity and storage of energy when stretched. The fibres of tendons are in parallel lines whereas those of ligaments may be crossed or in spirals according to the job required of them in holding the joint in stable alignment. Both attach to bone by a gradual transition through fibrocartilage, to mineralised cartilage to bone – a very strong and clever arrangement.

FIGURE 8:

A 1-month-old foal with a fracture to the proximal sesamoid (arrowed).

Some ligaments, such as the suspensory ligament (anatomists call it the interosseous muscle), contain significant numbers of muscle fibres but these disappear gradually during the later part of the first year of life.

It is surprising that these structures perform their function so efficiently so soon after birth when they have only been used in the 'weightless' environment *in utero*. It is interesting that young foals which gallop to exhaustion sustain fractures of the sesamoid bones at the back of the fetlock joints but very rarely strain their flexor tendons

FIGURE 9a:

An 18-month-old Thoroughbred, bred to sprint, which is quite mature for its age.

FIGURE 9b:

An 18-month-old Thoroughbred which is less mature than that in a) and as its croup is significantly higher than its wither will grow further in height.

or suspensory ligament (Figure 8). When older, such fractures are rare and the foal or yearling may then strain the suspensory ligament or its attachment to the sesamoid bone (a sesamoid bone is a bone within a tendon or ligament). This demonstrates that flexor tendons and ligaments may have more tensile strength than the bone within them in the newborn foal.

Conformational changes during growth

As the limbs of the newborn foal are further developed than its skull, spine or rib cage, and nearly as long as those of the adult, there is little space for the fetus to stretch its legs during its maximal growth phase, ie the last 3 months of gestation. It is a minor miracle, therefore, that so few are born with congenital limb deformities. The growth rate of young foals, particularly the lighter breeds such as Thoroughbreds, is phenomenal. Daily live weight gains of 4 lb or 2 kg are common in the first few weeks. Although foals and yearlings appear to have growth spurts, one in the first 3 months of life and a second between 9 and 12 months, their increases in body weight and height plot a steady rise which gradually levels off from 15 months and which would only be stopped by severe reduction in rations or chronic illness. They can achieve over 95% of their adult height and 90% of their adult weight by 24 months of age. The age at which they level off varies considerably between individuals (Figures 9 a,b) and there is a strong hereditary link.

FIGURE 10:

An 8-day-old foal with a slight carpal valgus of its right forelimb, which is normal at this age.

It is normal for the newborn foal to be 'knock-kneed' and it is difficult clinical judgement to decide when such a conformation i considered to be carpal valgus and abnormal (Figure 10). Som outward rotation of the forelimbs is also normal. Carpal valgus wit significant angulation is the commonest congenital limb deformity bu most foals correct themselves spontaneously during the second mont of life and require no more than limitation of exercise and remedia hoof care. It is believed that the extra pressure of weight-bearing on th outer side of the growth plate in the valgal limb stimulates growth o that side in order to correct the angulation. It is only when th deformity is too severe or the foal is over-exercised that the growt plate is damaged and the limb does not straighten spontaneously. Alsc the foal's chest broadens during the first 9 months and this naturall reduces any valgus or outward rotation of the front limbs. Angulation also seen through the fetlocks and the hocks, sometimes together an in opposite directions giving us what are known as 'windswept' foa (Figure 11). These foals also have a great capacity for self correction they are allowed exercise and given appropriate foot trimming early i life. Congenital and acquired angular limb deformities will be discusse in more detail in Chapter 15: Mediolateral Limb Deformities.

Varying degrees of uprightness or slackness through the pasterns an fetlocks are seen in the neonate. The former may be severe enough t be classed as a congenital flexural deformity (often called incorrectly contracture) and result in the foal being unable to stand withou knuckling over. Such cases require veterinary attention and carefu support. Foals which have flexural deformities of the knees can b especially difficult to manage and are likely to retain an 'over at th knee' conformation. An upright conformation is likely to persi during growth and in some foals, particularly the larger faster growin ones, it may worsen between 3 and 5 months of age. This change ma be associated with enlargement of the growth plates at the fetloc giving them an 'hourglass' shape (Figure 12). It is a response to pain i the limb and this off loading may also result in a toeing in or banc conformation. The commonest cause is physitis, which is a inflammation of the growth plate during its active ossification pha caused by excess pressure or weight bearing. Physitis is seen at the kne between 6 and 24 months of age and, more rarely, at the hock at th same stage. Other causes of the development of an upright c knuckling conformation during growth include osteochondros which arises from defective development of joints such as the fetlock hocks or stifles resulting in a painful arthritis. Over feeding or ov

FIGURE 11:

A 'windswept' foal with valgal angulation of the left hock and varus of the right hind fetlock and hock.

FIGURE 12:

Physitis apparent as prominence of the growth plates on the inside of the fetlock of a 4-month-old foal giving an 'hour-glass' appearance.

exercising can be responsible and careful management allied with regular observation is crucial for prevention and early correction. These diseases are members of a group of conditions which are known as 'Developmental Orthopaedic Disease'.

Slackness or over extension of the joints of the lower limbs is due to musculo-tendinous and/or ligamental weakness. Premature foals may exhibit this conformation and it gives the newborn foal an unsteady stance or gait. It is seen more commonly in hind limbs which usually strengthen and improve dramatically with exercise. Severely affected foals may require bandaging to support and protect their fetlock and pastern or they may need heel support with an extension if they walk on the bulbs of the heels. These deformities are discussed further in Volume II.

Development of the hoof and foot

The shape of the hooves is apparent in the Day 65 fetus (Figure 3a) and the pedal bone within it is clear on X-ray by 80 days (Figure 4b).

FIGURE 13:

The soft leaves of horn on the hoof of a newborn foal. Note the break line on the hoof wall from where they will be shed.

Photo courtesy of S. Caldwell, Newmarket.

FIGURE 14:

A sagittal section through the digit of a newborn foal. The extent of the soft leaves of horn is seen and also the open growth plates at the distal metacarpal, proximal 1st and 2nd phalanges.

The hoof is unpigmented and the horn tubules grow from the coronet downwards, producing leaves which give the sole a brush-like appearance. The outer horn hardens but the leaves of soft unpigmented horn form a soft cap, which prevents the foot from damaging the uterine wall during fetal movement in later pregnancy. The leaves have a break line along which they are shed when the foal bears weight after birth (Figures 13 and 14).

The horn of the foal hoof is quite soft compared with that of the adult. Exposure to air and exercise gradually hardens it during the first 3 months of life. The conformation of the hoof soon after birth is a template of that which it will have as an adult. Thus the shallow heels seen at 10 days old will still be apparent 2 years later – and may be worse if the heels are allowed to collapse. Likewise the narrow, donkey type hoof will show very little expansion during growth however much effort is made to spread the heels and quarters. Hoof conformation is also strongly heritable.

Changes in posture will have a profound effect on the conformation of the foal's hoof. The commonest reason in lighter faster growing foals is the acquired flexural deformity of the distal interphalangeal or corono-pedal joint within the hoof (Figure 15). This can develop at any time within the first 6 months of life, most commonly between 1 and 4 months old and only in front feet – sometimes one, sometimes both. This is believed to be due to pain within the limb or foot and occurs more frequently in dry years when the paddocks will be harder. The hoof becomes more upright and its dorsal or front wall may be vertical or knuckle forward. With less weight bearing the hoof narrows and the heels lengthen. Excess wear at the toe may lead to infection penetrating the white line. Resting these foals is important and veterinary and farriery attention are needed. This condition will be discussed in greater depth in Volume II.

FIGURE 15:

An acquired flexural deformity in a foal. These occur most commonly between 1–4 months and affect one or both front feet.

Adaptation of the skeletal system by training

Bone is a living tissue which adapts to the forces placed upon it and is replaced constantly throughout life. The lower limb of the mature animal has to withstand the stress of carrying half a ton of body weight at speed on a cannon bone and pastern bones which have a smaller cross sectional area than the human wrist. It has been demonstrated that the bones in the lower limb of the racehorse work very close to their breaking strain during galloping. The tube-shaped cannon bone thus develops very dense or compact bone. In direct response to the compressive and bending forces applied during training, the front part of the bone, or the shin, thickens more than its sides and back (Figures 16 a,b). This adaptation of shape and density is called remodelling. It is achieved by the work of specialised cells (osteoclasts), which resorb bone and, in its place, further bone is laid down in thicker and denser patterns by cells called osteoblasts. The latter cells are identical to those which modelled the bone in the embryo and developed it during growth. Surprisingly few exercise cycles are required for this process to be effective. Therefore the racehorse does not need or benefit from long arduous training work in order to make its 'bony' skeleton fit. It is commonly recognised that a mismatch between bone adaptation and training results in injuries such as stress fractures and sore shins. Of course the muscular and cardio-respiratory systems may require more conditioning than is ideal for the bones and tendons within the limbs – hence the skill of training.

The joints have 2 main functions. The principal one is to allow movement, and almost all of the horse's limb joints are only capable of movement in one plane, flexing and extending. The shoulder, hip and spinal joints are capable of limited rotational movement. The smooth cartilage lining, flexible joint capsule and lubrication by synovial fluid allow the surrounding muscles and tendons to implement this low friction movement while ligaments maintain the joint in a stable apposition. Their second function is to act as shock absorbers and is

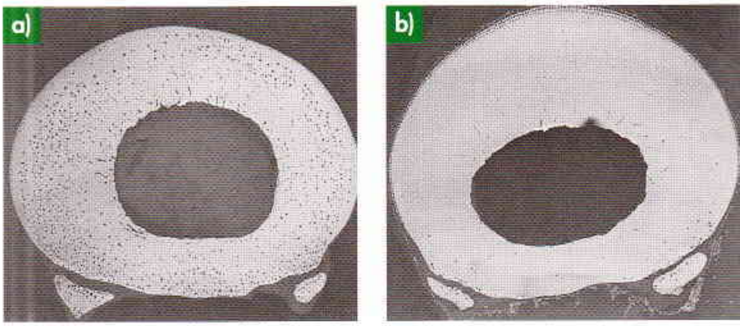


FIGURE 16:

a) Cross section of the cannon bone of an untrained 2-year-old.

b) Cross section of the cannon bone of a trained 2-year-old. Note the thicker wall of the bone.

Pictures courtesy of Professor L. B. Jeffcott, University of Cambridge.

equally essential to efficient motion. Concussion or pressure is absorbed by the subchondral bone plate, which is the bone underlying the cartilage of the articular surface. It is remodelled as described above and denser, more resilient bone is produced during training. The integral bones of a complicated joint like the carpus (knee) or tarsus (hock) spread the load across that joint by undergoing minimal compression and outward movement, thus reducing the force which is transmitted down the cannons to the lower limb.

Tendons are believed to lose their tensile strength and elasticity gradually with training and age. It has been shown that considerable heat is generated in the middle of the superficial flexor tendon during work and it is probable that this has a destructive effect on the mechanical properties and integrity of the tendon over time. It has to be assumed that other flexor tendons and ligaments undergo similar stress but, as they suffer strain injury less often, they must either be better adapted or, more likely, better protected by support from other structures.

In summary, the fetal limbs have 2 phases of rapid and critical development, the first between 30 and 50 days and the second from 250 days onwards when the fetus doubles in size. This rapid growth rate continues after birth and gradually levels out between 2 and 3 years of age. The production of a sound and well conformed athlete requires regular and careful observation, intelligent management and a lot of luck.

Chapter 5: Chronic foot lameness

Andy Bathe

Corrective farriery
a textbook of remedial horseshoeing

Chronic lameness originating in the foot is a very common problem in all types of horse. For the purpose of this chapter it will be defined as a persistent, mild to moderate lameness, without evidence of external cause or superficial pain. Acute causes of severe foot pain, such as fracture and sepsis, are considered in Volume II. Conditions such as corns or solar bruising, can cause chronic foot pain, but are discussed in other chapters. The complex structure of the foot, with many closely positioned structures, and the relative inaccessibility for clinical examination can make accurate diagnosis difficult. Recent advances in studying the pathology, anatomical relationships and biomechanics of the distal limb are furthering our understanding of the different conditions affecting this region. Good quality farriery is obviously critical in both preventing the development of some of these conditions, and in assisting with their treatment.

Diagnostic approach

There should be a standard approach to the case of chronic foot lameness. As with all lameness cases, the aim is to localise the site of pain and then to determine the pathology present. It cannot initially be presumed that a lameness is localised in the foot, and a full clinical and lameness examination should be performed. The remainder of this section emphasises those aspects of the examination that are particularly applicable to chronic foot lameness.

The signalment of the case may be helpful, eg navicular disease is uncommon in young and old animals. A thorough history should be recorded. The most useful facts to determine are the nature of onset of the problem (acute or insidious), the duration of the problem, the grade of lameness present and any responses to rest, exercise, shoeing or other treatment. The horse should be observed at rest to assess its stance and overall conformation. The feet and distal limbs should be inspected carefully to determine balance, conformation and symmetry. Standard veterinary textbook diagrams of ideal foot balance are unfortunately not very representative of the majority of real life situations, eg very few Thoroughbred horses or their crosses have a heel which is parallel to the dorsal hoof wall. In the assessment of asymmetric feet in this type of horse, the more textbook 'normal' foot may actually be relatively contracted due to chronic lameness, and the textbook 'abnormal' foot may be the sound one (see Figure 30, Chapter 6: The Principles of Foot Balance).

The distal interphalangeal joint capsule should be palpated dorsally, above the coronary band, to detect distension. The majority of the specific examination of the hoof is directed to ruling out more acute and superficial causes of hoof pain. The digital pulses should be assessed, the sole pared, the sole and wall inspected and hoof testers applied. If pain is elicited by hoof testers, it may be advisable to remove the shoe to examine the sole properly (see Chapter 2: The Diagnosis of Lameness). However, it is much easier to assess a subtle lameness problem if the horse remains shod.

The dynamic examination should include walking and trotting the horse on a firm, level surface. The dynamic foot balance and degree of lameness should be determined. As many cases of chronic lameness are bilateral, an overt lameness may not be evident in a straight line. Unless the lameness is severe, the horse should be lunged on both reins on hard and soft surfaces. The comparison between the degree of

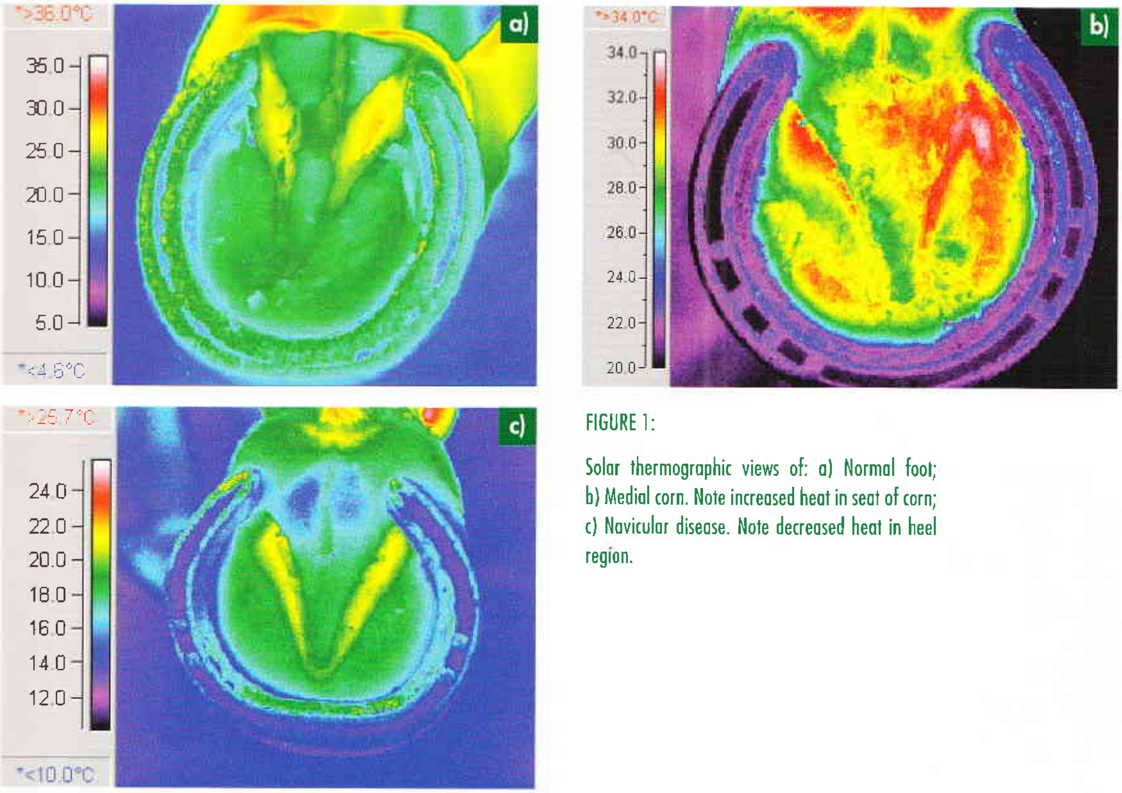


FIGURE 1:

Solar thermographic views of: a) Normal foot; b) Medial corn. Note increased heat in seat of corn; c) Navicular disease. Note decreased heat in heel region.

lameness on these surfaces is helpful, as the majority of chronic foot lamenesses are exacerbated on a hard surface. Flexion tests should be performed routinely, as a positive response would be expected in the majority of cases of navicular disease and distal interphalangeal joint pain.

Thermographic examination can be helpful in ruling out superficial foot inflammation, which will show up as 'hot' areas (Figure 1b). In chronic lameness there may be a relatively decreased coronary circulation due to decreased weight-bearing (Figure 1c), but thermography will not yield any information which will differentiate diagnosis. Thermography is covered in more depth in Chapter 3: Imaging the Foot and Leg.

Diagnostic local analgesia is invaluable in the evaluation of chronic foot lameness. An abaxial sesamoid nerve block (ASNB) is often used to rule in or out the presence of a foot lameness. There is less likelihood of inadvertently desensitising the fetlock joint with a block performed just below the base of the proximal sesamoid bones

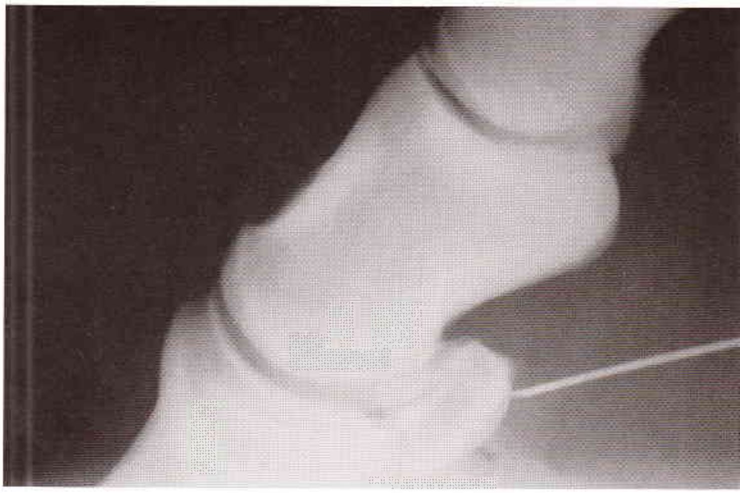


FIGURE 2:

Lateromedial radiograph obtained during a navicular bursal block, checking needle placement palmar to the bone.

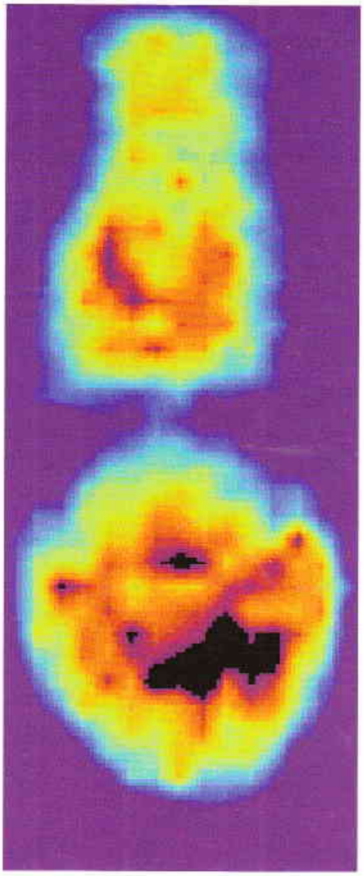


FIGURE 3:

Bone phase solar scintigram of foot, showing 'hot spot' at the region of insertion of DDFT.

rather than at the abaxial sesamoid level. Greater specificity is obtained by starting with a palmar digital nerve block (PDNB). The block should be performed as distal as possible, angling the needle axial and distal to the collateral cartilages. Theoretically this desensitises the palmar third of the foot, but in practice more of the foot may lose sensation, and the degree of solar desensitisation should be checked with hoof testers. Separate medial and lateral blocks may be helpful to localise the pain to a specific heel, whereas with most chronic conditions there is an approximately symmetrical response to the separate blocks.

Intrasynovial analgesia of the foot can be achieved by blocking the distal interphalangeal (DIP) joint and the navicular bursa. Recent experimental studies have confirmed clinical experience that these blocks are not as specific as once thought. Intra-articular analgesia of the DIP joint will yield a positive response in the majority of cases of navicular disease. It can also desensitise the sole, especially dorsally. This potentially confusing effect is less evident when using smaller volumes of local anaesthetic, and the degree of solar desensitisation should be checked after the block. Navicular bursal blocks are more technically demanding to perform accurately, and radiographic guidance is usually employed to ensure accurate placement (Figure 2). Although some desensitisation of the DIP joint and heel can occur, the loss of solar sensation is less marked than after a DIP joint block. This lack of specificity with intrasynovial blocks has led some clinicians to question their usefulness, and to abandon their routine clinical application. This author's opinion is that, in complex lameness cases, the maximal

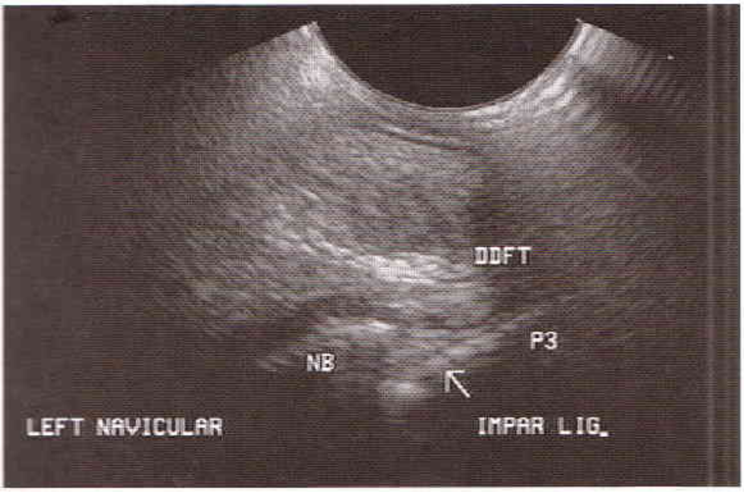


FIGURE 4:

Ultrasonogram of navicular region from the solar surface of the foot, after paring and poulticing the frog.

amount of diagnostic information is required to achieve an accurate diagnosis, and the careful interpretation of intrasynovial blocks is extremely helpful.

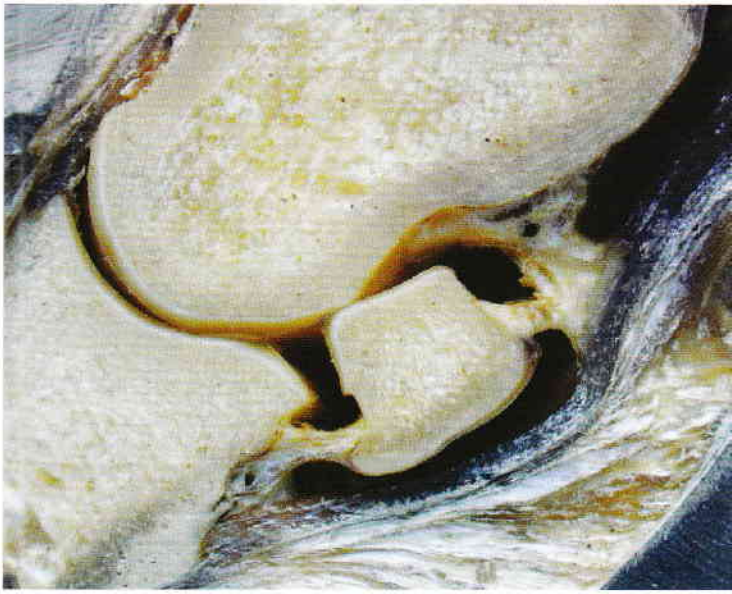
A full radiographic series of both front feet should be obtained in any case of chronic lameness that has been localised to the foot. The foot balance, as well as the DIP joint and navicular bone, should be carefully evaluated on the lateromedial projection. The palmaroproximal-palmarodistal oblique (PaPrPaDiO) projection, or flexor view, of the navicular bone is invaluable in assessing subtle pathology in this region. Poor radiographic technique often leads to sub-optimal images. Patience may be required to obtain truly diagnostic radiographs, and a beam angle of greater than 45° will give better results. A less collimated and exposed projection also allows evaluation of the wings of the pedal bone.

Gamma scintigraphic examination of the feet can readily be performed in a large number of referral centres, and is very helpful in cases where a definite diagnosis has not been obtained after local analgesia and radiography. As a physiological imaging technique it can yield information about bone pathology and remodelling, before abnormalities are evident with anatomical imaging techniques. Certain diagnoses, eg insertional tendinopathy of the DDFT can only be made with this technique (Figure 3).

Ultrasonographic examination of the foot is often unrewarding in cases of chronic foot lameness, despite being able to image the navicular bone, the DDFT and its insertion onto the distal phalanx

FIGURE 5:

Lateromedial view of a sagittal section of a desiccated foot. Note the close relationship of the distal interphalangeal joint and structures associated with the navicular bone.



through both solar and palmar pastern approaches (Figure 4). The pathology in the DDFT is seldom in the midline portion that can be imaged and, as the tendon is generally imaged in an off-incidence fashion, the identification of pathology is difficult. Collateral ligament injuries of the DIP joint may be apparent ultrasonographically.

The more advanced imaging techniques of magnetic resonance imaging (MRI) and computed tomography (CT) are slowly becoming more readily available for use when a diagnosis remains elusive, despite the use of all the techniques described above.

Chapter 3 covers all the above imaging techniques in more detail.

Navicular syndrome

This a common and well recognised chronic lameness affecting the navicular (distal sesamoid) bone and its associated structures. It is described as a syndrome because there may be a multifactorial aetiology and pathogenesis, and diverse clinical manifestations of the problem. The navicular bone itself, its cartilage or bursa, the impar ligament, navicular suspensory ligaments or deep digital flexor tendon (DDFT) may all be variably involved in the pathology. The dorsal half of the navicular bone is within the DIP joint (Figure 5), and thus pathology within these structures may occur together and is difficult to distinguish.

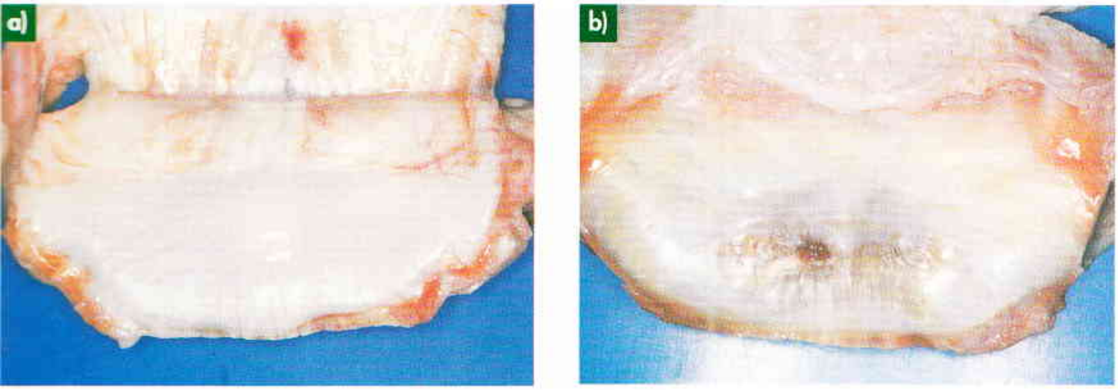


FIGURE 6:

Flexor surfaces of navicular bones, with DDFT reflected. a) Normal; b) Diseased: partial erosion of central fibrocartilage and a full thickness defect through to subchondral bone.

Aetiopathogenesis

There are 2 main groups of theories: vascular compromise and biomechanical. The theory of arterial occlusion leading to painful bone ischaemia has not been supported by experimental studies of altering blood supply, or by compatible histological changes. The biomechanical theory has reached predominance without direct evidence of its mechanism. Abnormal forces on the navicular bone may arise through excessive physiological loading, or through normal forces being applied to a foot with abnormal conformation. The latter situation should arise in horses with a broken back hoof-pastern axis (HPA). and low collapsed heels. However clinical cases do not necessarily have this type of conformation, and one study showed no difference in foot conformation between horses with navicular disease and those with non-navicular disease lameness. Recent biomechanical studies in horses with navicular disease have demonstrated an increased loading of the navicular bone in comparison to normal horses, but the load was decreased after palmar digital nerve analgesia. This suggests that the increased load on the navicular bone may be a compensatory mechanism, and the initial stimulus still needs to be determined.

The histopathological changes are characterised primarily by lesions on the palmar aspect of the navicular bone (Figures 6 a,b), which are similar to osteoarthritic changes in other joints.

Clinical signs

The classic description is of middle-aged horses, with a gradual onset, bilateral, progressive forelimb lameness. There is usually a shortened cranial stride phase. The horse may stumble more frequently and may point a forefoot. It seems more common in horses worked intermittently. The lameness is usually intermittent initially and may

improve with warming up. With chronicity there may be tl
development of a more narrow, upright foot shape.

Because the lameness is usually bilateral, an obvious head nod may n
be evident to the owner in the early stages. It may only be notic
when the lameness becomes asymmetric. If the lameness th
becomes equal on both forelimbs again, the horse may appear to be
temporary remission. There may have been prodromal signs of loss
performance, shortness of action or footiness. The problem may l
reported as being sudden in onset by the owner, when it has be
suddenly noticed.

Diagnosis

The classical findings are:

1. Chronic, bilateral, weight-bearing forelimb lameness, exacerbat by lunging in a circle on a firm surface;
2. Distal limb flexion test is usually positive;
3. Positive response to a palmar digital nerve block;
4. Positive radiographic findings;
5. Muscle wasting and pain in shoulder musculature as a seconda finding;

This author finds evidence of pain as a result of extension and ho
testing in the middle of the third of the frog to be less reliable.

The majority of cases will respond to a PDNB. It is usual for tl
lameness to switch to the other leg when the lamest leg is blocke
Occasionally an ASNB may be necessary to alleviate the lameness,
more commonly to produce further improvement in residual lamene
after a bilateral response to PDNB. About 80% of navicular disea
cases will respond positively to a DIP joint block, and this is employ
routinely in the diagnosis of this condition. A positive response to tl
block will also be obtained in cases of primary DIP joint pain, and tl
differentiation of these conditions will be discussed in the section
DIP joint pain. The speed of response to DIP joint analgesia does n
accurately distinguish between the 2 conditions. The navicular burs
block is usually employed when a diagnosis is not evident after tl
initial blocks and radiography. It is more difficult to perform th
many other blocks, and it seems to involve a slightly higher risk
complications. A proportion of cases of navicular syndrome that fail
respond to DIP joint analgesia will respond to intrabursal analges

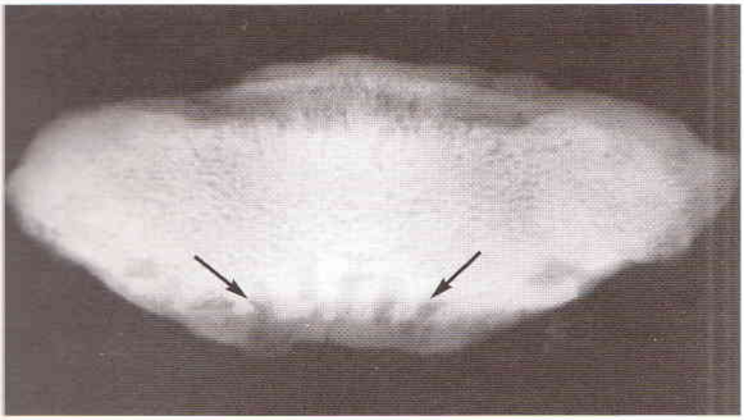


FIGURE 7:

Upright pedal projection of an isolated, diseased navicular bone. Arrows illustrate increased number and size of synovial fossae on the distal border.

and in these cases the pain seems to originate from the flexor surface of the fibrocartilage, the bursa or the DDFT, rather than from the bone itself. The quantity of synovial fluid should be assessed, as it may be increased with bursitis. Some cases of navicular syndrome fail to respond to a navicular bursal block, which may indicate the presence of adhesions, or poor spread to desensitise pain within the bone.

Radiographs should be interpreted in the light of clinical findings. A classical diagnosis of navicular disease is based upon appropriate clinical signs and radiographic changes. Some horses with palmar third foot pain may not have radiological signs, and scintigraphic examination can be helpful in these cases to determine if there is navicular bone involvement. Some horses may have apparent radiographic changes without these being a cause of lameness.

Figure 7 demonstrates classical radiographic signs of navicular disease on the dorsoproximal-palmarodistal oblique (DPrPaDiO) projection. Changes such as enthesiophytes, increased number and enlargement of the distal border synovial fossae, medullary cyst formation and distal border fractures may be identified. Enthesiophyte formation and distal border changes may also be found in sound horses. Although great credence used to be given to the significance of changes in the synovial fossae, the current recognition that the primary pathology is on the flexor surface of the bone means that greater significance should be given to changes evident on the PaPrPaDiO projection. In early cases of navicular disease, up to 70% of cases may have changes evident on the PaPrPaDiO view, but not on the DPrPaDiO projection (these views are shown in Chapter 3). Changes identified may include flexor cortex erosions (Figure 8) or roughening (Figure 9), and medullary sclerosis. Contrast radiography of the flexor aspect of the

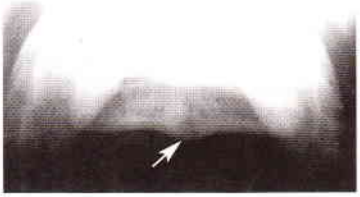


FIGURE 8:

Flexor view of a diseased navicular bone demonstrating erosion of flexor cortex (arrowed).

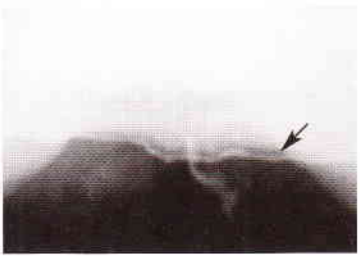


FIGURE 10:

A contrast bursogram outlining the palmar surface of cartilage (arrowed). Also seen is the contrast representing the withdrawn needle tract.

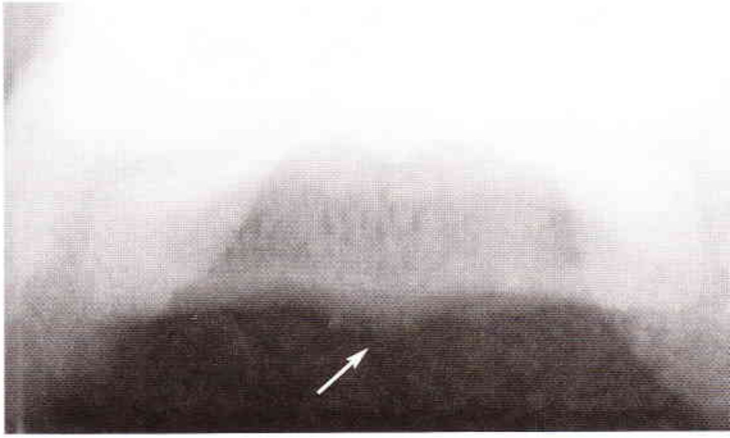


FIGURE 9:

Flexor view of a diseased navicular bone demonstrating roughening of flexor cortex (arrowed).

navicular bone can be carried out after injecting an iodine-containin contrast agent into the navicular bursa (Figure 10). This can assist i identifying cartilage defects, which will be present before osseou changes are visible on radiography.

Many cases of early navicular syndrome will not show radiographi changes sufficiently clear to allow a specific diagnosis to be made Gamma scintigraphic examination can be helpful if the diagnosis i uncertain. The solar projection is the most useful view, and an area o increased radionucleotide uptake may be identified in the region o the navicular bone (Figure 11).

Diagnostic endoscopy of the navicular bursa can be performed b introducing a 4 mm arthroscope into the navicular bursa unde general anaesthesia. In cases which block out to the bursa, but i which no radiographic abnormalities are evident, it can assist in th evaluation of the soft tissues (Figures 12 a,b).

Treatment

Just as there is not one type of navicular syndrome, there is not on single, effective treatment. Many of the principles for the treatment o chronic foot lameness are the same whatever the specific diagnosis, an they are discussed in depth in this section.

Farriery: Corrective farriery is the mainstay of treatment. The mo critical aspect is to attempt to balance the foot and correct an imbalances that may be present. Correcting a broken back HPA will decrease the pressure on the navicular region. The importance of bringing back the break-over point has recently become emphasised, and will decrease the pressure on the navicular region at the end of the stance phase. A rolled toe has only a minimal effect in bringing back the break-over point. A rocker toe will have more effect, but care must be taken to set the shoe back into the toe adequately, otherwise any beneficial effect is lost. The use of toe clips should be avoided. The use of quarter clips allows the shoe to be set back effectively (Figure 13). The use of a Natural Balance shoe (Figure 14) allows a more dramatic palmar placement of the break-over point, but excessive solar pressure should be avoided. Nails should be placed dorsal to the widest part of the foot. Eggbar shoes have been used successfully for the treatment of navicular disease, but this author questions the traditional view that they 'support the heels' by extending beyond them. Force transference between the shoe and hoof can only take place in the region of contact, and extending the shoe further beyond the heel will not influence this. It has been stated that eggbar shoes will prevent hyperextension of the coffin joint on a soft surface and rotation of the foot, thus avoiding high stresses on the navicular region. However, as the lameness in navicular disease is much more significant on a hard than soft surface, this does not seem to be a major consideration. It is possible that the additional stability provided by the bar shoe connecting the 2 heels may be of benefit, as the heels are often weak and sheared. There may be force transference from a straight or eggbar shoe to part of the frog. This can be increased further by the use of a heartbar shoe, which has yielded benefits in some cases of navicular disease that have not responded to eggbar shoes.

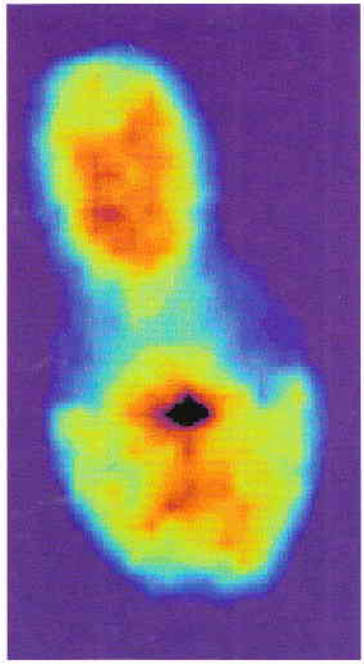


FIGURE 11:

Bone phase solar scintigram of horse with navicular disease.

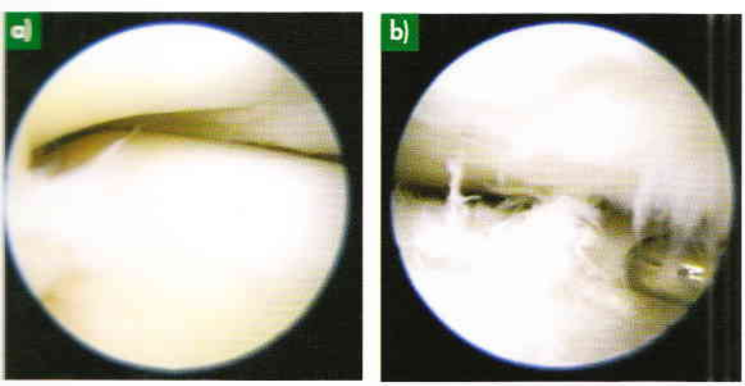


FIGURE 12:

Endoscopy of the navicular bursa: a) Normal; b) Fibrillation of fibrocartilage and DDFT.

FIGURE 13:

Use of quarter clips to allow setting back of break-over point.

In cases with severely collapsed heels and a broken back HPA, wedge or graduated shoes may be used to decrease the load on the DDF and navicular bone. This is best used as a temporary measure only, subjectively there is a tendency towards decreased heel growth, whic is counter-productive in the long-term. It is often difficult t encourage heel growth, and the best results may be obtained with th use of Natural Balance shoes. Pads can be used to decrease th concussive forces transmitted through the foot, but again are be employed as a temporary measure, eg during the summer montl when the ground is harder. Foot balance is discussed in more detail i Chapter 6.

Exercise: This will be used in conjunction with other forms c treatment. If there has been an acute exacerbation of lameness, then period of rest may be necessary initially. If the lameness is mo chronic and low grade, the horse can start controlled exercise straigl away. Low impact work is better, on a soft, uniform surface. It generally better to keep the horse moving as much as possible, e walking and turnout rather than prolonged periods of box rest. Th further exercise plan should then be determined depending upon tl horse's clinical progress.

Medical treatment: A number of drugs are used frequently in tl management of navicular disease. Non-steroidal anti-inflammato drugs (NSAIDs) are effective and economic. Phenylbutazone is tl most commonly used NSAID. None of the other agents have bee proven to have any greater efficacy to justify their greater expens Phenylbutazone can either be used in the short term in acute diseas

FIGURE 14:

Natural Balance shoe: square toe allows easy break-over. Figure 27 demonstrates the same foot before corrective farriery.

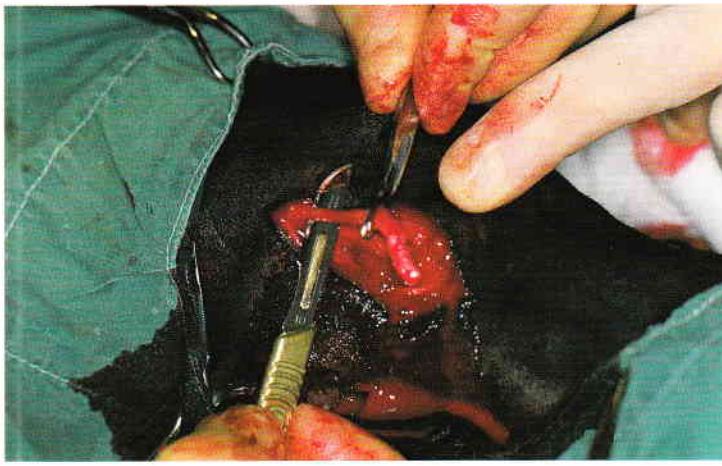
or for maintenance in chronic disease. Although there are concerns over side effects, these are rare in adult horses. It is not a cure, but it may allow horses to be worked satisfactorily, and some mild cases may 'work through' the problem. It is not a permitted medication under many racing and competition jurisdictions.

Isoxsuprine is a peripheral vasodilatory drug, frequently used by general practitioners. Although there is no longer thought to be a vascular aetiology for navicular disease, secondary vascular congestion can occur. However, any response to the medication is generally only temporary and this author does not consider this to be a particularly effective form of treatment. A number of other vasoactive drugs, eg warfarin, metrenperone and pentoxifylline, have been tried but have not stood the test of time. Corticosteroids can be injected either into the DIP joint or directly into the navicular bursa, often in conjunction with hyaluronan. This can be particularly effective in cases of navicular bursitis, or in cases with concurrent DIP joint synovitis. The effect is only temporary in more severe cases.

Systemic 'chondroprotective' drugs such as hyaluronan (hyaluronic acid), eg Legend/Hyonate, and polysulphated glycosaminoglycans (PSGAGs), eg Adequan, are employed commonly as adjunctive treatments in arthritic conditions. The clinical effect in reducing a visible lameness is minimal, but they may be of some benefit in mild cases. Oral glycosaminoglycans (GAGs) are marketed heavily as feed supplements, the majority containing chondroitin sulphate and glucosamine. They have minimal effect in treating lameness, but may be useful for the 'stiff' horse and for maintenance therapy of horses that have responded well to other treatment.

FIGURE 15:

Intra-operative view of a palmar digital neurectomy.



Surgical treatment: A number of different procedures have been used in th treatment of navicular disease. Palmar digital neurectomy is probabl the oldest form of treatment for navicular disease. It is only appropriat if there has been a good, positive response to PDNB. The surgica technique is to remove a minimum of 3 cm of the nerves at the mid pastern level, taking care to check for accessory branches (Figure 15). I is normally carried out under general anaesthesia. There is a loss c sensation to the palmar third of the foot, so the horses may have a increased tendency to stumble post operatively and may not be awar of a solar penetration. There can be a number of complications, such a reinnervation, painful neuroma formation and DDFT rupture. Th procedure is not permitted under Jockey Club and FEI rules. It doe however, offer an option to remove pain where treatments have failec

Navicular suspensory desmotomy is a surgical technique that aims t remove the elastic anchor on the navicular bone, but the actu mechanism of action is uncertain. There is an encouraging success rat at 6 months after surgery, but the majority of cases then suffe recurrence of lameness. The technique is performed infrequently.

Prognosis

For classic navicular disease, with clinical and radiographic changes, th prognosis is generally poor for the horse to continue at its previous lev of athletic usage. The prognosis is better for a lameness which is le severe and of shorter duration, but worse with a predisposing angul limb deformity. Horses that start with a poorer foot conformatio actually have the capacity to show a greater response to correcti farriery by improving the foot balance and biomechanics. Horses use

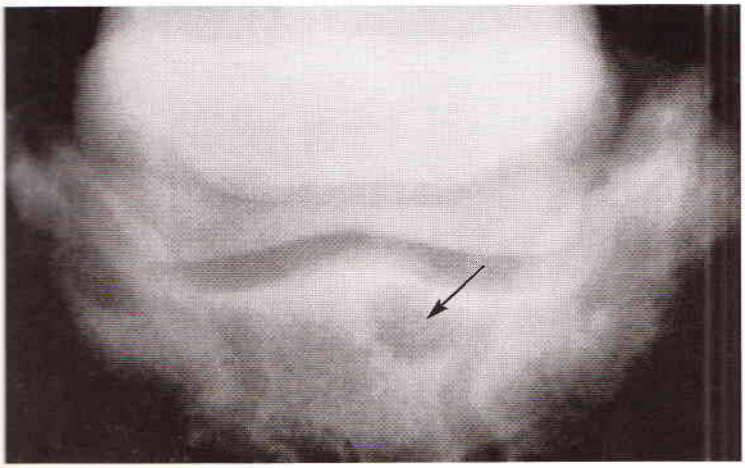


FIGURE 16:

DPrPaDiO radiograph of horse with subchondral cystic lesion (arrowed) in the distal phalanx.

for non-competitive work, or in the more lenient disciplines, eg polo, may be able to compete satisfactorily on NSAIDs. Many competitive horses can be managed successfully to perform at a lower level. Many horses are incorrectly diagnosed with navicular disease and may have either a poorer prognosis (eg a DDFT tear) or a better prognosis (eg palmar third syndrome).

Distal interphalangeal joint pain

Although pain can often be localised to the coffin joint region, specific understanding of the pathology involved is seldom definitive. The diagnosis can be controversial because of the difficulties in interpreting DIP joint analgesia. Traumatic joint disease is the most common problem in athletic horses, due to concussive forces transmitted to the most distal joint in the limb. Osteoarthrosis may occur secondary to intra-articular fractures of the middle or distal phalanx. Small osteochondral fragments of the extensor process of the distal phalanx may represent fractures but some, more rounded, fragments may be incidental findings of no clinical significance. Subchondral cystic lesions of the phalanges (Figure 16) can cause DIP joint pain. Injuries of the collateral ligaments can cause a severe lameness acute in onset.

Diagnosis

The presentation is normally of a forelimb lameness with few localising signs, and it has to be differentiated from navicular disease.

On clinical examination, there will often be palpable distension of the dorsal joint capsule (Figure 17). The lameness is often bilateral and will

FIGURE 17:

Palpation of DIP joint distension.

be exacerbated by lunging on a hard surface and by flexion tests. Diagnosis requires a positive response to a DIP joint block. The synovial fluid should be assessed critically for an increase in pressure and decreased viscosity. The majority of cases are negative to a navicular bursal block. Affected horses will often block out to a PDNB, and definitely to an ASNB. Radiographic examination should be used to rule out the presence of changes consistent with navicular syndrome. The majority of cases will have no, or subtle, periarticular osteophyte production and remodelling of articular margins. The extensor process is the most usual place to see changes (Figure 18), but beware of over-interpreting normal variations. Scintigraphic examination is often unremarkable. Ultrasonography can be useful for assessing the collateral ligaments, although patience is required to achieve diagnostic and repeatable images.

Treatment

Corrective farriery involves correcting any imbalances, bringing back the break-over point and providing adequate heel support. Pads may be used in the short term to decrease concussive forces if the horse has work on a hard surface (the use of hoof pads is covered in more detail in Volume II).

Intra-articular medication should normally yield a significant improvement if the diagnosis is correct and there is no serious underlying pathology. The most commonly used medication is a combination of low dose corticosteroids, eg triamcinolone, and hyaluronan, eg Hyonate or Hylartil. The efficacy of corticosteroids

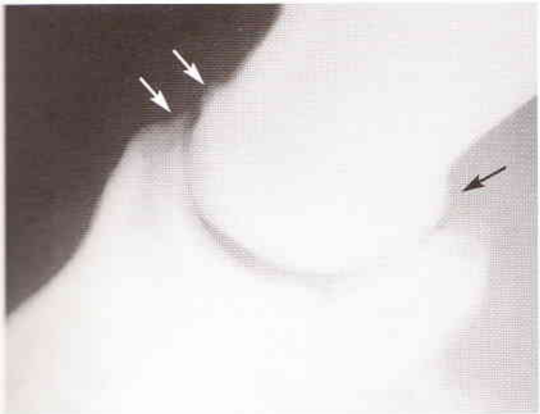


FIGURE 18:

Radiographic changes in DIP joint disease. Arrows illustrate new bone formation.

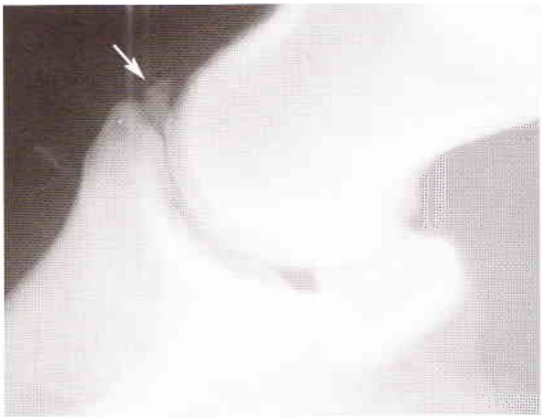


FIGURE 19:

Lateromedial radiograph of small extensor process fracture (arrowed).

used in the treatment of equine joint disease was once questioned, but clinical experience and research work have shown that they are extremely beneficial if used at correct doses. The horse should be given controlled walking exercise until sound. For a mild lameness the horse should be re-examined 2 weeks after treatment and returned to normal exercise if sound, or re-medicated if there is persistence of lameness. DIP joint pain associated with ligamentous injury will require a more prolonged convalescent period. Arthroscopy can be used to remove chip fractures of the extensor process (Figure 19) or to evaluate the joint in cases which are non-responsive to medical therapy (Figure 20).

Prognosis

The prognosis is generally good for mild lameness cases. It is poorer if the lameness is bilateral, or if there are serious conformational abnormalities underlying the problem. It can be difficult to differentiate early navicular disease from DIP joint pain and, if there is a poor response to treatment for DIP joint pain, the diagnosis should be re-evaluated.

FIGURE 20:

Arthroscopic image from a horse with DIP joint disease.

Deep digital flexor tendinitis and insertional tendinopathy

This is a more recently recognised cause of chronic foot lameness with no localising signs. Strains of the DDFT can occur within the foot or

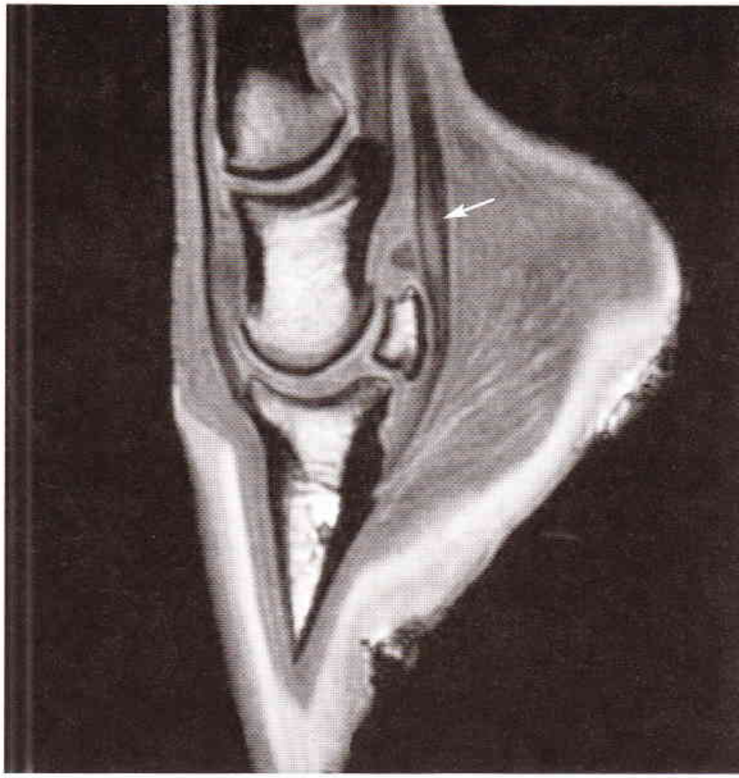


FIGURE 21:

MRI image of a DDFT injury proximal to the navicular bone (arrowed). Figure courtesy of Michael Schramme, Animal Health Trust, Newmarket.

distal pastern region, or there can be pain and inflammation at the insertion of the DDFT onto the distal phalanx. These injuries can occur due to a single traumatic insult, or result from repeated loading, especially of a foot with poor conformation. Advanced diagnostic methods are required to make an accurate diagnosis. Although much rarer than navicular syndrome or DIP joint pain, it should be considered whenever there is a persistent foot lameness without a diagnosis being made by conventional means.

Diagnosis

In some instances soft tissue swelling on the palmar aspect of the distal pastern may be palpable. The pattern of lameness often differs from navicular disease or DIP joint disease, as it will be equally apparent on soft or hard surfaces. There will normally be a positive response to a PDNB, although an ASNB may be required occasionally. A navicular bursal block is more likely to be positive than is a DIP joint block. Radiography will normally be unremarkable, although there may be subtle roughening of the distal phalanx in the region of insertion of the DDFT, evident on the lateromedial projection. Gamma scintigraphic examination is extremely helpful. In the soft tissue phase, the outline of the DDFT may be evident. In the bone phase the region of insertion of the DDFT may be evident on the solar view (Figure 3), positioned more dorsally than the navicular bone (Figure 11). Ultrasonography is often unrewarding, as has been discussed earlier.

MRI (Figure 21) and CT have both been shown to be effective in achieving a specific diagnosis. These techniques require general anaesthesia, are limited in their availability and are expensive. The next 'holy grail' of foot diagnostics is the development of MRI scanning that can be performed with the horse in the standing position, as this should increase the utilisation of this method for accurately identifying soft tissue injuries within the foot.

Treatment

Both the insertional and purely tendinous injuries require rest and 6–9 months may be required. Corrective farriery involves balancing the feet, bringing back the break-over point and providing extra support with a bar shoe. Elevating the heel will decrease the load on the DDFT. Wedges may be helpful in the early stages if there is a severe lameness, but a good heel depth is required in the long term, and the convalescent period should be utilised to allow good trimming to encourage this. A bar shoe may be beneficial when the horse is brought back into work.

Prognosis

The prognosis is generally poor, although there have been no published series available to evaluate the outcome of a large number of cases.

Pedal osteitis

Pedal osteitis is inflammation of the distal phalanx, often resulting in demineralisation and sometimes in new bone formation. It used to be a very common diagnosis, covering a complex of diseases, but is now thought to be rare as a significant diagnosis in isolation. Septic pedal osteitis is discussed separately. The generalised form usually affects both front feet and can be caused by persistent concussive trauma, especially in horses with thin, flat soles and a long toe, low heel, and also in chronic founder. A more localised form can occur in regions of hoof

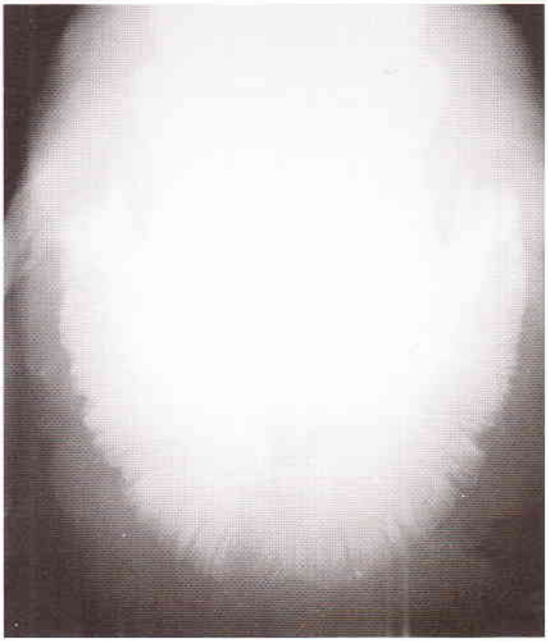


FIGURE 22:

DPrPaDiO projection of horse with generalised pedal osteitis.

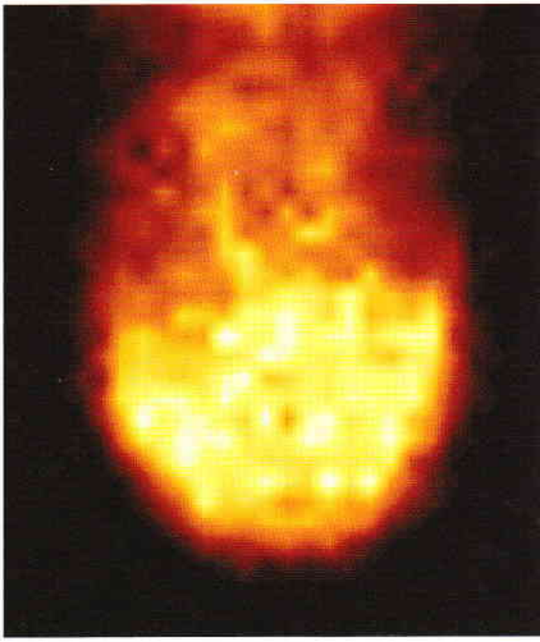


FIGURE 23:

Solar scintigraphic image of horse with pedal osteitis.

wall deformation or secondary to conditions such as abscesses, hoo wall cracks and corns. It can be difficult to determine if the lamenes is actually due to pedal osteitis, or if the bone changes are simply indicative of the severity of the soft tissue pathology and pain that i causing them.

Diagnosis

The clinical presentation can be variable. The lameness will normally be exacerbated on a hard or uneven surface. There will often be sola bruising and sensitivity to hoof testers, as would be expected giver the predisposing hoof conformation. Lameness will be localised to the foot by perineural analgesia, but there should be minima response to intrasynovial analgesia. Radiographic changes include roughening of the dorsal aspect of the distal phalanx on the lateromedial projection. The DPrPaDiO projection is usually the most helpful, and compatible signs include demineralisation arounc the solar margin, loss of vascular foramina, increased size and numbe of vascular canals and, occasionally, fractures of the solar margir (Figure 22). These changes may also be present in sound horses, sc

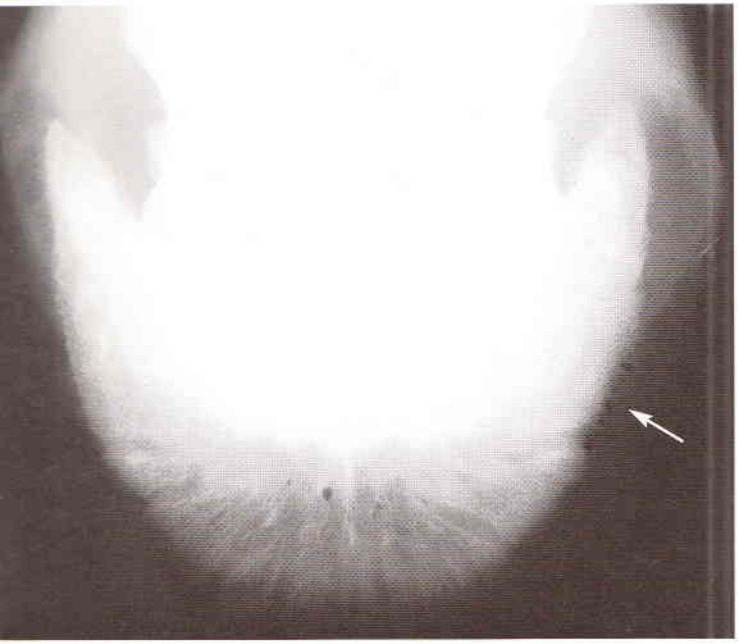


FIGURE 24:

DPrPaDiO projection of horse with focal pedal osteitis (arrowed).

gamma scintigraphic examination can be helpful to confirm a diagnosis of pedal osteitis (Figure 23). Localised areas of pedal osteitis may be evident as focal regions of lysis (Figure 24) or of new bone formation. The radiographs should be inspected carefully to rule out more common causes of lameness, such as navicular syndrome or DIP joint pain.

Treatment

Any primary cause will require treatment. Any imbalances should be corrected and, if there is a flat soled conformation, a broad, well seated out shoe will be beneficial. Pads can decrease concussion, as long as they do not cause additional pressure on the sole. The horse will need to be rested until it is sound and then gently brought back into work, preferably on soft surfaces. Chronic cases may require long-term NSAID administration.

Prognosis

This depends upon the severity of the condition and the original cause. Chronic cases generally carry a poor prognosis.

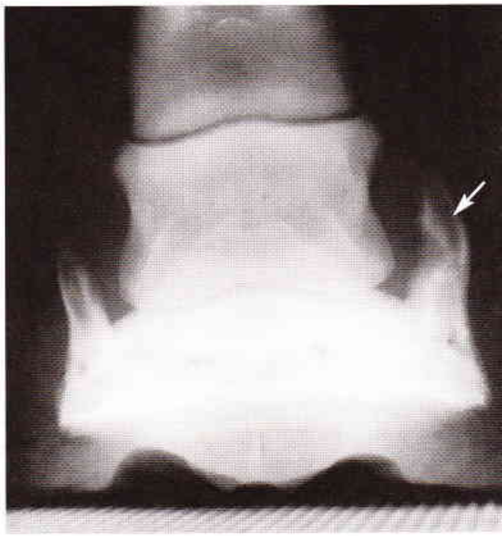


FIGURE 25:

True dorsopalmar radiograph demonstrating sidebone (arrowed). Note predisposing mediolateral foot imbalance.

Ossification of the collateral cartilages (sidebone)

Ossification of the collateral cartilages of the distal phalanges is mos commonly seen in large, flat footed animals. It normally starts at th junction between the cartilage and the bone and progresses proximally It can be considered a normal finding in older horses and heavy breeds but can cause transient lameness during ossification. Poor foo conformation and hard work may predispose horses to this condition

Diagnosis

This is an uncommon cause of lameness. Pain, hardening and swellin may be present on palpation over the cartilages. Any lameness shoul be abolished by a palmar digital nerve block. Horizontal bean dorsopalmar radiographs, with the foot in a weight-bearing position will show the collateral cartilages without superimposition Radiographic evidence of ossification of the cartilages does not mea that this is the cause of a lameness (Figure 25), and other differential should be excluded. Separate centres of ossification may be presen and should not be mistaken for fractures.

Treatment

As lameness is usually transient, the horse will require a period of res Any imbalances should be corrected and a broad shoe, fitted wide an long at the quarters and heels is applied. Chronic cases may requir long-term NSAID administration.

FIGURE 26:

Foot with palmar third foot syndrome due to overhang of heels.

Prognosis

The prognosis is usually good for early cases, but poor with chronic lameness.

Palmar third foot syndrome (PTFS)

This is a poorly defined clinical syndrome, and synonyms include pre-navicular syndrome and caudal foot pain. For the purposes of this text, PTFS will be defined as occurring in horses with a positive response to a palmar digital nerve block, but without definitive evidence of a specific disease process. Whilst some clinicians commonly diagnose PTFS, non-specific heel pain can also be seen as an 'umbrella-term'. Early or subtle cases of any of the conditions so far described in this chapter could all come into this category. The condition is often related to collapsed heels, mediolateral imbalance, sheared heels and chronic corns. The author's definition of PTFS excludes superficial heel pain alone (eg chronic corns), but these conditions will often occur together as the predisposing conformational problems are the same.

Diagnosis

The presentation is often similar to horses with navicular syndrome or DIP joint pain. A long toe, low heel conformation is common, and the heels may significantly overhang the heels of the shoe (Figure 26). Pain is often elicited with hoof testers. The lameness is abolished with a

FIGURE 27:

'Reverse rotation' of the distal phalanx in a case of PTFS.

palmar digital nerve block. There is usually minimal response to D joint analgesia, but there may well be a response to a navicular burs block. Radiography is unremarkable, except for confirming poor fo balance. A common finding is that the solar margin of the dist phalanx is horizontal or even elevated at the toe (Figure 27). The latt is often a very significant finding, as it indicates that increased stra will be exerted in the heel region by the DDFT. Scintigraph examination should be unremarkable, but this author has seen son cases where there was an increased uptake in the navicular bon presumably related to the increased mechanical loading in this regio

Treatment

This revolves around corrective farriery and rest to allow the pain a inflammation to subside. All imbalances must be corrected and t break-over point brought back. An eggbar or heartbar shoe should fitted for stabilisation, although in some cases a better response may obtained with Natural Balance shoes. If the heel is very low, th elevation with either a wedged pad or graduated shoe may bring abo temporary relief. Refractory cases are not uncommon, and require tur out on soft ground for a minimum of 3 months, without shoes and wi aggressive, regular foot trimming to remove any under-run heel.

Prognosis

This depends upon the severity of the condition and the degree conformational abnormalities. In this author's experience t influence of the quality of farriery on prognosis is even more mark than it is with the other causes of chronic foot lameness. Many cas can be managed satisfactorily without being cured.

Chapter 6:
The principles of foot balance

Simon Curtis

Balance is the term used to describe the relationship between the horse's limb, foot and horseshoe. It incorporates the way that farriery affects the horse, both standing (static balance) and moving (dynamic balance). The farrier alters the balance of the foot by trimming the foot, selecting the type of shoe, and placing the shoe. Good farriery involves matching, as closely as possible, the foot with the leg so that the shape and proportions of the foot are the most suitable for that limb. The way the horseshoe is attached to the foot can either enhance or impair it.

Introduction

There is often a belief that foot balance and farriery in general ar not scientific; that it is an art and cannot be quantified. This viev suits most observers of farriery, not least the farriers themselves Farriery may not have been defined by strict rules that can be applie universally, but this does not mean that it is not a science; it only mean that it has yet to be defined. The forces (both natural and induced) tha affect the equine foot are not divorced from those that govern the res of the universe. We should view farriery as having almost infinit variations, all of which have recognisable patterns that can usually b predicted. In the same way, in tennis, no 2 shots are identical but the are all still governed by the laws of physics.

In simple terms we should be able to recognise certain commo factors regarding limb and foot conformation and predict a outcome based on a change in the way the horse is shod Unfortunately, though we start with the simplest leg and foot in th mammalian world, a number of complications come int consideration. The shape of the leg (conformation) varies, as doe breed type, hoof quality, the environment, injuries and diseases. W have to accept that the principal reason for shoeing a horse is not t 'balance' it. Horses are shod to protect their feet from wear an injury and also for grip, the very same reasons that horseshoeing wa invented 2,000 years ago. The first complication to be recognised i that, however well a horse is shod, its balance is changed immediatel by lifting the foot further from the ground. From that point on, th balance deteriorates as the hoof grows down and forward and th shoe wears.

It must be borne in mind that many hoof balance problems are cause by poor leg conformation. The hoof distorts because of the uneve loading of pressure from above. Judicious shoeing may maintai soundness in a horse with poor conformation, but it will not alter th limb of a mature horse. Very few hoof imbalances are caused b farriers. If they were, one could observe similar problems on ever horse shod by an individual farrier. Most imbalances are not cause directly by the farrier but farriers are more often guilty of no recognising the conformation or its effect upon the hoof capsule. The therefore do not take the necessary action to correct it. The farrie needs to be aware at each shoeing of any hoof distortion so that he ca reshape the foot and bring it back into alignment.

Broken back hoof-pastern axis (HPA) is usually induced by shoes being left on too long and/or short shoeing. Short-fitted shoes and shoes left on too long will eventually cause lameness, which may be permanent. Any hoof imbalance is aggravated by leaving too long a period between shoeing and/or trimming. The hoof grows increasingly out of balance as each day passes. Many conformational problems are insurmountable, a misaligned limb slowly causes the foot to distort, damaging irrevocably ligaments, joints, the pedal bone and the navicular bone. The horse becomes lame in a matter of weeks but the damage has been accumulating for years. Corrective shoeing for these cases is a long-term prospect and often disappointing.

Principles of balance

It is perhaps best to consider that there are principles to balancing feet which should be used as guidelines. This author strongly believes that there are some 'golden rules' in the preparation of a foot and the fitting of a horseshoe. These rules are ideals and the closer we are to obtaining them, the more likely the horse is to perform to its maximum potential and to remain sound for a prolonged period. In most circumstances the principles stated in this chapter will maintain or improve balance. These rules make farriery more methodical. By being more methodical and recognising simple assessment guidelines, we are able to gather and compare information.

Assessment of balance

The assessment of the balanced foot can be broken down into the lateral and anterior views and into the static and dynamic balance, in other words when the horse is standing still or moving.

Static hoof balance

Static hoof balance is assessed when the horse is not moving. The horse must be stood up square so that it is bearing weight evenly on all 4 feet. It should be on a clean, level surface, large enough to allow room around the horse for safe viewing, and assessed as a whole, each leg individually and each leg picked up (Figure 1). The hooves should be appraised for shape and distortion, whether they are over-grown, have growth rings or lesions (Figure 2). The shoes should be looked at with regard to their suitability (Figure 3).

FIGURE 1:

One assessment of static hoof balance involves picking up the foot and examining the shoe and solar shape.

FIGURE 2:

A lateral view shows the length of foot and details such as growth rings.

FIGURE 3:

Viewing the shoe on the foot provides information regarding wear and length of shoe.

A general assessment must be made of the hoof shape and it proportion to a particular horse and breed must be made. Where ther are growth rings and they are parallel, they may just signify a chang of environment, diet, or an illness. If they diverge or are compressed i one part of the hoof wall this shows that the hoof is under sever uneven stress or that it is not being nourished adequately in certai areas, eg laminitis creates a distorted hoof wall with growth ring diverging at the heels and closing dorsoproximally.

The type and size of the shoes is noted along with any additions t normal shoeing, eg studs, road nails, rolled toe. The wear pattern of th shoes should be noted. The horse may drag its toes, severely wear on branch or not break-over in the centre of the toe (Figure 4).

Anterior view

This is used to look at the foot and limb at rest, from the front. Th front limbs should be assessed looking down the spinal axis of th horse and from the front of each individual limb, ie the way the foo is pointing (Figure 5). A vertical axis through the centre of the canno bone should bisect the hoof into equal halves (Figure 6). The hoof wa

FIGURE 4:

Severe toe wear of a hind foot may be caused by lack of fitness or flexion of the hock. In this case, weakness due to 'wobbler' disease affected the horse's gait.

FIGURE 5:

A view through the spinal axis of the horse shows the left fore (on the right) to be rotated out.

FIGURE 6:

An imaginary line through the centre of the left fore cannon and hoof shows the hoof (indicated) capsule to be offset laterally.

should be at the same angle on both sides. The wall should not flare out or run under (Figure 7). The hind feet and limbs should be looked at from directly behind and directly in front of the limb. If the coronary band is not horizontal it should not be the farrier's primary objective to level it. It is certainly a sign that all is not well with the horse's balance but it is unlikely that trimming of one side of the hoof to tilt the hoof capsule is the answer.

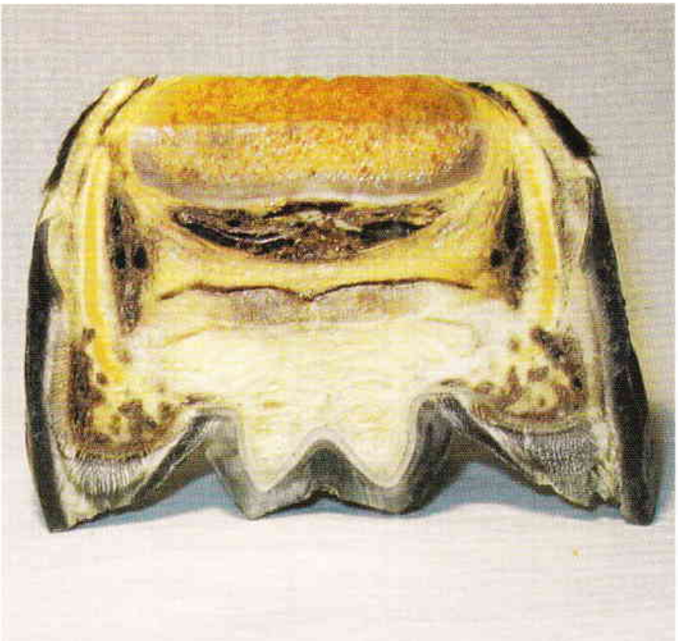


FIGURE 7:

A lateromedial section through a hoof capsule shows the left side under-run (convex) and the right side flared (concave).

FIGURE 8:

The right fore (left side) is typical of a toe-in horse tha has an offset knee and slightly varal fetlock. The hoo flares medially.

Looking at the whole horse from the front tells us about his action and the resulting distortion of the hoof capsule and the wear on the shoes. If he is wide in the chest and has offset knees it is likely that he 'toe in', is flared medially and upright on his lateral wall. He probabl paddles when he walks, lands hard on his lateral wall and breaks ove on his outside toe (Figure 8). His shoe wear reflects this action; it i worn from the outside branch to the outside toe. If the horse is bas wide and has knock knees (carpal valgus), or has an outward rotation he will have a hoof capsule that is distorted laterally so that it flares o the lateral wall, is upright or under-run medially and may have th medial bulb shunted proximally. His action will dish and he wi probably land on the lateral hoof wall, and load onto the medial sid during the weight bearing phase, breaking over on the inside toe. If hi uneven landing is severe he will be prone to corns and even quarte cracks (Figures 9 a,b,c,d).

The 2 examples above follow the rule that 'function follows form' i that the horse's conformation controls the way that it moves. Th

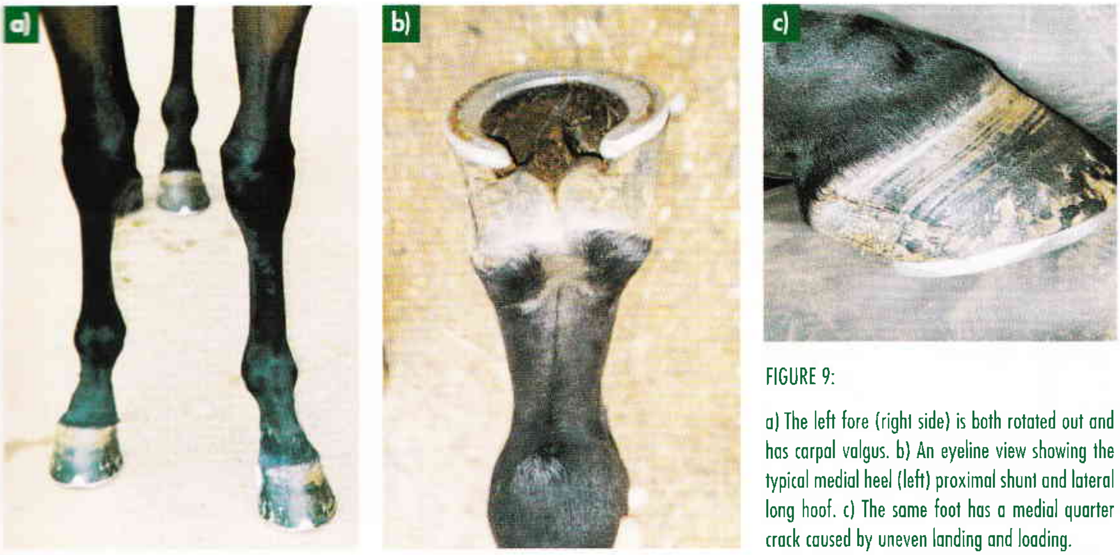


FIGURE 9:

a) The left fore (right side) is both rotated out and has carpal valgus. b) An eyeline view showing the typical medial heel (left) proximal shunt and lateral long hoof. c) The same foot has a medial quarter crack caused by uneven landing and loading.

secondary effect is that the hoof capsule distorts due to uneven loading, a case of form following function. It does this for several reasons:

1. It is continually growing and can therefore be influenced by pressure away from its correct alignment.
2. It is not firmly fixed to the skeleton, eg the hoof wall is attached by the laminae; which by their nature are flexible and the coronary band is only attached to the skin.
3. The hoof may wear unevenly.
4. Horn is compressible.

The long axis (front): By looking down the long axis of the cannon, pastern and hoof capsule one is able to 'eyeline' the mediolateral relationship of the shoe, hoof and leg. The leg is held by the cannon as close to the carpus as possible and allowed to hang loosely. The head must be pressed to the horse's shoulder to give a good view. On the front limbs, this gives the best guide to mediolateral balance. A 'T' square aligned along the back of the cannon takes away the guesswork and subjectivity of assessment. It not only shows whether the solar surface is at 90° to the long axis but also highlights distortions and flares (Figure 10).

FIGURE 10:

The 'T' square allows for a more objective assessment of the hoof capsule's relationship with the leg.

The front foot can also be brought forward and hung from just above the knee, allowing it to flex naturally. A view is then gained by looking down on the hoof capsule from above. This gives a good vision of the

FIGURE 11:

The leg is brought forward and a view taken down the cannon, giving an alternative assessment of the leg and hoof capsule.

FIGURE 12:

Viewing a hind leg for balance is best done from directly in front or behind the direction that it points.

FIGURE 13:

The solar shape should be trimmed as symmetrically as possible. Here an injury to the heel (A) has distorted the hoof. Normal heel (B)

relationship between the cannon, fetlock, pastern and hoof capsule (Figure 11).

The long axis (hind): Due to the anatomy of the hind limb it is not possible to assess mediolateral balance in relation to the long axis in the same way as for the front feet. Because of the reciprocal apparatus the leg cannot be hung loosely when picked up; the fetlock cannot extend with the hock flexed. Looking over the point of the hock gives some information but this alone should not be used to decide the exact plane of the foot. The best information is gained by observing the foot on the ground. The horse must be seen to have its foot placed in a natural and relaxed manner, bearing weight evenly on all 4 feet. The observer should stand just off the front of the horse, directly in front of the hoof and cannon. This is usually at about 10% out from the spinal axis (Figure 12). A similar view can be taken from behind. The T-square stood upside-down on the ground can be used a guide to the eye.

FIGURE 14:

The HPA should be in alignment.

Solar view: Looking at the underside of the hoof can tell us a lot about foot balance (Figure 13). The frog is the best guide to the foot's

FIGURE 15:

a) Poorly shod and neglected, the long toes and collapsed heels create stresses to the dorsal laminae, the flexor tendons and other areas of the foot. b) By bringing back the break-over point and heels and shoeing with length, these stresses are reduced.

symmetry. A trimmed frog is a wedge-shape that always remains centrally located and aligned along the dorsopalmar axis of the distal phalanx (PIII). All other parts of the hoof capsule distort around it. The bulbs can shunt unilaterally, the sole drops and the white line can become distended.

Lateral view: From the side, the horse is viewed for dorsopalmar (D/P) balance (Figure 14); it is essential that the HPA is in perfect alignment. Ideally the hoof wall and angle at the heel should also align. A radiograph should not be necessary to assess D/P balance as the phalanges are only covered by a thin layer of tissue and skin. The top third of the dorsal hoof wall will always remain parallel with the distal phalanx behind it (the only exception is during acute founder when PIII has rotated).

Broken back HPA: If the HPA is broken back, then areas of the foot and leg will come under greater stress, which may result in lameness (Figures 15 a,b and 16):

1. The dorsal wall laminae are subjected to tearing forces due to the lever arm of a long toe and extended break-over point. Distension and haemorrhage in the white line is a sign of this.
2. Greater strain occurs in the suspensory apparatus. The suspensory apparatus is the system of tendons and ligaments that allows the horse to lock its limbs and rest standing up. It also protects the horse's fetlock from hyperextension during fast work and jumping.

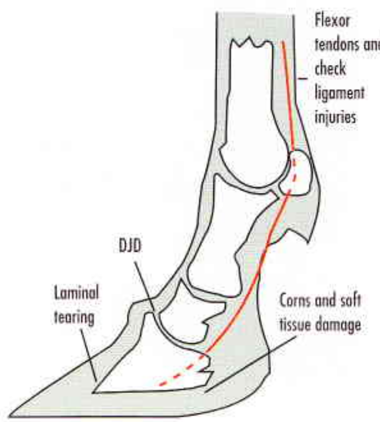


FIGURE 16:

Long toes and low under-run heels cause or exaccerbate conditions of the foot and leg.

FIGURE 17:

A broken forward HPA. After 6 weeks growth, note the strong heel.

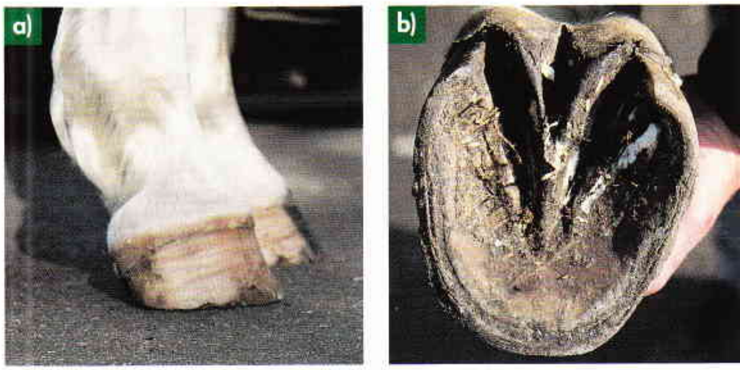


FIGURE 18:

a) A club foot has a broken forward HPA, a steep dorsal wall and high heels. b) A solar view shows that typically it has a hind shape, the hoof quality and attachment are poor from the quarters forward. A club foot does not usually have contracted heels.

FIGURE 19:

An upright foot (closest) is narrower and higher than the opposing front foot. The heels are usually contracted. Figure 1 is a solar view of an upright contracted foot.

The flexor tendons and the inferior check ligament are particularly affected.

3. Degenerative joint disease (DJD), especially of the distal interphalangeal joint (DIP), may be caused.
4. Navicular syndrome is frequently linked to this imbalance. The extra tension on the deep digital flexor tendon (DDFT) must cause greater pressure upon the navicular bursa and bone.
5. Soft tissue in the caudal half of the foot is damaged, eg corns are usually associated with this conformation.

Broken forward HPA: A broken forward HPA (Figure 17) is seen when the dorsal hoof wall is more upright than the pastern axis. Although not as serious as a broken back HPA, this can still lead to stumbling and excessive landing on the heels. A broken forward HPA with a steep, sometimes concave, dorsal hoof wall is called a club foot. The solar shape is similar to a hind foot with wide heels and a well developed frog (Figure 18 a,b).

Upright foot: An upright foot should not be confused with a club foot. The HPA is in alignment and the solar shape is usually oval and contracted at the heels (Figure 19). The cause of an upright foot, especially if unilateral, may be an injury to that limb at some time. Another, unproven, supposition is that the upright foot is the result of the limb on that side being shorter than the opposing limb. The upright foot grows in this manner due to less weight bearing and makes up the height difference.


FIGURE 20:

Shoe length should be appropriate to the conformation: Both a) and b) are due for reshoeing. a) Has a heel length beyond the buttress but requires more; b) Is a more upright conformation without requirement for extra length.

Bull-nosed foot: This type of foot has a very convex dorsal hoof wall and is more often seen in the hind feet. Characteristically the pastern gives the impression of being displaced caudally and the bulbs of the heel are very prominent. This is undoubtedly an optical illusion. The growth of horn at the toe is always longer than appears from a solar view. It is easy to believe that this shape is created by dumping the toe; in this author's experience this is not the cause. The wall, especially at the toe, is very long and the distal phalanx is high up in the hoof capsule often lying parallel with the ground (see Figure 5c in Chapter 3: Imaging the Foot and Leg). This is sometimes described as a reverse rotation.

Shoe wear

The wear pattern of the shoes obviously relates to the horse's action during movement. At all times, while the foot is on the ground, the foot is moving (see Figure 10, Chapter 16: Shoeing for Grip). Wear is caused to the shoe at landing, sliding and at break-off. Analysing the data that we gain from looking at the wear on the shoe may well help in deciding both the present balance of the horse and also a future shoeing regime. We need to consider the factors involved carefully and relate them to the wear that we see:

1. The surface on which the horse works may be: a manege, turf, sand, rough ground, road or a combination of these.

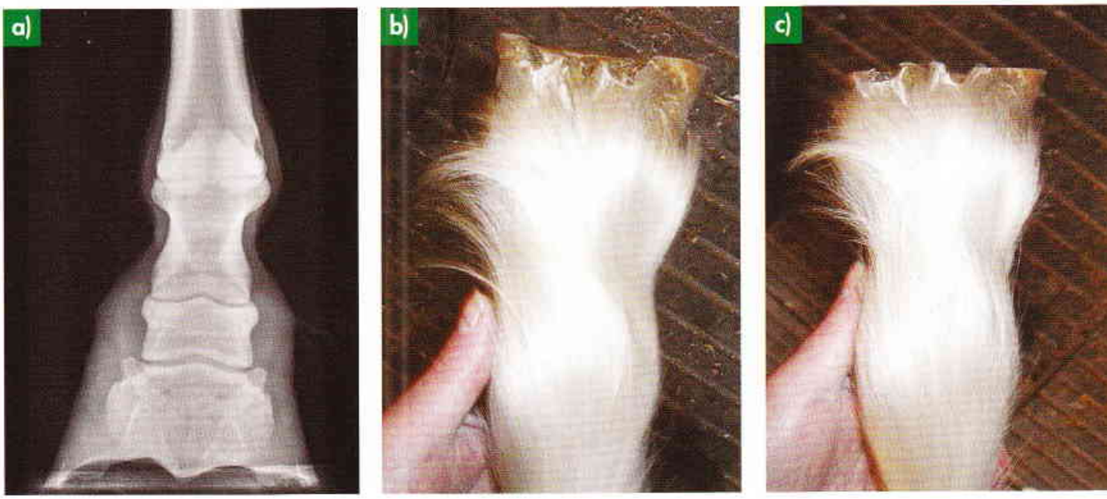


FIGURE 21:

a) A true dorsopalmar x-ray of b) and c) shows a mediolateral imbalance. b) Eyelining confirms that the lateral (left) side is longer. c) The lateral wall is trimmed to align at 90° to the long axis of the cannon.

2. Age and fitness; toe dragging is common in the older or less fit horse
3. The type of shoe; steel or aluminium, wide or narrow web.
4. The length of time since shoeing.
5. Additions to the shoe; road nails, studs, borium.
6. The shape of the foot and shoe fit.

Front shoes usually wear quite evenly with the toe rolled by the break-over; a toe-in horse will wear the outer toe more and a base wide toe-out wear the inner. Offset knees with the accompanying varal fetlock and toe-in conformation have a paddling action, which causes wea along the length of the lateral branch.

Hind shoes wear in a totally different manner to front shoes. Th reason for this is that the main joint of the limb, the hock, flexes in th opposite direction to the knee. This may seem too obvious to poin out but it is surprising how often assumptions are made about hin limb balance and shoe wear based on the front. Hind shoes are ofte worn off square at the toe in a manner never seen in front. This i usually related to a lack of flexion in the hock. The foot has a lowe flight arc and, although it leaves the ground, the toe is tapped down a it swings under the body. The branches usually wear level wit sometimes slightly more wear to the lateral side. Only when this i excessive, or if the medial branch is worn more than the outside should concern be shown.

Shoe length: Shoe length is a factor in examining the shoes. The classi mistake is to run one's thumbs up the bulbs of the heels, while holdin the foot up, and feel the length of the shoe protruding beyond the heel. This is only a valuable guideline if the foot is correctly trimmed in the first place. If the heels are long and under-run, and could have been dressed back, then it may be that in relation to the foot and limb the shoe is still short. Conversely, a well dressed foot shod 'penny on a penny', may be shod with sufficient length (this aspect of foot balance is discussed further in the *Shoeing for Dorsopalmar Balance* section of this chapter). Shoe length is best assessed by standing back from the horse and taking in the limb conformation and foot shape in conjunction with shoe length (Figures 20 a,b).

Dynamic hoof balance

Although much information regarding the horse's balance can be gleaned statically, it is necessary for a complete assessment to see the horse in motion. Farriery cannot influence the limb in the air, all the farrier can do is affect the foot landing, during the weight bearing phase, and taking off (break-over). Almost all hoof balance-related injuries arise in the landing and weight-bearing phases of the stride and these can be affected by both foot trimming and shoeing.

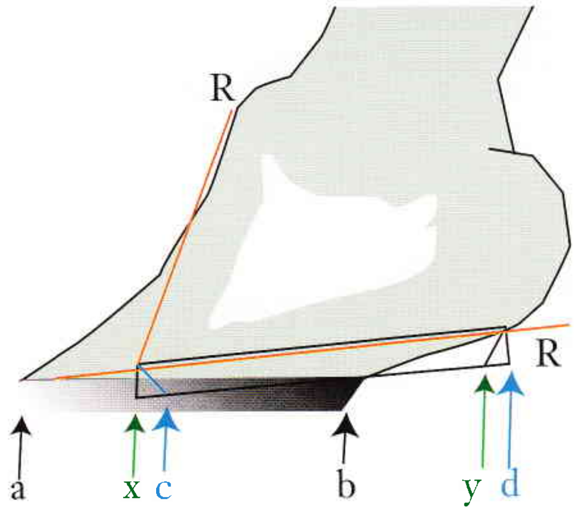
Anterior view

By standing directly in front of the horse while it is walked towards you a good view is gained of both the movement of the limbs in the air and also their landing and take-off. By squatting down low, it is possible observe the instant that the foot strikes the ground. Good mediolateral (side-to-side) balance is seen when the hoof lands level. If the hoof is out of mediolateral balance, then one side lands first (contact) and the other side is immediately slammed into the ground (impact) in the weight-bearing phase.

A typical example of this is seen in the horse that 'toes-out' (Figures 9 a,b,c). As his foot lands, the outside toe (which is usually flared) impacts first and as the body weight passes over the limb and foot the inside heel is snapped down. The weight of the horse is rolled over the inside toe as the foot breaks over and lifts off. This type of action is liable to cause the medial (inside) heel to shunt up higher than the lateral (outside) heel. It may also cause corns on the inside and quarter cracks to the hoof wall. The inside heel appears higher at first glance and is often trimmed down to 'level it' with the lateral heel. This is the very worst thing that can happen because it creates a greater dynamic imbalance. The excessive loading on the medial side of the hoof causes the bulb and coronary band on that side to become displaced

FIGURE 22:

Trimming 'toes back, heels back' is an essential requirement prior to shoeing. a) and b) are the original break-over and caudal support points, x) and y) is after trimming, c) and d) are further improvements gained by the shoe, ie rolled toe and upright heels. This diagram illustrates the often surprising improvement in heel angle, as seen in Figure 15.



proximally (shunted). This mistake occurs when the foot alone is assessed out of context with the limb. The only way to avoid this mistake is to eye-line the limb; ideally with a T-square.

Lateral view

The observation of gait from a lateral viewpoint can also help in foot trimming. In the well balanced horse, the foot should land level or slightly heel first. Horses that land toe first are usually showing signs of pain in the caudal area of the foot and are prone to stumbling. A horse with bull-nosed feet will often land toe first (this may be the cause of the convex wall rather than the cause of the gait). Where the toe is long and the heels are under-run, break-over is delayed and the body weight is lifted higher in order to move forward. Where there is or has been a laminitic condition, the toe will usually flip up in an exaggerated manner and the foot will clearly land heel first.

Shoeing

The phrase 'shoeing for balance' incorporates the foot preparation (trimming), shoe selection and the positioning of the shoe on the foot. It is essential to achieve as much as possible by trimming. It is true to say that, if the foot is not prepared correctly, then no type of shoe or shoe fit will improve matters. Because it is easier to visualise and describe a shoe than a change to the foot balance, the focus has all too often been on the shoe. In other words the shoe is seen in the same way as a drug is seen. If the foot has collapsed heels, give it an eggbar if it has laminitis, give it a heartbar. We need to view shoes as orthopaedic devices that enhance the foot preparation and give an additional biomechanical effect.

Shoeing offers us an additional way of adjusting the balance of the foot. As a general rule, the foot will be placed, in relation to the limb, in the direction that a shoe is extended. To achieve this, the foot must be trimmed strictly in accordance with the following guidelines:

1. The solar surface must be at 90° to the long axis of the cannon (Figures 21 a,b).
2. The dorsal wall must be dressed back straight to align with its proximal third (this may be detrimental in some cases associated with laminitis); the break-over point must still be caudal to this point, Figures 15 a,b).
3. The heels must be dressed back to their caudal extremity (the widest part of the frog).

FIGURE 23:

The left side of the foot has been trimmed. Note that the toe has receded and the heel buttress is now more caudal (arrowed). This effect is shown diagramatically in Figure 22.

Shoeing for dorsopalmar balance

Foot preparation: If the horse has a broken back HPA, with a long flared toe and an under-run crushed heel, both the toe and the heels must be dressed back. The heels are just as important as the toe. It is easy to understand the increased leverage of a long toe and quite simple to see where to trim. Dressing the dorsal wall back to align with the proximal third has long been an accepted rule of foot balance and this can be confirmed by a lateral radiograph. The type of toe on the shoe can bring the break-over point back further. Balancing the heels is less well understood and harder to quantify because there is not the same exact guideline. Many farriers describe the point to which the heels should be trimmed as 'the widest point of the frog'; unfortunately this is somewhat ambiguous. Another guide is to trim down until the horn tubules are straight. This could lead to unfortunate circumstances if adhered to regardless of the depth of foot. Although unable to state a hard and fast rule, this author believes that, if a foot is trimmed with both the above guidelines in mind, the heels will be improved. Figures 22 and 23 show the effect of the 'toes back, heels back' principle.

Shoeing: The shoe selected must take into account the type of exercise that the horse will do and its biomechanical requirements. The break-over point is moved caudally depending on the type of toe. A conventional toe places it under the trimmed toe, whereas a rolled toe

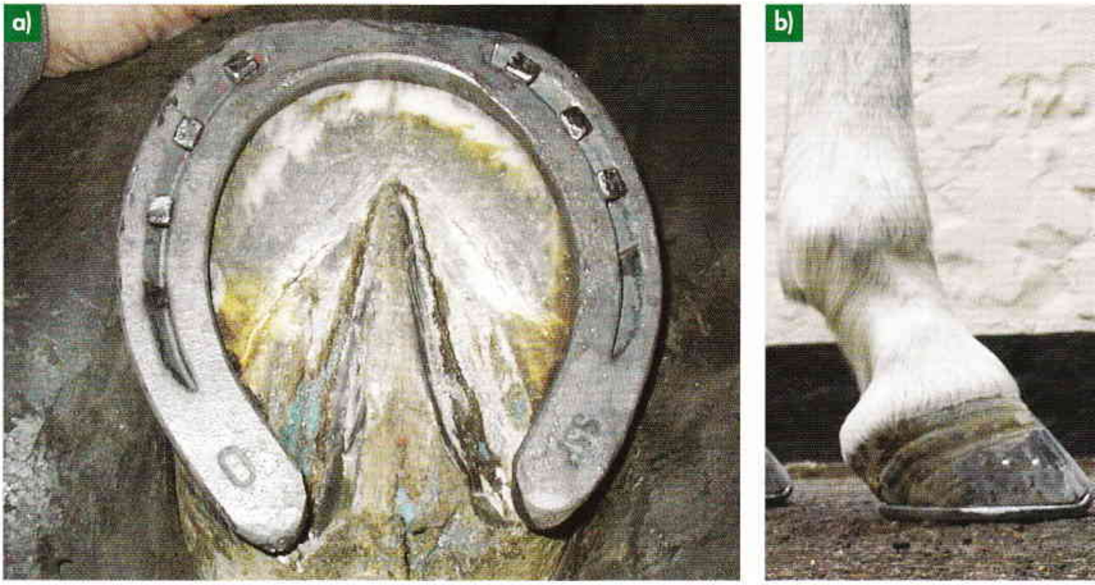


FIGURE 24:

a) The heels of this shoe extend to cover the heel buttress to the widest part of the frog. b) The heel length can been seen to extend beyond the buttress and
rocker toe brings back the point of break-over.

will bring it back 5–10 mm. A rocker toe moves the break-over poi back further and a square toe, especially if also rolled, can bring it ba 30–40 mm. As a rule of thumb the caudal extremity of the shoe shou extend to where the lateral sulci begin. This is for an open shoe wi upright heels (Figures 24 a,b). Nevertheless it should be reiterated th length of heel is meaningless without the correct heel trimming.

The eggbar: The eggbar shoe has long been used when there is a ne to improve a broken back HPA. It is often said that an eggb 'supports the heels' or that it 'spreads the weight'. Both of the phrases trip off the tongue but are quite meaningless wh examined. The first begs the question: how does a piece of me separated from the heel bulbs by air support anything? As to t second, there is, of course, more shoe between the ground and t foot, but the horse's weight remains the same as does the bearing ar of the foot.

So how does the eggbar work, as it undoubtedly does, when t trimming of the foot and the fitting of the shoe are correct? It h the added beneficial effect of giving more rigidity to the ho

FIGURE 25:

A lateral view of a horse shod with eggbar shoes. These usually also have rolled or rocker toes.

FIGURE 26:

A solar view of a fitted eggbar (Figure 25). Note that the caudal length is halfway between the heel buttress and the bulbs. The heels should sit on the middle of the web as indicated by the dotted lines.

capsule by reducing shearing movement. A straight bar will improve rigidity but will not give the same influence in repositioning the foot in relation to the limb and body weight of the horse. The eggbar can be seen as a caudal extension shoe. It is very effective when the hoof trimming is correct and it is applied on the correct principles (Figures 25 and 26).

One difficulty in fitting eggbars, is that most horses that require them have low collapsed heels and often an over-developed frog. The bar usually needs seating out in order to avoid direct pressure upon the frog. Despite this it remains the most useful shoe in the farrier's repertoire (the making of eggbars is covered in Chapter 7: Making and Adapting Bar Shoes).

Natural balance

The terms 'natural balance' shoeing and 'four point' trim or shoeing have come to the fore in recent years. The style of both foot preparation and shoe is based on trying to emulate the wear of free ranging feral horses. The main proponent of this type of shoeing is Ovnicek although Emery, Van Hoosen and Miller (1977) wrote

FIGURE 27:

A natural balance shoe has a toe that is square and rolled, moving the break-over point caudally (arrowed).

extensively on wear patterns to the hoof of the feral horse. The ma characteristic of the shoe is the square widened toe, which is rolled half its width. The shoe is also seated out at the toe. The shoe is fitte with the break-over set caudal to a conventional fit (Figure 27).

This author's opinion on this style of shoeing is that it has much mer when used in the correct circumstances. Later chapters show its us particularly for shoeing cases of chronic founder. It has also served th purpose of raising the debate about break-over and the value simulating nature. However, severe doubts must be raised about th virtue of shoeing every horse regardless of their type and use in th manner. We need to remember that there is little that is natural abou the horse today; they are larger, saddled, shod, live in damp climate walk on the road, etc. We cannot just pick out one aspect of the hor and emulate (possibly erroneously) what we believe to be natural.

Elevating heels: It is possible to elevate heels where trimming and shoeir alone cannot correct the HPA. There are various ways to achieve thi Shoes can be forged to increase the height at the heels. This takes sk and time and adds to the weight of the shoe (Chapter 8: Shoeing f Tendon Lesions). Weld-on wedges have been available in recent yea and have the advantage of minimal weight addition and ease of fittin

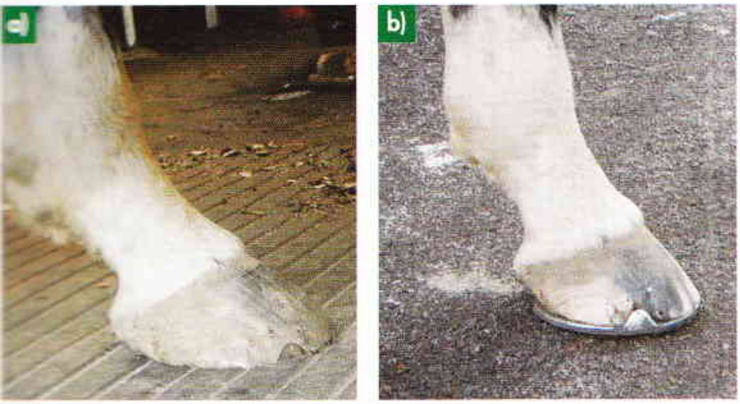


FIGURE 28:

a) A long hind foot with a slightly bull-nosed appearance. b) After trimming and shoeing. Note the improved HPA and heel angle.

provided a welder is available. Plastic and aluminium shim wedges are widely used as the easiest and lightest way of adding height (see Volume II). These slip between the shoe and the foot and are usually riveted into position. They have a tendency to wear because of the expansion and contraction of the foot at the heels.

Changing the elevation of heels of the front feet by any means other than trimming should be seen as a last resort and certainly not a long-term answer. Heels raised in the ways mentioned above have a tendency to crush and collapse further. It is very unusual to find hind feet broken back with under-run heels as seen in the front feet. No doubt this is due to them only bearing about 40% of the horse's weight. Hind feet are frequently elevated for reasons not directly related to balance, eg for the treatment of bone spavin. The heels are elevated not to correct a perceived imbalance in the foot but rather to alter the balance of the limb in order to alleviate a condition (this is covered in more detail in Chapter 9: Shoeing for Hind Limb Conditions.).

The bull-nosed foot: Trimming involves paring the hoof wall, especially at the toe. The foot should be placed back on the ground and frequent lateral assessments made. There is almost always more foot to be removed than at first seems apparent from a solar view. When trimmed in the above manner the hoof capsule rotates forward and takes on an altogether different appearance. A conventional hind shoe, with more length, is all that is needed (Figures 28 a,b).

Some hind feet and limbs require considerable extra length. These tend to be horses that stand and move with their feet further under them than is desirable. A hind shoe that has the heels 'donkeyed' out allows a shoe of length to be fitted that does not impinge upon the frog.

FIGURE 29:

The club foot seen in Figures 18 a) and b) after shoeing. Note that the heels remain high and the HPA is still broken forward.

FIGURE 30:

A horse with an asymmetric imbalance (odc footed). The flat, collapsed foot (nearest) require as much attention as the upright foot.

The club foot: A club foot is a chronic condition which cannot be curec It is usually the result of an unresolved flexural deformity involvin the DDFT. Over-trimming of the heels of the club foot may throv such excessive strain upon the flexor tendons and the sub-carpa check ligament that lameness results. That is not to say that the farrie should not attempt to improve the shape. Some judicious trimmin of the heels and protection of the toe is advised. Where the dorsa hoof wall is concave it should be dressed back to straight. On balancing guideline is to trim the foot so that the sum of it dimensions match the sum of the dimensions of the normal foot o the other side, eg if the normal foot is 12.5 cm X 12.5 cm and th club foot has a width of 11.5 cm, trim the heels until the length i 13.5 cm. The farrier should try to create a straight HPA. There shoul not be an attempt to match the feet in shape, it is difficult enough t nail to a club foot securely without trying to shoe cosmeticall Because of the internal stress to the laminal attachment, the club foo is prone to poor quality hoof wall which can cause difficulties whe nailing. Seedy toe is often presents and this compounds shoein difficulties (Figure 29).

Upright foot: An upright foot needs alternative shoeing considerations t the club foot. Growth is more even, ie not growing mainly at the heel

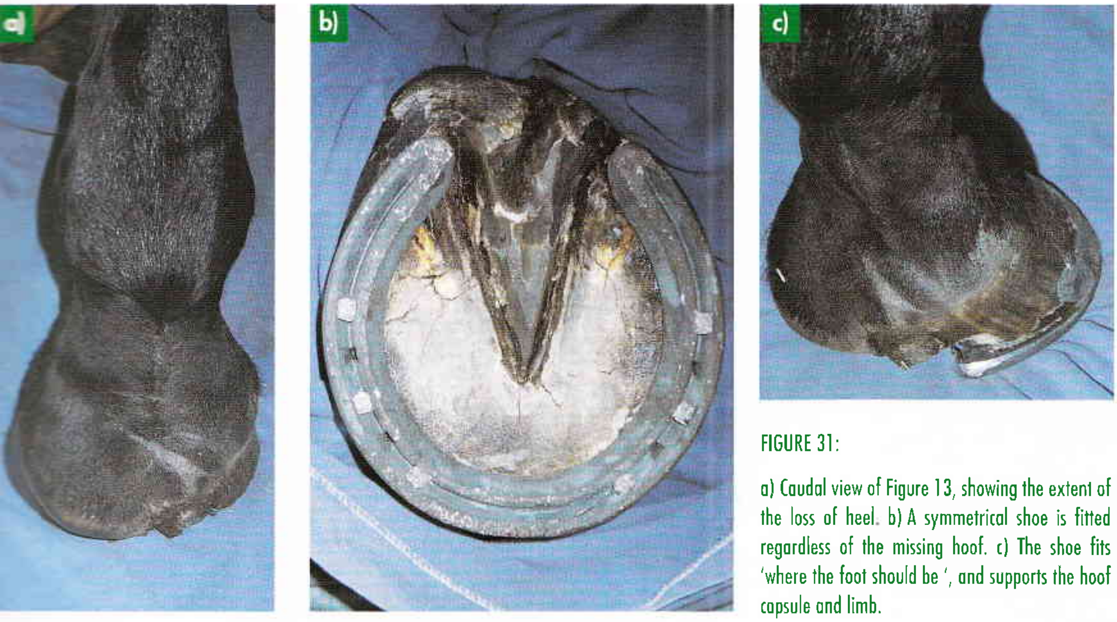


FIGURE 31:

a) Caudal view of Figure 13, showing the extent of the loss of heel. b) A symmetrical shoe is fitted regardless of the missing hoof. c) The shoe fits 'where the foot should be ', and supports the hoof capsule and limb.

Excess growth should be brought down equally while maintaining the HPA. The shoe fit should provide width for expansion because, if the cause of the contraction no longer exists, hoof shape may improve. Although it is unlikely that an upright contracted foot would ever return to a normal shape, shoeing in this manner usually brings about a noticeable improvement over months and years. It is important to give equal attention to the other foot and limb.

The opposing limb to the upright foot is usually wider and flatter (Figure 30). This may be due to extra weight taken on it when the upright foot was formed by a non-weight bearing injury. The flat foot may continue to carry more weight than the upright foot. If there is a concerted attempt to bring the height of the upright foot down, additional strain may be thrown upon the flat foot. It is usual to support the caudal area of the flat foot by shoeing with length or possibly an eggbar shoe.

Shoeing for mediolateral balance

The front foot is trimmed for balance prior to shoeing:

1. The hoof wall bearing surface of the front foot is trimmed at 90% to the long axis of the cannon.
2. Any flares are dressed back so that the wall runs straight from the coronet to the bearing surface.

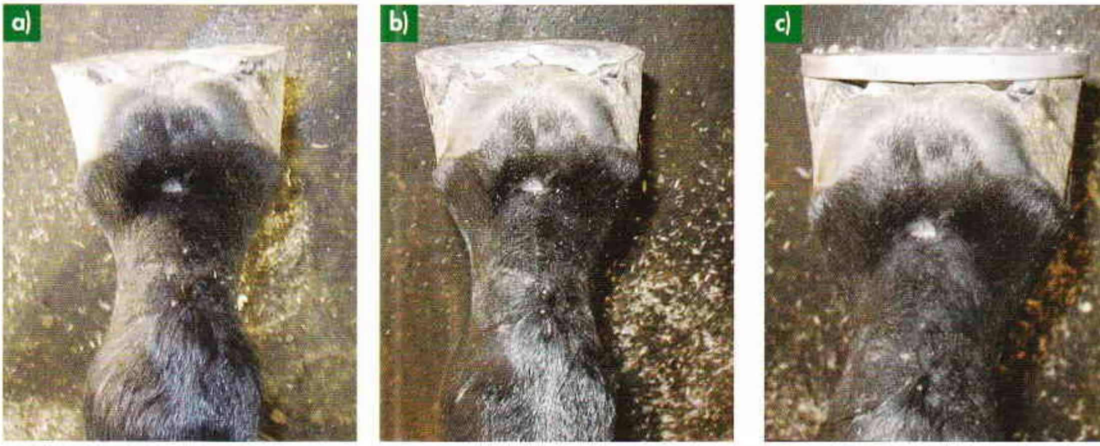


FIGURE 32:

a) A toe-in horse with a foot that flares medially (left) and is high laterally (right). b) The foot is dressed as close to balance as possible. c) An eggbar shoe is fitted tight to the medial side and wider on the lateral. d) A view from above shows the lateral extension, which places the shoe more symmetrically under the limb.

3. The solar shape is trimmed so that the shape is both symmetric around the frog and without flat spots (Figure 31 a,b,c).
4. The hind foot is balanced using 2 and 3 above and also the anterio and posterior views described earlier in the assessment section. I simple terms, the farrier should be trimming to place the hoo under the limb so that a line through the long axis of the canno bisects the hoof capsule equally.

It must always be remembered that the primary cause of an imbalance eg conformation, usually remains with the horse all its life; therefore reassessment and rebalancing should be carried out at each shoeing. I is not always possible to achieve 1 and 2, but it is essential that at eac shoeing they are attempted. The inability to gain perfect balance b trimming is an opportunity to use the horseshoe to complete the job

FIGURE 33:

A hind foot shod with some lateral extension (right side), where the heel runs under (solar view Figure 34).

FIGURE 34:

Drawing the inner web of the lateral branch ensures that the buttress rests on the shoe while the shoe gives lateral width and retains the shoe section depth.

The design and the placement of the shoe are additional factors that are used.

Lateral extension shoes: In the case of a mediolateral imbalance, where trimming alone will not bring the centre of balance back through the middle of the hoof, the shoe can be set wider to support the limb more evenly. A shoe that extends horizontally beyond the distal border of the hoof wall is known as a lateral extension shoe. This is the generic name; to be precise the name should refer to whether the extension is on the medial or lateral side of the foot. An extension can be anything from just fitting a shoe a few millimetres wide (Figures 32 a,b,c,d) to a 'jug handle' shoe with an extension of more than 10 cm.

There are a number of ways to make a lateral extension shoe. The simplest is just to fit the shoe wide of the foot and box off the edge of the shoe. Re-stamping and pritcheling nail holes further in the web of the shoe allows for wider fitting with secure nails. Fitting the shoe normally to the foot and then welding an extension to the shoe as required is a simple and accurate method. Using a round bar section for this method creates a good finish that is not easily pulled off. Hand

FIGURE 35:

A leg with a mediolateral imbalance.

FIGURE 36:

The solar view of Figure 35 shows that the medial hoof wall has suffered multiple abscesses caused by the uneven loading.

FIGURE 37:

A polymer hoof repair has been used to repair and elevate the medial side.

forging lateral extension shoes tests even the best shoemakers (the making of lateral extension shoes is covered in Chapter 9).

Fitting lateral extension shoes: A good rule of thumb when fitting an extension is that once it comes out from the foot it stays out, ie if it begins to come out from the toe quarter and extends 5 mm, then it stays out at least that distance until it passes the heel. There are many formulae given for calculating the width of an extension. Most of them are based on theoretical geometric shapes which look very good on paper but are impractical in real shoeing. If a mature ridden horse requires a medial extension, we are constrained by the fact that it may strike the opposing limb and that it may easily be pulled off. In the majority of cases the extension should equalise the distance from the outer edge of each branch to the centre of the foot (a line dorsopalmar through the frog). In severe cases, where a lateral extension is required, it is possible to extend out so that the centre of weight bearing equally bisects the medial and lateral margins of the shoe.

FIGURE 38:

A solar view shows a symmetrical shoe fitted. The blue colour is Dental Impression Material filling in the cavities.

Hind extensions: Many medium to large horses are quite base narrow behind, often with varal fetlocks. These horses wear severely on their lateral branches and crush the horn on that side. Another sign of this uneven stress is the hoof wall disintegrating and causing nailing difficulties. After following the guidelines to trimming, shown above, a shoe with some lateral extension will open the stance and reduce the compression on the lateral hoof wall (Figures 33 and 34).

Where the hind legs are weak or cow-hocked the hind feet need medial support. Although there is risk attached to shoeing with width on the medial branch, some should be given. Extra length will help to achieve the same result.

Unilateral elevation: Where it is felt that mediolateral balance of the solar plane has not been achieved, a shoe can be fitted that is raised on one branch. This should only be done after serious consideration of both the aims and the potential side effects. With the advent of acrylic and polymer hoof repair materials, this can be achieved on the hoof and a flat shoe fitted (Figures 35, 36, 37 and 38).

Further reading

Curtis, S.J. (1999) *Farriery – Foal to Racehorse.* Newmarket Farriery Consultancy, England.

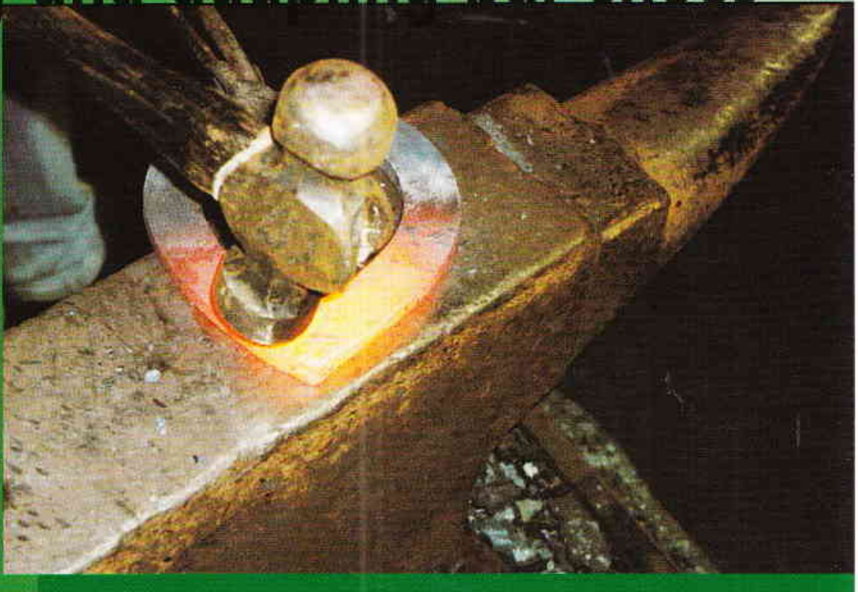
Emery, L., Miller, J. and Van Hoosen, N. (1977) *Horseshoeing Theory and Hoofcare,* Lea & Febiger.

Hickman, J. and Humphrey, M. (1988) In: *Hickman's Farriery.* 2nd Edn. J.A Allen, London. pp 214 - 217.

Stashak, T.S. (Ed) (1987) *Adams' Lameness in Horses.* 4th Edn. Lea & Febiger Philadelphia.

Williams, G. and Deacon, M. (1999) *No Foot No Horse.* Kenilworth Press Ltd

Chapter 7:
Making and adapting bar shoes



Sandy Beveridge

A bar shoe is one in which the heels are joined in a continuous ring of metal. A wide variety of styles and types are used in remedial shoeing. Bar shoes are used to: 1) move the loading from one area of the foot to another, eg the heartbar unloads the hoof wall and makes more use of the frog; 2) stabilise the hoof capsule, eg a straight bar reduces capsular movement; and 3) act as an orthopaedic device to alter foot limb position, eg a fishtail moves the foot caudally in relation to the limb.

Although there is an increasing number of manufactured bar shoes, there will never be a commercial need to produce the variety and type of shoes required in the farriery treatment described in this book. The ability to hand make bar shoes is essential in remedial farriery.

Only regular practice forging these shoes will ensure a high standard.

L = Foot length; W = Foot width; H = Heel width

FIGURE 1:

Heel width as shown to widest part of frog.

Material selection for bar shoes

It is important when selecting material for bar shoes to remember that, once the shoe has been made, it will add weight to the heel area of the shoe. The size of foot and type of horse is the first consideration, eg whether the horse would still be in work or turned out. When selecting material suitable for bar shoes, the width of the material is more important than the thickness as all bar shoes are designed to support the caudal area of the foot or limb. It is also important when making straight bar shoes for the width of the bar to be at least the width of the shoe material or wider, thus displacing the weight more evenly over the back third of the foot and frog (eg with a shoe section $^{3}/_{4}$ inches x $^{3}/_{8}$ inches [19 mm x 9 mm] the bar minimum should be $^{3}/_{4}$ inches [19 mm] or $^{7}/_{8}$ inches [22 mm]).

In situations where a patten or fishtail shoe is being considered, the rule is to select as light a section of material as possible in order to reduce its weight. However, it is also important to ensure that the gauge of material is not so light that it will bend under the horse's body weight.

Sizing bar shoes

Listed below are the bar shoes that are used in modern farriery practice and the methods of sizing the shoes to feet. These sizes are not suited to all farriers as everybody works steel in different ways. Nevertheless they may prove useful in assisting the beginner. The sizes are based on measuring to the point where the shoe should finish (Figure 1). It is useful when making a straight bar for feet to measure width between heels, as well as width and length of foot.

Guide chart for sizing

This chart will work for feet of width 140–155 mm (5 $^{1}/_{2}$ to 6 inches). Deduct approximately 25 mm (1 inch) for smaller feet.

Straight bar	width + length + 4 inches (100 mm) approximately
Eggbar	width + length + 4 inches (100 mm) approximately
Heartbar	width + length + 5 inches (125 mm) approximately
Patten bar	width + length + 8 inches (200 mm) approximately
Fishtail	width + length, then double

To simplify sizing, the chart is based on width, length and an amount. This amount is based on all shoes made out of flat bar and includes the amount needed for upsetting the toe, the toe bend and fullering.

Forging the weld

There are various methods for forging weld ends or scarfs for bar shoes (Figure 2 a,b,c).

Although some preparation methods may differ, there is one hard and fast rule that all welds must overlap left over right unless you are left

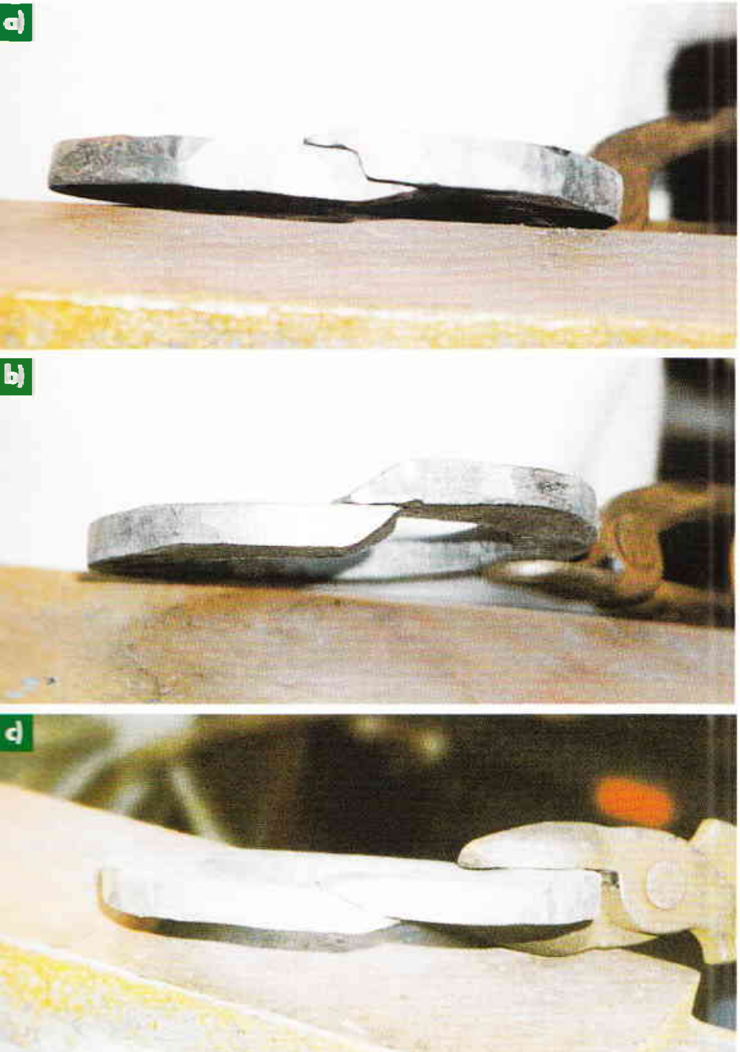


FIGURE 2:

The 3 types of scarf: a) Step scarf; b) Overlap scarf; and c) Traditional scarf.

handed in which case you would overlap right over left. This is t prevent the weld ends slipping away from each other as you strik them during welding.

With all welds, each overlapping branch of the weld ends are tapere down as finely as possible and are tight together to ensure that durin welding the weld ends or scarfs are worked easily into the bar fac leaving no trace of the join.

The principle of forge welding is to join 2 separate ends of materi using only a heat source, hammer and anvil. The traditional metho involves overlapping the scarfed ends of the weld; they are then brough to the same temperature. At this point, the scarfs can be worke together using even hammer blows, concentrating on working the end of both sides of the scarfs initially, then allowing the hammer blows t overlap each other and work across each weld end. It is often mad easier by using the toe of the hammer on the scarf ends in th beginning. This should ensure minimum traces of scarfs in the bar face

Welding with gas

Traditionally the source of heat was a coal or coke fire, as it could hea metal to a welding temperature very efficiently. Nowadays gas forge are very popular and, although the technique of welding the 2 scarfe ends together remains the same, it is usually more beneficial to us some form of flux to assist the weld ends to bond. This enables th ends to be welded together at a much reduced temperature. The flu is applied after both ends are scarfed together just before weldin (Figure 3).

It is advisable to bring the material up to a cherry red heat befor applying the flux along all edges of scarfs on both sides of the material The weld is then brought to a yellow heat and, at this point, it i possible to see the flux taking on a glazed and running appearance. Th same procedure is repeated as with a coal or coke fire, cleaning off a flux slag with a wire brush after initial hammer blows have joined th weld ends. Sometimes when welding in the gas forge it may b necessary to concentrate on only one side of a bar with the firs welding heat. A second welding heat is required for the other side o the bar. In between each welding heat, flux is placed around the weld

FIGURE 3:

Flux is applied around the margins of the scarfs. This is necessary when welding in gas.

To ensure maximum heat efficiency in the gas forge and prolong th fire's life, it can be useful to put a small cutting of scrap steel in th forge before the welding procedure begins. This will allow the wel

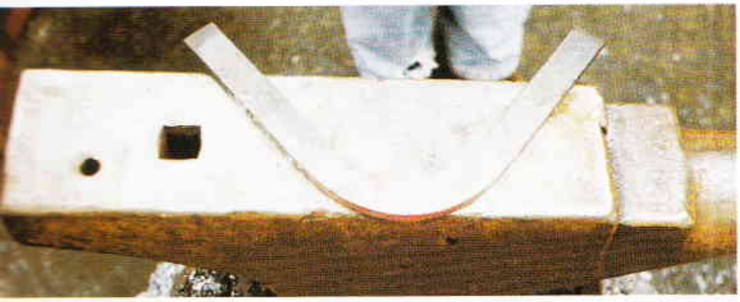


FIGURE 4:

Upsetting the centre of the bar, before turning the toe produces a wider web at the toe.

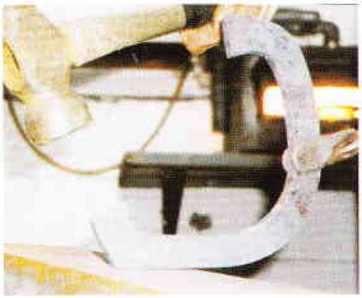


FIGURE 5:

To 'hockey stick' a heel, the bar is turned at approximately 120°, the tip is cooled and the bar is forged back into the heel.

area of the shoe to be raised off the forge bottom and keep the flux off the bottom of the fire. It also allows the heat around the surfaces of the weld to be more even.

Forging the straight bar

Cut the material to the required length using the guide shown previously.

Step 1: Mark the material in the centre then halve the width you require the bar to be and mark it from each end. If you need any extra width in the corners of the bar, allow a further $^1/_2$ inch (14 mm) length to each end for hockey sticking.

Step 2: The metal is heated at the toe and upset. It is important to gain extra width at the toe area before the toe bend is made. This gives the toe area of the shoe a better wear quality and prevents the toe being the narrowest area of the shoe once the fullering has been completed.

Step 3: The toe bend is finished. At this point the metal should be slightly broader at the toe area (Figure 4).

Step 4: The branch is bent at half the bar width required. If hockey sticking, an extra $^1/_2$ inch (14 mm) is allowed. The tip is cooled and forged back towards the face of the anvil (Figure 5). The quarter of the branch is forged and the end scarfed. The scarf end is allowed to fan to the inside keeping the back of the bar straight. The centre mark at the toe is used for guidance when forging in the first side of the bar (Figure 6).

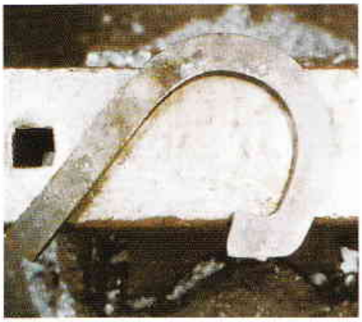


FIGURE 6:

One side of the shoe has been forged and turned. Note that the scarfed bar aligns with the centre mark.

Step 5: The same procedure is repeated on the other branch of the shoe and the scarfs prepared for welding. Once the scarfs have been

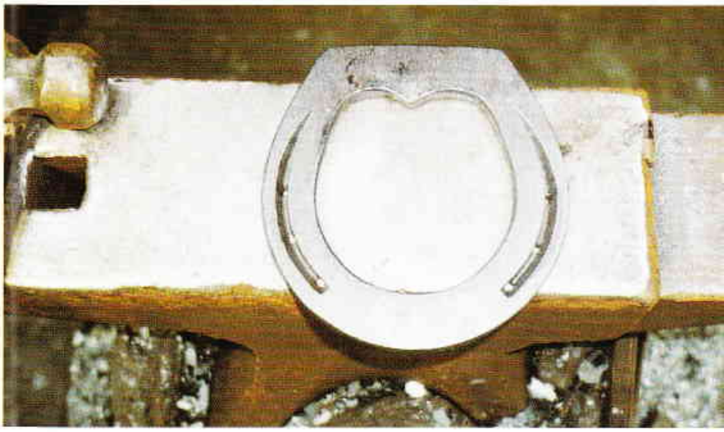


FIGURE 7:

The finished straight bar shoe is symmetrical and has a well defined bar with heels of a good width and defined angles.

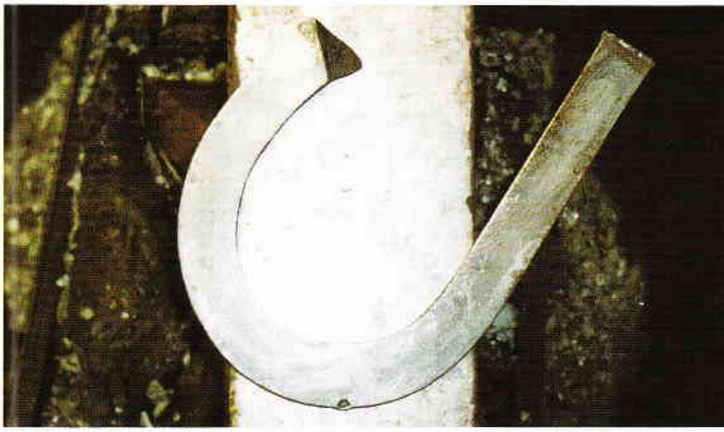


FIGURE 8:

One half of the eggbar is turned and the end scarfed. The centre mark is used to align the branch.

welded, forging concentrates on the frog plate. One should ensure tha the point of the frog plate points at the centre of the toe of the sho

Step 6: The finished straight bar shoe is three-quarter fullered. Th width at the corners of the bar and the width of material at the to should be wider than the web of the branches (Figure 7).

Forging the eggbar

Using the sizing guide on page 132, select the material length.

Step 1: Mark the centre of the material, upset the toe, forge the to bend and outside quarter and the scarf end (Figure 8).

Step 2: Repeat this on the other branch and overlap the scarfed end

Step 3: Bring the shoe to an even welding heat and work in the sca ends with the toe of hammer on the face of the shoe (Figure 9).

FIGURE 9:

Using the toe of the hammer the scarfs are blended in at welding heat.

FIGURE 10:

The caudal area of the eggbar is seated out on the foot surface to relieve the frog of undue pressure.

FIGURE 11:

The finished eggbar is fullered and nail holed. Note the nail hole positions. It is a common mistake when making eggbars to place the nail holes too far back.

Step 4: A second welding heat is taken and the top and bottom edges of the scarfs are welded on the bick.

Step 5: Seat the area of bar on the frog surface of the shoe (Figure 10).

Step 6: Finish the shoe by three-quarter fullering. The centre mark should still be in the centre of the shoe (Figure 11).

Forging the patten bar shoe

Using the sizing guide in this chapter, select the material length.

Step 1: Mark the centre of the material and from each end and mark half the width of bar required. Mark the height that the bar sides have to be.

Step 2: Forge the toe into the shoe.

Step 3: Bend the first mark from the toe outwards (Figure 12).

FIGURE 12:

After the toe is turned the branch is bent outwards at the first mark.

FIGURE 13:

The bar is turned down across the web to form the shoe heel. Note how this causes a heel to be formed that keeps the shoe away from the frog.

Step 4: Still with the first mark bend across the web to form the hee (Figure 13).

Step 5: Bend on the second mark, again across the web and scarf the end (Figure 14).

Step 6: Repeat the same process on the other branch. Keep this bar branch slightly more upright.

Step 7: Forge both quarters to shape the shoe and overlap the scarfed ends.

Step 8: The shoe is brought to a welding heat and the scarfed ends forged together. Forging after welding should concentrate on the bar corners and make them crisp.

Step 9: The shoe is fullered and the toe rockered (Figure 15).

Step 10: The bar should sit level and stable on the anvil.

The finished width of the bar should be similar to the width of the shoe. The height of both bar branches should be the same but the inside branch more upright, in order to reduce the chance of injury to the opposite limb (Figure 16).

Forging the fishtail shoe

Using the sizing guide in this chapter, select the material length.

Step 1: Mark the material in the centre and mark from each end hal the length that the bar is required to be. Mark a further 3–4 inche (75–100 mm) in from the initial bar marks on both ends for the lengtl required for the fishtail (see the sizing chart).

FIGURE 14:

The bar is bent across the web at the second mark to form the bar. At this point it is scarfed.

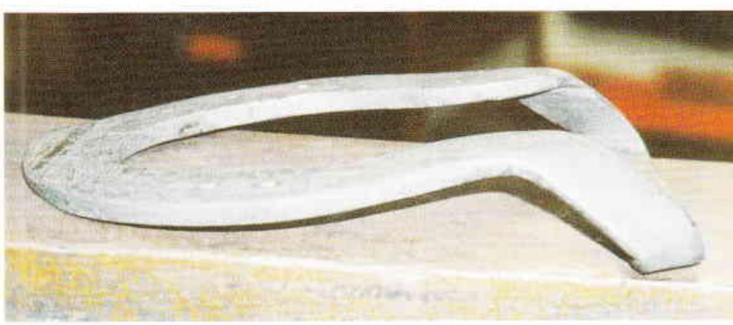


FIGURE 15:

The finished patten bar shoe is stable with a slight rockered toe and the bar flat to the ground surface.

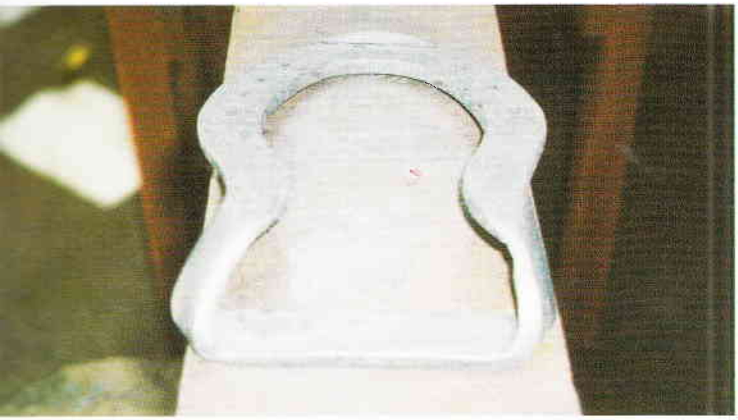


FIGURE 16:

Note that the medial (right) side is more upright to reduce injury to the opposing limb.

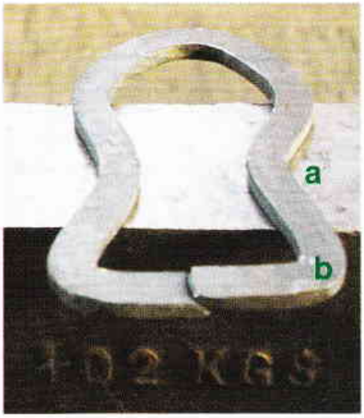


FIGURE 17:

The branch is bent out at the first mark from the centre (a) then bent in at the second mark (b). The scarfs are overlapped and the shoe is ready for welding.

Step 2: Bend the branch out from the first mark from centre (Figure 17).

Step 3: Bend the branch in at the second mark from centre and scarf the end.

Step 4: Repeat the same process on the other end and bend the toe.

Step 5: The quarters of the shoe are forged and the scarfs blended for welding (Figure 17). The scarfs are welded and the shoe three-quarter fullered.

Step 6: The toe can be rolled or clipped. A clipped toe is recommended for stability as the horse will be on box rest and will not benefit from a rolled toe (Figure 18).

FIGURE 18:

The finished fishtail usually has a large strong toe clip.

Forging the heartbar shoe

Using the sizing guide on page 132, select the material length.

Step 1: Mark the centre and mark from each end the required length of the frog plate. Remember to allow for tapering of each end of the plate where the material will lengthen by approximately 50%.

Step 2: The tapered end is bent to form the heel/frog angle and scarf down one side.

Step 3: The process is repeated on the other end and the toe is turned (Figure 19).

FIGURE 19:

The tapered ends of the frog plate are inflected inward and scarfed prior to turning the shoe.

FIGURE 20:

The heartbar is formed and the scarfs along the frog plate aligned and blended.

FIGURE 21:

The frog plate is bent back in a vice using tongs. This makes the welding area accessible.

FIGURE 22:

The finished heartbar: the frog plate must be of a size and length appropriate to the required function and foot on which it is used.

Step 4: The shoe is turned at the quarters and the scarfs blende (Figure 20).

Step 5: The back third of the shoe is heated, including the frog plat and is bent backwards with tongs. This makes the area to be welde more accessible (Figure 21).

Step 6: The shoe is now ready to weld. The scarfs are worked in on th face of the frog plate and also down the edges of the frog plate to gi it shape.

Step 7: The shoe is heated all over after welding and bent back unt the frog plate is level with the shoe.

Step 8: The shoe is fullered and finished (Figure 22).

Using aluminium for bar shoes

Aluminium is widely used nowadays. It can be as mechanically effective as mild steel for many shoes and has the advantage of being 20% of the weight of steel. With the exception of the patten bar shoe and the fishtail, the other bar shoes listed in this chapter can be made from aluminium. The patten bar and fishtail may yield under body weight if made from aluminium, and therefore is not recommended.

For graduated bar shoes, aluminium is lighter and therefore better. Graduated eggbars or straight bars are made in the same fashion as ordinary eggbars and straight bars, the only difference being that graduated material must be upset into the length at each end before beginning with the toe bend (Figure 23).

Most of these shoes can be bought from retailers, as can the mild steel shoes mentioned earlier, with very good standards of quality. They can be fabricated with the use of a gas welder or a tig welder which is designed for welding aluminium. They can also be forge welded using a heat source of gas or coke.

The method of preparing the scarf ends is similar to the mild steel technique, except that the scarf ends should be at a steeper angle when they are brought together (Figure 24). This allows the aluminium flux and rod filler to run through the scarfs when heating in the fire.

FIGURE 23:

Both ends of an aluminium bar are upset prior to forging an elevated bar shoe.

FIGURE 24:

Scarfing for aluminium welding needs to be steeper than for steel.

FIGURE 25:

The aluminium coil and flux is placed over the scarf prior to welding.

FIGURE 26:

The finished aluminium straight bar shoe.

FIGURE 27:

'Checking' the shoe on the anvil sets the bar away from the frog when the bar is forged.

The procedure for making aluminium bar shoes is as follows:

Step 1: Prepare the weld ends but keep the scarf ends more upright (Figure 24).

Step 2: Apply the flux and coil flux rod wire over one side of the weld only (Figure 25).

Step 3: Place in the fire. The rod filler and flux will take on a resin appearance and run through the weld. Remove the shoe from the fire and place the bar on the anvil. Place the hammer on top of the scarfed area and press firmly for around 20 seconds. Then lightly brush off any slag with a wire brush and forge down the frog plate (Figure 26).

Variations of bar shoes

There are numerous variations on the 5 types of bar shoes. These can usually be incorporated into the manufacture of the shoes.

Seating

When fitting straight bar shoes to feet that have a prominent frog, there is often a need to take a step out of the foot surface of the bar to accommodate the frog and reduce direct pressure on this area. This can be done by checking the required area out of the bar on the edge of the anvil before the scarfs are forged (Figure 27), or the shoe can be welded at the bar then a flattening tool is used on the bar to achieve the same result. It is also necessary to remember that both of these procedures will stretch the material and make the bar wider, so this must be considered when calculating the size of the shoe.

Hockey sticking

It is sometimes necessary with a straight bar shoe to give the rear third of the frog more support, when making a bar that needs to accommodate very low and weak heels. The foot may need more width of material at the corners of the bar to give added strength and support to the buttress of the heels. The forging method used for this procedure is known as hockey sticking the bar.

After the toe bend, the bar is bent at an angle of approximately 120°. The tip of the material is cooled. The metal is worked back towards the anvil surface and gradually the metal can be worked into the corners of the bar (Figure 5). This procedure must be completed before the scarf ends are forged.

FIGURE 28:

A rocker toe is turned up to promote break-over. On a patten shoe it helps stability.

Relieving frog pressure

Often, feet that require a straight bar or eggbar have a conformation which will give rise to a prominent frog. It is also common to find that the soles of the feet are very flat and have lost their concavity. It is necessary in such cases to seat out the solar surface of the shoe to minimise sole pressure when feet are weight bearing.

It is common when fitting eggbar shoes to seat out the inner foot surface edge of the bar area around the frog to relieve pressure. This prevents the sharp edge of the bar from cutting into the back portion of the frog (Figure 10). It is common practice to fit most of the listed bar shoes with rolled or rockered toes (Figure 28). However, it is best to analyse each case individually as the main function of rolled toes is to increase break-over. It is not uncommon to combine a rolled toe with side clips giving both stability to the shoes on the feet and ease of break-over.

Three-quarter bar shoe

The three-quarter bar shoe is used for corns which need treatment whilst shod (Figure 29). This is perhaps not so commonly used nowadays, but is very straightforward to make. It is best to make a straight bar shoe then use a cropper to cut away the area needed to expose the seat of corn. This ensures that the sizing of the shoe is the same as the straight bar. It also makes it easier to produce a symmetrical shoe.

FIGURE 29:

A three-quarter bar shoe should remain balanced.

The half heartbar shoe

A half heartbar shoe is used for a mediolateral imbalance, where a horse loads heavily on one heel. It is used for centralising pressure over the foot. The making of this shoe is straightforward. To size it, measure

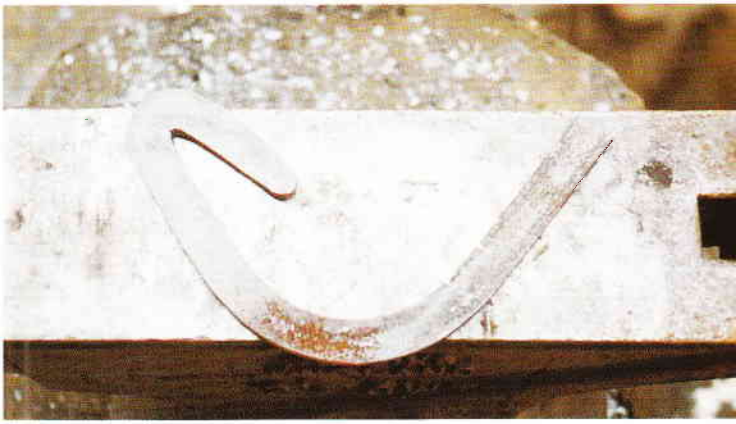


FIGURE 30:

The initial preparation for a half heartbar is to taper and inflect the frog plate prior to the toe bend.

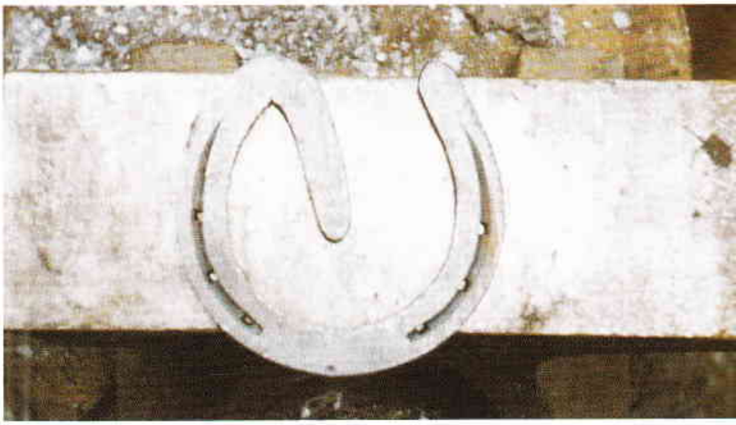


FIGURE 31:

The finished half heartbar is balanced with the frog plate running up one side of the frog.

the foot width and length then add the distance down the lateral cleft of the frog on the side that frog support is needed. Ideally the frog support should extend no further than $^3/_8$ inch (9 mm) behind the point of the frog. It is necessary to deduct $^1/_2$ inch (14 mm) from the total length as the plate will draw when tapering it from its original section. You will also need to add the amount needed for the toe bend.

Before making the shoe, mark the distance from one end, the amount needed for the frog plate, then mark the material in the centre between the mark for the frog plate and the other end of the material. Taper down the frog plate end and bend it in at an acute angle (Figure 30). This allows for the toe bend using the centre mark for guidance. Once the toe bend has been forged, the outside branch is bent and the frog support positioned more in line with the frog. Once the shoe is completed you can rasp the frog support if it is too long (Figure 31).

Chapter 8:
Shoeing for tendon lesions

Jim Ferrie and Anthony Clements

Injuries to the tendons of the distal limb of the horse are relatively frequent. Tendon lesions can be broadly classified into the 2 main categories of tendinitis or straining of the tendon and trauma leading to rupture or transection of the tendon. Within these categories lesions can be further subdivided depending on location and type of tendon involved. Tendinitis is usually seen in performance horses and affects flexor tendons almost exclusively. Traumatic injuries are also common and can affect any tendon although the superficial digital flexor tendon (SDFT), deep digital flexor tendon (DDFT) and extensor tendons are most commonly implicated due to the relatively exposed nature of the tendons and lack of soft tissue covering.

FIGURE 1:

Graduated aluminium front shoes are perfect for relieving strain on the DDFT.

Anatomical considerations

The anatomy of the distal limb has been covered extensively in Chapter 1: Anatomy of the Equine Leg. A knowledge of the origins and insertions of the digital flexor and extensor tendons will allow the biomechanics of corrective shoeing to be understood. For instance raising the height of the heels will reduce the load on the DDFT but, as a consequence, the load on the SDFT and suspensory ligament (SL) will increase. Therefore, although this type of shoe may be advocated in certain conditions it may be contraindicated in others (Figure 1).

Diagnosis

Examination of tendon lesions should always involve a thorough clinical examination (see Chapter 2: The Diagnosis of Lameness). In tendinitis lesions, particular attention should be applied to the location of any heat or swelling and careful palpation of the tendons, both weight bearing and non-weight bearing, can be invaluable in helping to localise the lesion. In traumatic lesions, palpation of tendons and checking for their presence or absence in expected areas is useful; an observation of stance during weight bearing may also be helpful. Digital palpation of the wound and its extremities using an aseptic technique may also yield valuable information.

The gold standard for assessing tendon lesions remains ultrasonography (see Chapter 3: Imaging the Foot and Leg). This permits an accurate assessment of the location and extent of injury and allows a more accurate prognosis to be given. Regular ultrasonographic assessment is also invaluable for monitoring healing and return to exercise. In the authors' opinion an accurate assessment of a tendon lesion cannot be made without ultrasonographic evaluation.

Extensor tendons

Tendinitis

Tendinitis of the extensor tendons occurs rarely due to the low level of loading experienced by these tendons. At maximal loading the extensor tendons only receive approximately 10% of the load received by the flexor tendons. Treatment involves employing the principles advocated for flexor tendon injuries (see page 148).

Transection/rupture

Damage usually occurs due to trauma, and injury to the extensor tendons is most commonly seen in jumping horses. Loss of function of the long or long and lateral digital extensor tendons may result in stumbling and knuckling over of the limb. Loss of function of the lateral digital extensor tendon alone is unlikely to affect the gait significantly. With time, affected animals learn to flip the digit forward during the swing phase of the stride overcoming any problems. Prognosis for extensor tendon lesions is good as full function is not necessary and tendon resection can be used as a method of treatment.

Treatment

Lesions are usually traumatic in nature and standard principles of wound management should be employed. Suturing of the tendons is unnecessary and often impossible. It should be noted that the extensor tendons have synovial sheaths as they pass over the dorsal aspect of the carpus and, if affected, these should be treated accordingly.

To prevent knuckling over and subsequent damage to the fetlock joint, a toe extension shoe can be fitted. The extension should be turned up at the end to mininise delay in break-over. In severely affected cases a rigid dorsal splint of the distal limb may be required as a short term measure; PVC guttering is excellent for this purpose.

The flexor tendons and the suspensory ligament

Tendinitis

Tendinitis affects horses involved with all types of activities and there is increasing evidence that it is the result of chronic overloading of the tendon leading to gradual weakening of the extracellular matrix and not a single catastrophic event. The SDFT of the forelimb is affected most commonly due to its smaller cross sectional area, compared to the DDFT, and the greater stress placed on the SDFT during fetlock hyperextension. Certain predisposing factors have been suggested including:

1) High speed work - athletic horses most commonly affected;

2) Fatigue - leads to loss of co-ordination and poor tendon stabilisation by muscle;

3) Abnormal conformation or poor foot balance - long toes, low and under-run heels, sloping pasterns;

FIGURE 2:

A patten shoe to elevate the heels to reduce tension in the DDFT (see Figures 4 and 5).

4) Too hard or too soft ground - hard ground increases speed, soft ground increases work load;
5) Age – increasing age has been associated with a gradual degeneration in fibre alignment in the central region of the SDFT;
6) Exercise – there is evidence to suggest that high intensity exercise results in degeneration of the SDFT.

The suspensory ligament (SL) originates as a muscle but develops a ligamentous structure as the horse matures. There is also thought to be some degeneration with age resulting in lesions of the SL desmitis being seen more commonly in mature horses. However, unilateral injuries are seen in young animals and are presumably due to sudden hyperextension of the fetlock. Injury may occur in one of 3 regions: the origin of the SL; the body of the SL; or the branches of the SL.

Treatment

After a diagnosis has been made, treatment of tendinitis or desmitis should be considered a priority as the inflammatory cascade will result in further fibre damage. Treatment should consist primarily of cold hosing to reduce heat, support bandaging and anti-inflammatory medication. A number of other therapies have been advocated including tendon splitting, intra-lesional medication and superior check ligament desmotomy but there is still much debate as to which therapy is best.

Recommendations for farriery are as follows:

FIGURE 3a:

A concave hand forged fishtail shoe on a hind foot.

FIGURE 3b:

A fabricated fishtail shoe. Keeping the inner branch of a fishtail straight avoids it being pulled off by the opposite foot.

FIGURE 3c:

A fabricated fishtail shoe – lateral view. Welding the old shoe on the ground surface elevates the heel of the foot slightly.

DFT Correct balance of the foot is desired. Long toe, low heel conformation is to be avoided as this results in hyperextension of the fetlock joint.

DDFT To reduce tension on the DDFT a raised heel or patten bar shoe can be fitted. This unloads the DDFT thereby loading the SDFT and SL. It is not desirable to keep this type of shoe fitted for longer than 10 weeks as this may result in contracted heels. The height of the heel elevation should be reduced gradually at 2–3 week intervals (Figure 2).

L Support can be offered by using a caudal extension (fishtail) shoe. The length of extension may need to be reduced in forelimb lesions to prevent interference (Figures 3 a,b,c).

Forging a fishtail and a patten shoe from a straight or eggbar

Select a bar shoe 2 sizes larger than would fit the hoof (see Figures 4 a,b,c, 5 a,b,c and 6 a,b).

Accessory ligament of the deep digital flexor tendon or inferior check ligament

Increasing the height of the heels will reduce loading of the DDFT and consequently of the accessory ligament of the deep digital flexor tendon (ALDDFT). These authors have had some success in low grade ALDDFT tendinitis using a Tennessee navicular shoe (Figure 7).

FIGURE 4a:

Select a bar shoe 2-sizes larger than would normally fit the hoof.

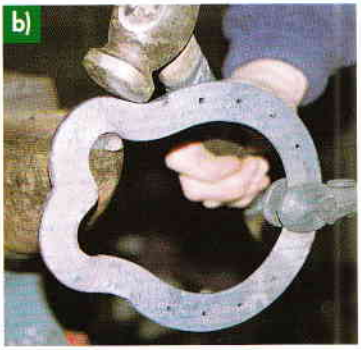


FIGURE 4b:

Using the point of the horn and the round face of the hammer, forge the fishtail.

FIGURE 4c:

The completed fishtail.

FIGURE 5a:

The patten bar is formed from the fishtail.

FIGURE 5b:

The bar is flattened on the ground surface.

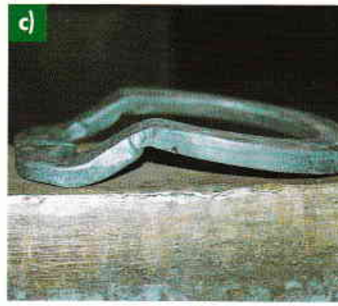


FIGURE 5c:

The height of the bar can be varied by pulling th bar towards the toe.

FIGURE 6a:

A lateral view of a hind patten shoe.

FIGURE 6b:

A hand-made hind patten bar shoe (see Chapter 7: Making and Adaptin Bar Shoes, for forging instructions).

Transection/rupture

Flexor tendon lacerations occur most commonly when a horse catche its leg on a sharp object, as a result of a wire cut or from interferenc during exercise. The vital importance of the flexor tendons makes an injury to these structures a possible career ending or even lif threatening event. It is crucial to assess damage accurately and ever effort should be made to repair the tendon(s) if a return to athleti activities is to be attempted. Damage to the region of the tendo within the digital flexor tendon sheath carries a more guarde prognosis due to the likelihood of synovial sepsis, the prolonge healing time and the possibility of restrictive adhesion formation.

FIGURE 7:

Tennessee navicular shoe, ideal for mild check ligament strain. The principle behind this shoe is that break-over is in the centre of articulation of the coffin joint.

Assessment

It is important to ascertain the viability of the neurovascular bundle as disruption of this structure may lead to necrosis of the distal limb and necessitate euthanasia. If, however, this structure remains intact then treatment can be attempted.

The stance shown by the horse during weight bearing may give an indication of the structures involved.

SDFT The fetlock will drop but will not touch the ground (Figure 8a).

DDFT Injury to this structure alone usually occurs due to a penetrating wound distal to the fetlock joint; otherwise the SDFT is likely to be involved as well. The flexor tendon sheath is likely to be involved with an injury to this region. When weight is placed on the foot the toe turns upwards (Figure 8b).

SDFT and DDFT

The fetlock drops and the toe turns upwards.

SDFT, DDFT and SL

The fetlock joint will rest on the ground and the toe will turn upwards. If the extensor tendons are also damaged then the foot will remain flat on the floor.

SL Occurs commonly in racing animals with or without fractures of both of the proximal sesamoid bones. Disruption is caused by extreme hyperextension of the

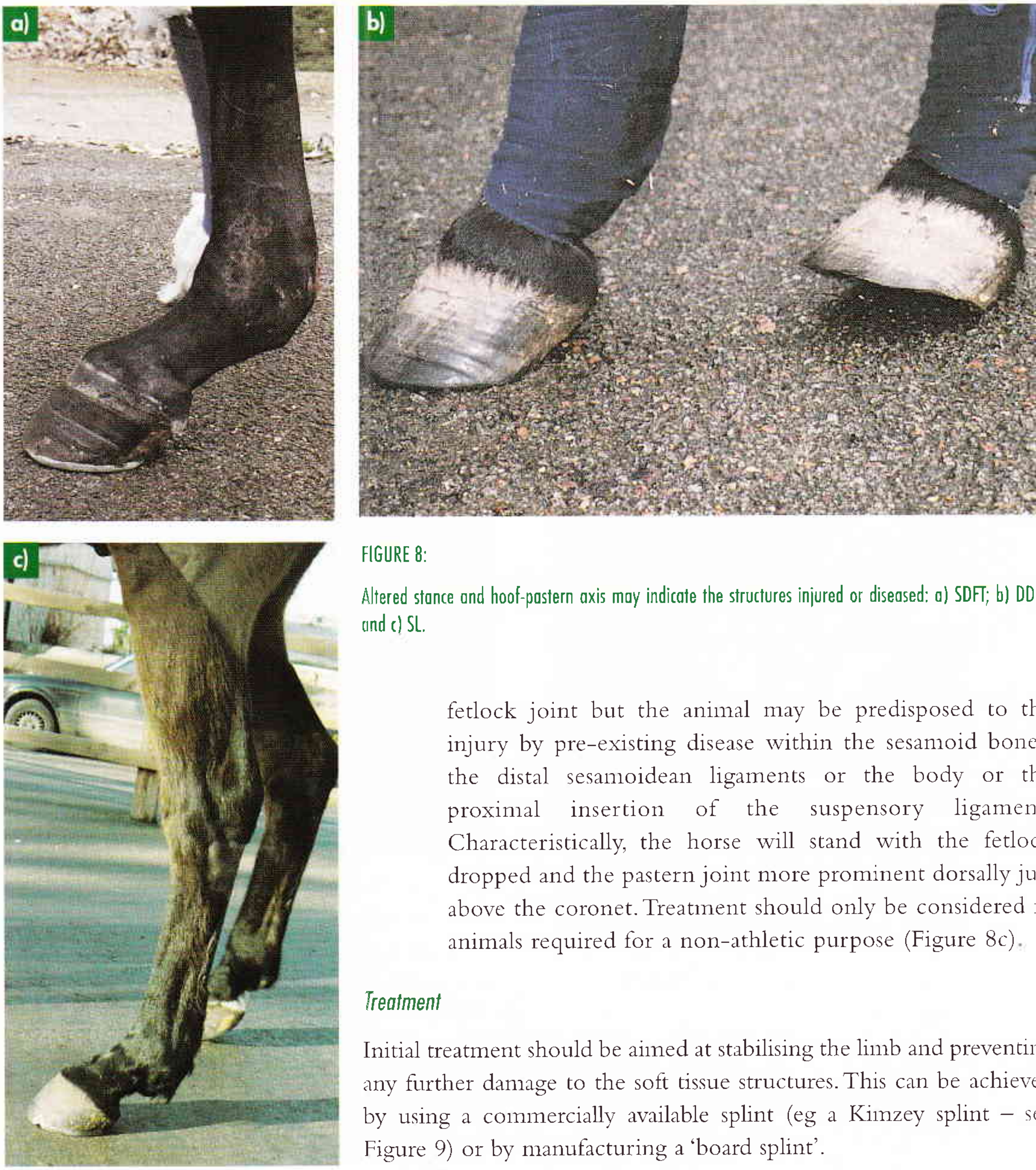


FIGURE 8:

Altered stance and hoof-pastern axis may indicate the structures injured or diseased: a) SDFT; b) DD
and c) SL.

fetlock joint but the animal may be predisposed to th
injury by pre-existing disease within the sesamoid bone
the distal sesamoidean ligaments or the body or th
proximal insertion of the suspensory ligamen
Characteristically, the horse will stand with the fetloc
dropped and the pastern joint more prominent dorsally ju
above the coronet. Treatment should only be considered i
animals required for a non-athletic purpose (Figure 8c).

Treatment

Initial treatment should be aimed at stabilising the limb and preventin
any further damage to the soft tissue structures. This can be achieve
by using a commercially available splint (eg a Kimzey splint – se
Figure 9) or by manufacturing a 'board splint'.

A 'board splint' can be fashioned by drilling 2 holes through the ho
and shoe at the toe region. Two matching holes are then made at th
end of a piece of strong board. The board is wired to the solar surfac
of the foot and the fetlock flexed to allow the board to b
incorporated into a thick dressing on the palmar or plantar aspect
the limb, thereby fixing the distal limb in this position.

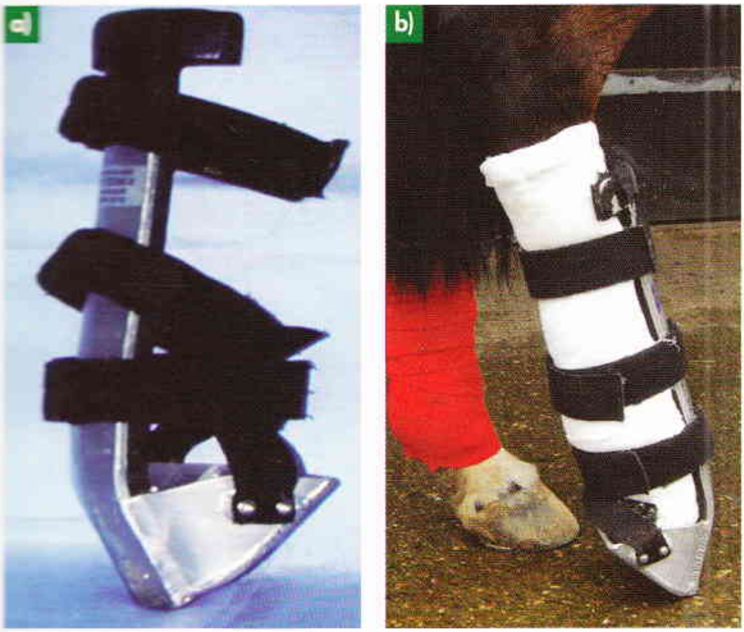


FIGURE 9:

The Kimzey Leg Saver Splint allows a horse to be moved a short distance whilst protecting from further aggravating the injury.

Treatment involves repair of the transected tendons by suturing with non-absorbable material (eg monofilament nylon) to bring the ends of the tendons into the closest proximity possible and allow healing. General anaesthesia is necessary. Various suture patterns are advocated, including locking loop and pulley systems, all of which aim to reduce adhesion formation, minimise gap formation and preserve intrinsic blood supply. However even the strongest patterns can only achieve a breaking strength of approximately 35 kg whereas load values at the walk for equine SDF and DDF tendons are 362.9 kg and 421 kg, respectively. It is imperative, therefore, that additional support is given to the limb.

This can be achieved by fitting the horse with either a cast or a rigid splint system to prevent movement. The advantages of a splint are that dressings can be changed to assess soft tissue healing and that physiotherapy can be initiated at an early stage of healing which may be useful if the tendon sheath is involved. In the forelimb, a cast to the level of the proximal metacarpus is sufficient but, in the hind limb, a cast to the level of the proximal tibia is required. If this full limb cast is not fitted, flexion of the hock and stifle by the reciprocal apparatus will result in tension on the flexor tendons, particularly the SDFT and may lead to break down. The limb should be cast with the fetlock joint partially flexed to reduce tension on the tendons.

FIGURE 10:

Fetlock support shoe. Note the padding for the fetlock and proximal pastern to rest on.

The lesions are likely to be traumatic in origin and conventiona management of the wound and any synovial structures is advocatec Laminitis of the contralateral limb is a common sequel with this typ of injury and the fitting of a heartbar shoe or solar support pad recommended.

If economic considerations are important, transection of the SDF only can be treated by surgical repair followed by the fitting of fetlock support brace.

It is recommended that a repaired tendon is protected from full weigh bearing for a minimum of 12 weeks. After this period further suppo should be given by a fetlock support shoe to prevent hyperextensio of the fetlock joint (Figure 10). As the limb has been cast or splinte with the fetlock joint partially flexed, elevation of the heels warranted to avoid a sudden alteration in fetlock flexion after the ca has been removed. The degree of support and heel elevation should b decreased gradually over the following 12 weeks at 2–3 week interval Following this the horse should be fitted with a caudal extension sho (Fishtail) to help support the fetlock joint. The length of thes extensions may have to be compromised when used in the forelimb t prevent interference.

Arthrodesis of the fetlock joint can be considered for those cas where there is complete disruption of the suspensory apparatus wit fractures through both sesamoid bones.

Further reading

Auer, J.A. (1999) Flexural Deformities In: *Equine Surgery* 2nd Edn. Eds: J.A. Stick & J.A. Auer. W.B. Saunders, Philadelphia. pp 753-765.

Curtis, S.J. (1999) *Farriery – Foal to Racechorse.* Newmarket Farriery Consultancy, England.

Flecker, R.H. and Wagner, P.C. (1986) Therapy and corrective shoeing for equine tendon disorders. *Comp. cont. Educ. pract. Vet.* **8,** 970-976.

Smith, R.W. and Webbon, P.M. (1999) Physiology and pathophysiology of tendon and ligament. In: *Equine Medicine and Surgery.* 5th Edn. Eds: P.T. Colahan, I.G. Mayhew, A.M. Merritt & J.N. Moore. Mosby Inc. Missouri. pp 1358-1362.

Stashak, T.S. (Ed) (1987) *Adams' Lameness in Horses.* 4th Edn. Lea & Febiger, Philadelphia.

Chapter 9:
Shoeing for hindlimb conditions

Jim Ferrie and Paul Lentelink

The hock is the most common site of pain causing hind limb lameness not referable to the foot. In the hock region, local soft tissue swelling can be present in lame horses but this can sometimes also be seen in sound horses. Examples are distension of the tarsocrural joint pouches ('bog spavin') and distension of the tarsal sheath ('thoroughpin').

If hind limb lameness is present, specific analgesic techniques (nerve and joint blocks) can be used to localise the lameness to an anatomical region in the hind limb. The most common cause of clinical lameness associated with the tarsus (hock) is bone spavin. Remedial farriery is often part of the management in cases of bone spavin.

Remedial farriery may also play a role in the treatment protocol for curb (plantar ligament desmitis) and cases of intermittent upward patellar fixation (locked stifle).

Spavin

Bone spavin, or osteoarthritis of the small hock joints (ie the tarsometatarsal, centrodistal [distal intertarsal] and occasionally the talocalcaneal-centroquatral [proximal intertarsal] joints) is a degenerative joint disease (DJD) of the hock (Figures 1 a,b). The joints involved are low motion type joints, in contrast with the tarsocrural joint which is a high motion joint and responsible for most of the flexion/extension of the hock. The DJD of these low motion joints can cause lameness of varying severity, is usually gradual or insidious in onset and often bilateral. It is seen most commonly in mature horses, of all breeds. Sometimes horses with bone spavin are presented to a veterinary surgeon for suspected back pain. Bone spavin is commonly associated with poor conformation and it is believed that sickle hocks or cow-hocks can predispose to spavin.

Horses with bone spavin will commonly have a positive 'spavin test' (flexion of the hock). However, this test stresses not only the tarsal joints, but also the hip, stifle and, to a lesser extent, the fetlock and digital joints. Therefore, it is not a conclusive test that proves spavin. Lameness of the hock and stifle may cause similar symptoms and therefore the stifle must be examined as well when proximal hind limb lameness is suspected.

In more advanced cases of bone spavin the range of flexion may be reduced and in some cases, with extensive new bone formation at the joint margins, the outline of the medial/distal hock can be distorted.

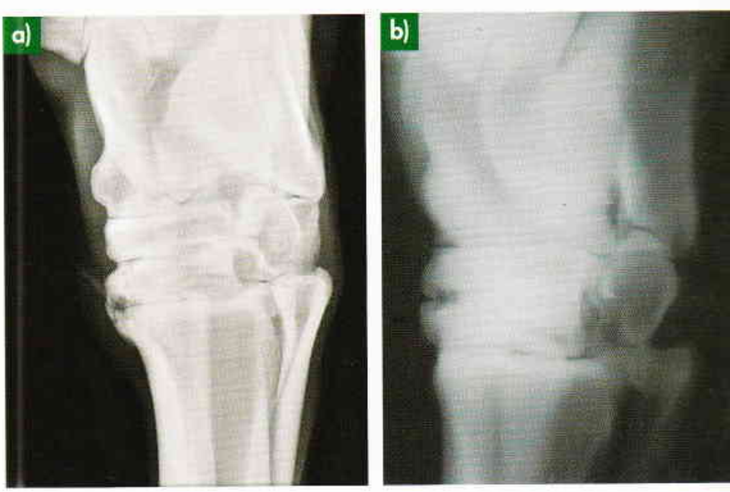


FIGURE 1:

Radiographs demonstrate bony changes in advanced cases of spavin with extensive bone lysis and new bone formation. Note that a) is a digital image, hence the enhanced quality.

Because the condition causes pain, the cranial phase of the stride is commonly shortened and the height of the foot flight is reduced. Sometimes horses drag their toes resulting in excessive wear of the shoe at the toe. In bilateral cases, the hind limb gait can appear stilted. Horses with early signs of the condition tend to warm out of the lameness after some work, but in severe or advanced cases the lameness might get worse with work.

The diagnosis is generally based on a combination of a positive result to joint and/or nerve blocks (intra-articular and perineural analgesia) and radiography. A low 6-point nerve block can be used to rule out lower limb problems. On radiographic examination, which normally requires 4 radiographic views of the tarsus, bone lysis and/or sclerosis (new bone formation), peri-articular osteophytes and narrowing irregularity of joint spaces can be seen in advanced cases. Because the condition is often bilateral, both hocks will often be examined radiographically.

However, some early cases show only mild or no radiological changes. In these cases a bone scan (nuclear scintigraphy) can be very useful to detect bone spavin because it is a very sensitive method (Figure 2).

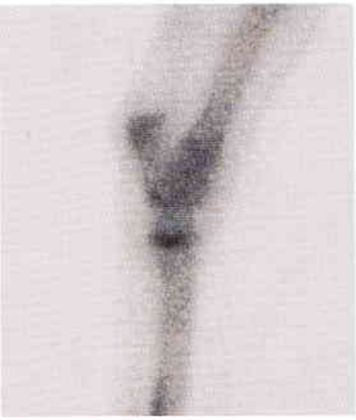


FIGURE 2:

A nuclear scintigraphic bone scan demonstrating increased uptake of the radiopharmaceutical in the region of the lower hock joints.

Treatment of the condition is aimed at eliminating pain and keeping the horse useful, rather than restoring normal function of the joint. Surgical and non-surgical treatments have been described and corrective shoeing is often part of the treatment in both approaches.

Conservative treatments (non-surgical) consist of systemic or intra-articular medication, adaptation of the horse's exercise routine (there is no benefit to be gained from rest only) and/or corrective shoeing. Remedial farriery can be used together with long term (sometimes permanent) systemic administration of non-steroidal anti-inflammatory drugs (NSAID), ie phenylbutazone, with varying results. More predictably successful, but not always permanent, is intra-articular medication with corticosteroids. Sometimes this will be combined with hyaluronan (eg Hyonate or Hylarlil). Lameness is improved in most horses treated with these substances, but will often recur in 2 to 6 months.

Surgical procedures include neurectomy, Cunean tenectomy or procedures that aim to fuse opposing articular cartilages (surgical arthrodesis). Procedures that are used to achieve bony fusion include removal of articular cartilage with or without bone grafting and

FIGURE 3:

Full extensions: a) A rear view of a full lateral extension (right side); b) A rear view of full extensions with trailers.

drilling tracts with or without metal implants. Surgery requires a greater financial investment and the risk of general anaesthesia, although small, has to be taken into account. In general, results are variable with all these procedures. Recently chemical arthrodesis has been described whereby the articular cartilage is destroyed with a caustic chemical, but results so far are disappointing compared to other surgical techniques.

Shoeing for spavin

Several shoeing adaptations have been described, of which lateral (outside) extensions or trailers, or heel elevations and rolled or squared off toes are most commonly used.

The lateral extension is used in an attempt to make the horse more comfortable, by changing the weight distribution. It is believed to function by altering foot-ground weight distribution and foot orientation during stance. Horses with spavin attempt to unload the dorsal/medial aspect of the small tarsal joints by redistributing their weight. In the authors' experience, horses with acute bone spavin tend to carry the lame leg in a fashion that will take as much strain off the medial aspect of the tarsal joint as possible. The lateral extension helps to support the coronary band when the foot lands laterally and prevents adduction of the limb underneath the horses' body.

FIGURE 4:

a) A wrongly placed extension (note lateral heel rolling under the hoof); b) Concave handmade heel extension (loop shoe), replacing the wrongly placed extension shoe; c) Welded heel extension; this is not much larger than a trailer.

Full and partial extensions

A full extension is one in which the shoe extends beyond the hoof capsule medially or laterally, starting at the toe and ending beyond the heel (Figure 3).

Partial extensions are variations of full extensions whereby the length and width are determined by the action and conformation of the animal (Figure 4 a,b,c).

The main functions of extension shoes are to equalise weight distribution on the limb and hoof and re-align the gait of the horse.

Determining the extension

The action of an affected horse can vary, depending on the severity of the condition and the conformation of the horse. A good way of determining the placement and width of the extension/trailer required is to watch the animal move and place the extension just behind the first point of contact between the hoof and a level surface. Such placement will widen the stance and gait, and take some strain

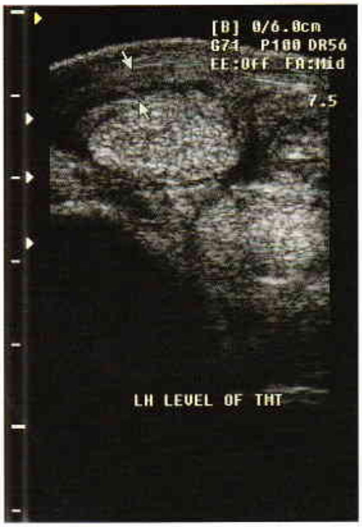


FIGURE 5a:

A transverse ultrasonographic image of the soft tissues behind the hock. The arrows indicate marked swelling of the supporting soft tissue structures behind the SDFT.

FIGURE 5b:

A longitudinal image of Figure 5a demonstratin the obvious soft tissue swelling that is detecte clinically.

off the hock. Should level footfall not be possible at this time, a media wedge could be used, the height of which can be reduced graduall the lameness recedes.

Curb (plantar ligament desmitis)

Curb is a well defined enlargement at the plantar aspect of the hoc approximately 8–10 cm (3.5–4 inches) below the point of the hock. can result from injury and inflammation to a number of the soft tissu in this region, including the superficial digital flexor tendon (SDFT the plantar ligament and the retinaculum supporting this regio Predisposing conditions include sickle hocks ('curby hocks') and cow hocks. The abnormal conformation is believed to impose addition stress to the plantar ligament. Curb can also be seen in horses with normal conformation when trauma occurs while pulling up sharply jumping.

A horse with pain in this region will sometimes stand with its hee raised and go on its toes to relieve tension on the plantar ligamen Curb-like deformation at the tarso-metatarsal junction should b

FIGURE 6:

A graduated shoe (lateral view). Note the rolled toe and the heel fitting length.

FIGURE 7:

Upward fixation of the patella causes an inability to flex the hock and stifle which results in toe dragging when walking is attempted.

imaged with radiography and ultrasonography. Ultrasonography can demonstrate thickening of soft tissue structures involved (sometimes the plantar ligament is not involved) and generally shows a mottled hypoechogenicity of damaged structures (Figures 5 a,b).

A curby hock appearance in young horses may be associated with crushing of the tarsal bones secondary to incomplete ossification at birth. With radiography this can be assessed. The condition also has to be differentiated from 'false curb' where the proximal end of fourth metatarsal (lateral splint bone) is large or prominent (lateral to the plantar ligament).

FIGURE 8:

Concave square toe with lateral trailer.

Treatment includes application of cold packs in the acute phase, an NSAID followed by rest. To relieve the tension on the plantar ligamen the heels can be raised by fitting a shoe with sloping wedge raise heels (Figure 6). Calkins are not advisable because these cause to much resistance.

Intermittent upward fixation of the patella

This is a condition seen more commonly in Shetlands or miniatur breeds and Standardbreds. It may be related to an excessively straigh stifle conformation, malformation of the stifle joint or the result o inadequate quadriceps muscle tone. When the patella is fixed the hors is unable to flex the limb, because the limb is locked in extension.

As a result of this the toe is dragged as the horse tries to mov forwards (Figure 7). This often occurs when the horse is led out of th box. When the patella unlocks, the hind leg may suddenly hyperflex This can sometimes be confused with stringhalt. As part of conservative treatment these cases can be fitted with laterally wedge shoes. It has been demonstrated experimentally in Shetland ponie that these shoes influence stifle joint kinematics. When the conditio is seen in performance horses after a rest period, it will generall resolve with increased fitness and no further treatment. Exercise u hills, which develops the quadriceps muscles, may be beneficial. Whe the upward fixation occurs very frequently or fails to respond t

FIGURE 9:

A hand-made lateral extension with fabricated medial wedge (left branch).

conservative treatment, the medial patellar ligament is severed surgically. Because the apex of the patella can fragment following medial patellar desmotomy, conservative treatment should be tried first and a period of rest is required following treatment.

Poor conformation

Poor conformation can be another factor leading to hind limb problems. For example, base narrow horses (feet close together) are often bow-legged. This gives the horse a tendency to 'brush'. Brushing is when one foot crosses into the flight path of the other, striking the hoof or the leg in the process. A shoe with a lateral trailer and a square toe often benefits these horses (Figure 8). The principle behind the lateral trailer is that as the foot lands, the trailer causes the hoof to turn inwards, resulting in the break-over point of the next stride being more central to the toe of the hoof instead of medial. Horses shod in this style will, in the authors' experience, develop a wider stance and a wider stride pattern, when walking on firm ground.

Level footfall is desirable in both front and hind limbs. It is therefore sometimes necessary to use a unilaterally wedged up branch in a shoe to achieve this (Figure 9). Often it is the medial branch that requires building but there are conditions, such as upward patellar fixation, that require a lateral wedge.

FIGURE 10:

After drawing down the inner branch, the steel is marked giving $^1/_2$ inch extra to the outside branch.

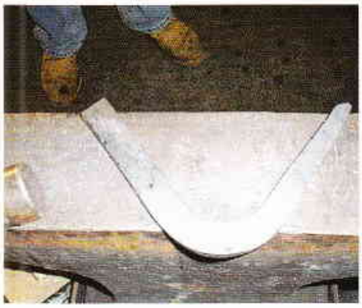


FIGURE 11:

The toe is bent and the fullering is marked.

FIGURE 12:

The trailer is forged.

FIGURE 13:

After bending branch, fuller and nail hole. Note position of fuller to gain a definite stop at the toe.

FIGURE 14:

The position of the fuller and the hammer creates a clean finish to the fullering.

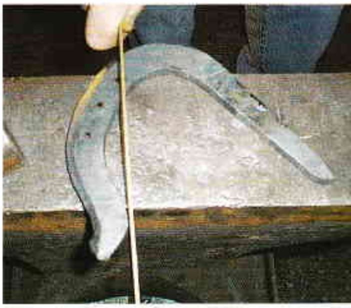


FIGURE 15:

The completed branch with the toe nail hole parallel to the inside of heel.

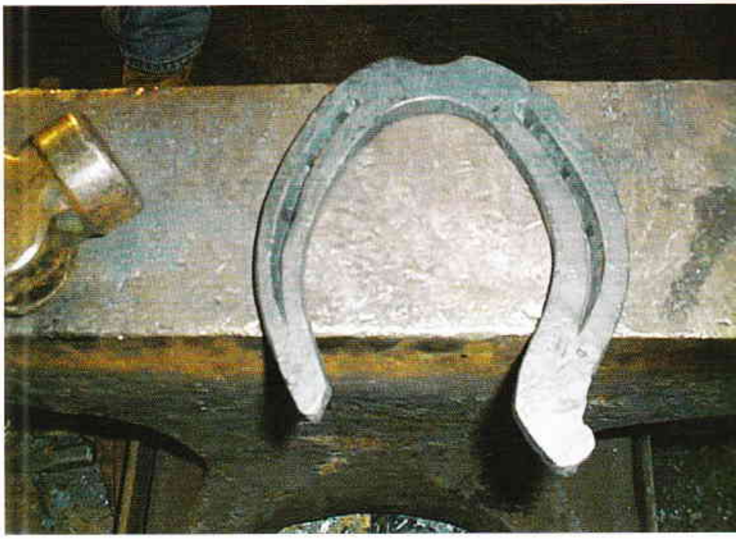


FIGURE 16:

The completed shoe.

Shoemaking for hindlimb lameness

The fullered lateral extension with trailer and clip

To determine the size and section of steel required, the hoof size and width of wall has to be given consideration. Generally, a section should be selected to incorporate the width of the extension required plus the width of the wall. To gauge the length of steel required to make the shoe, the inner branch is drawn down and the hoof measured. For this type of shoe, double the length of the shoe required plus 5 cm (2 inches; Figures 10 to 16).

A concave square toe shoe with trailer (machine-made shoe)

Select the appropriate shoe size after trimming the hoof. The angle of the trailer depends upon the foot flight pattern;the greater the angle of the trailer, the more the foot will turn upon landing (Figures 17 to 22).

FIGURE 17:

Offset the lateral branch.

FIGURE 18:

The lateral branch is offset to enable easier forging.

FIGURE 19:

Forge trailer by dropping the tong hand down whilst striking the heel.

FIGURE 20:

The completed trailer.

FIGURE 21:

Restore the width of the section by drawing down the inside web of the shoe.

FIGURE 22:

The completed shoe with a square toe and lateral trailer.

FIGURE 23:

Select the appropriate round material for the extension.

FIGURE 24:

Weld the extension as shown, leaving approx 4 cm ($1\frac{1}{2}$ inches) to forge the trailer.

FIGURE 25:

The completed extension.

FIGURE 26:

Select a length of steel longer than required. Forge the heel at an angle of 45°.

FIGURE 27:

Measure the length of the extension required, allowing approximately 5 cm (2 inches) extra for the bend. Forge the loop.

FIGURE 28:

Mark the steel longer on the outside branch, th the clips 5 cm (2 inches) from the centre.

FIGURE 29:

Square and safe the toe after bending.

FIGURE 30:

Follow standard shoemaking procedure. Note advantage of using concave over flat steel is ability to avoid a grabbing action upon gro contact.

FIGURE 31:

The square toe and trailer with a medial wedge.

FIGURE 32:

Note the gradual taper of the medial wedge from the inside toe quarter.

FIGURE 33:

Take a short heat approximately 25 mm (1 inch) from the end before jumping up the branch.

A welded lateral extension (concave machine-made hind shoe)

Select the appropriate size of shoe after trimming the hoof. The width and length of the extension is dependent upon how the hoof lands on a flat surface. The extension should come no further forward than the first point of contact with the ground (Figures 23 to 25).

A concave lateral extension (loop shoe)

To determine the size and section of steel required, the hoof size has to be given consideration. Generally, a section is selected to incorporate the width of the extension required and the size of hoof. To gauge the length of steel required to make the shoe the extension must be forged first, then the appropriate length cut to suit the size of shoe required. Again, use twice the length of shoe required, plus 50 mm (2 inches) after the loop is forged (Figures 26 to 30).

Fabricated medial wedge with trailer

After trimming and fitting the appropriate shoe to the hoof, should level footfall not be attainable by trimming alone, a medial or lateral wedge can be added to the shoe (Figures 31 to 32).

Tips on forging a wedge

Should a wedged branch be required on a hand-forged shoe, the procedure outlined in Figures 33 to 35 should be followed.

FIGURE 34:

Allow the branch to swell both sides.

FIGURE 35:

Flatten on one side only, thus doubling the height of the wedge.

Further reading

Back, W., Ebell, P. and Klarenbeek, A. (2000) The effect of laterally wedge shoes on the sagittal and transversal plane kinematics of Shetland ponie *BEVA Congress Handbook,* pp 198.

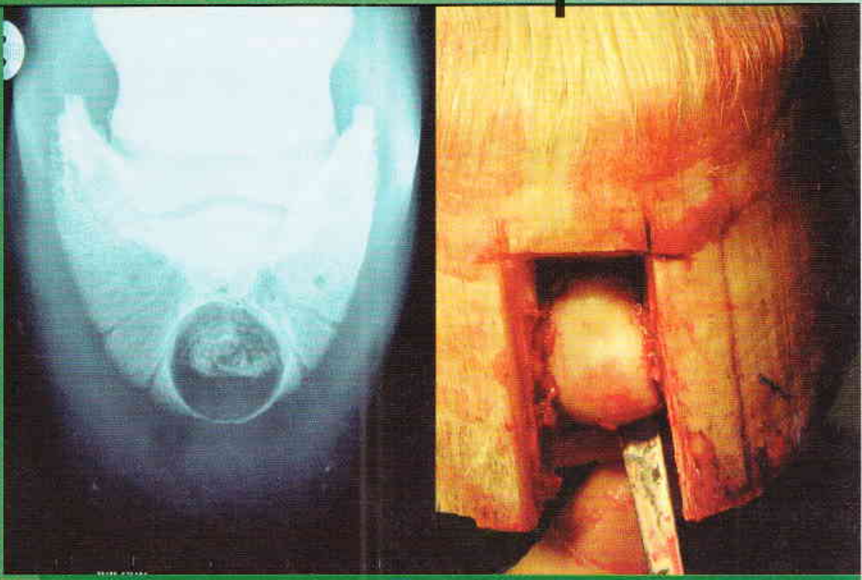
Butler, J.A., Colles, C.M., Dyson, S.J., Kold, S.E. and Poulos, P.W. (2000 *Clinical Radiology of the Horse.* Second Edn. Blackwell Science Ltd, Oxfor

Gough, M. and Munroe, G. (1998) Decision making in the diagnosis an management of bone spavin in horses. *In Practice* **20,** 252-259.

Schramme (2000) Degenerative diseases of the hock: treatment options. *BEV Congress Handbook,* pp 71-72.

Schramme, M.C., Platt, D. and Smith, R.K.W. (1998) Treatment o osteoarthritis of the tarsometatarsal and distal intertarsal joints of the hors with monoiodoacetate: preliminary results. *Vet. Surg.* **27,** 296.

Chapter 10:
Keratoma of the hoof capsule



Tim Greet

A keratoma is a relatively uncommon lesion, which is usually considered to be a tumour of the keratin producing cells of the epidermal laminae at the coronary band. The cause is unknown, but it may occur spontaneously or following capsular trauma. In fact the lesion may represent a chronic hyperplastic response to injury rather than a genuine tumour.

Affected horses may be lame to a variable degree, or show no signs of lameness. The lesion occurs typically in the toe region and less commonly elsewhere. It usually grows distally from the coronary band occupying space between the dorsal hoof wall and the distal phalanx (pedal bone). Such growth can cause visible distortion of the dorsal hoof wall and characteristically produces deviation of the white line towards the centre of the sole (Figure 1). Lameness may result from development of increased pressure within the hoof capsule, or because of an ascending infection resulting from the disruption in continuity of the solar-mural junction. In such cases pain on application of hoof testers or percussion is usual.

Types of keratoma

A radiographic assessment of the foot is valuable. Both dorsopalma and lateromedial views are useful, although the former is mos effective in demonstrating the typical appearanc Characteristically there is a circular lytic area at the margin of the dist phalanx (Figure 2). This area of lysis should not be confused with th crena, a normal radiolucent area seen in the distal phalanx of som horses. The lytic area corresponds to the keratoma in size and shap and is the result of pressure-induced osteolysis.

There are 2 basic types of keratoma, the **cylindrical** and th **spherical** forms (Figure 3). Both are amenable to surgical resectio Typically the cylindrical form originates at the coronary band an gradually grows distally, whereas the spherical form may be found any site on the dorsal hoof wall. The 2 types are sometimes see together in the same foot. In fact this author has encountered multip lesions in a number of horses. Occasionally the cylindrical for appears to originate distal to the coronary band.

A keratoma may be resected from the hoof of a horse under a gener anaesthetic or local analgesia. This author prefers the former approac although friendly debates frequently occur with our farrier used t working on standing rather than recumbent horses! However th patient is positioned, the surgery must be performed using a distal lim tourniquet (Figure 4) to allow accurate visualisation of the lesion an in particular, its origin.

FIGURE 1:

A typical deviation of the white line towards the sole, which occurs because the keratoma occupies laminar space. Note the typical appearance of flaky white keratoma tissue, readily differentiated from surrounding normal horn.

FIGURE 2:

A dorsopalmar radiographic image of a typical spherical keratoma. Note the characteristic radiolucent area within the distal phalamx and the sclerotic margin of the lesiion.

FIGURE 4:

This tourniquet is the standard method of haemostasis in a standing patient. It is applied after the administration of a palmar digital ('abaxial sesamoid') nerve block. The tourniquet consists of a standard cohesive 'flexible' bandage tape, which is usually applied over gauze or gamgee swabs rolled up and placed over the vessels at the level of the abaxial surfaces of the proximal sesamoid bones. This ensures even pressure over the vessels. There will commonly be loss of venous blood when the vascular tissues of the foot are incised. However if there is any sign of arterial blood, the tourniquet should be re-applied before continuing with the procedure. It is common practice to administer sedation, which is typically a cocktail of an alpha 2 agonist and an opiate.

FIGURE 3:

A typical spherical keratoma. In this case it was associated with a much larger cylindrical keratoma, hence the need for the creation of a large dorsal hoof wall defect. Such keratomas are usually seen as multiple lesions. Note that there are several smaller spherical keratomas in this figure.

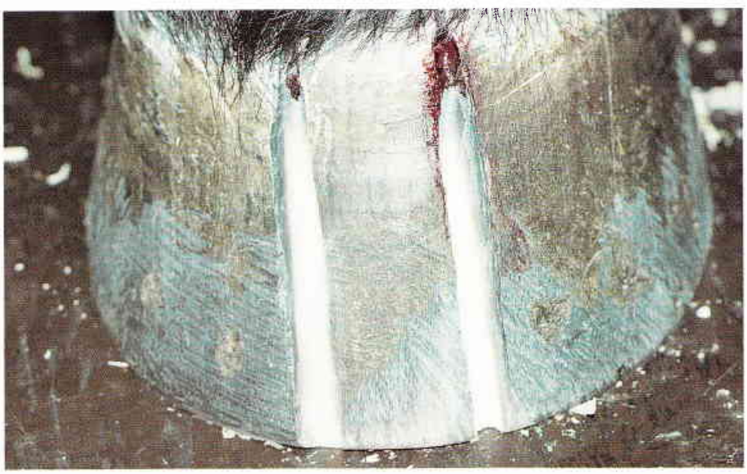


FIGURE 5:

Two parallel cuts are created in the dorsal hoof wall. These should correspond to the size and site of the keratoma, as judged by the solar appearance of the lesion or from radiographic images. Note that the cuts are created as far proximally as the coronary band but do not cross it. Most cylindrical keratomas seem to originate from the level of the coronary band and great care should be observed when ensuring complete excision of the keratoma without coronary band injury. It is easiest to lever the hoof wall upwards to the coronet and try to peel the keratoma away from underlying tissue at its origin.

FIGURE 7:

This is the defect left after excision of the keratoma in Figure 6. The extent of the lesion within the distal phalanx can be identified by the marked depression left after its removal. It can also be seen how far proximally the lesion has originated. It is usual practice to carry out curettage of the underlying bone and careful debridement of the epidermal laminae at the coronary band in an attempt to minimise the risk of a recurrence of the lesion.

FIGURE 6:

This is a cylindrical keratoma excised in its entirety with the dorsal hoof flap. Note that it extends the length of the hoof wall and has been peeled away from the epidermal laminae at the coronary band.

FIGURE 8:

This is the solar appearance of the hind foot of a middle-aged pony with 3 cylindrical keratomas. Two are clearly visible in this view before any extensive paring of the sole has been carried out. Notice just how wide and deformed the white line has become, reflecting the extensive nature of keratoma formation in this foot.

It is usually quite easy to identify the location of the lesion from the appearance of dorsal hoof deformity, the deviation of the white line or from radiological evidence. The lesion has a white flaky appearance which is usually differentiated easily from the sole even if it is depigmented. Two parallel cuts are made on either side of the keratoma through the full thickness of the dorsal hoof wall (Figure 5

Some bleeding is inevitable even with a correctly applied tourniquet because it is impossible to exsanguinate the foot. However, this should only consist of venous blood and should not be profuse. If there is evidence of bright arterial blood, or if haemorrhage is profuse or persistent, the tourniquet should be re-applied.

The keratoma is undermined and peeled away with the overlying hoof wall from the underlying laminae and distal phalanx, to the coronary band or to the level of origin of the lesion (Figure 6). In some cases it may be difficult to identify the origin of the lesion precisely and under these circumstances it is safer to presume that the origin is proximal. The most crucial aspect of this procedure is to ensure the lesion is removed in its entirety (Figure 7) in order to avoid regrowth of the keratoma, which can happen if there has been incomplete removal. However this must be achieved without injury to the coronary band itself with consequent potential hoof maldevelopment.

Following surgical resection of the lesion, the hoof wall defect should be packed with gauze swabs soaked in a dilute solution of povidone-iodine. These can be kept in place with a hoof bandage, but the author much prefers the use of a modified hospital plate with a dorsal flange. This ensures even pressure is maintained over the wound, discouraging the development of exuberant granulation tissue. This dressing can be changed daily until dry keratinised cuticle has formed.

FIGURE 9:

After further paring of the sole (see Figure 7), the third keratoma is now clearly visible. Note the lamellar structure of this keratoma, which is rather unusual, as is its grey colour.

FIGURE 10:

This is an upright dorsopalmar radiographic image of the foot in the 2 previous figures. Three circular radiolucent areas within the bone of the distal phalanx reflect osteolysis as a result of pressure from the keratomas. Note just how much bone has been lost and how near the keratomas have grown to the distal interphalangeal ('coffin') joint. This is partly an optical illusion.

FIGURE 11:

The same radiographic view as Figure 9, after surgical removal of the keratomas; indicating further loss of bone from the distal phalanx.

FIGURE 12:

The foot after application of a shoe and standard hospital plate. Note how much tissue has been lost from the foot. The shoe was glued on as an emergency procedure during surgery when the extent of the hoof wall loss became apparent.

FIGURE 13:

The iodine-soaked gauze swabs are then packed into the defect under firm pressure. This is important to prevent the development of exuberant granulation tissue.

FIGURE 14:

Once the defect has been completely packed with iodine-soaked gauze and then gamgee swabs, the aluminium visor is attached. This is a modification of a dorsal-flanged hospital plate. It allows easy access for daily re-packing. Most importantly, it ensures that the dressing is kept in place, applying pressure to the healing tissues, to minimise exuberant granulation. As with all hospital plates, it is important to instruct owners on application and removal of the plate and visor with a spanner. Lack of care during these manoeuvres may result in cross-threading the bolt and a malfunction of the apparatus.

The author has treated a pony with 3 keratomas in one hind foot. This involved a radical surgical procedure under general anaesthesia with extensive removal of dorsal hoof wall, laminar tissue and bone from the distal phalanx. Post operative management required the application of a specialised type of hospital plate with a dorsal visor, to protect the exposed tissues and to ensure healing without development of exuberant granulation tissue. The case is illustrated to demonstrate that a full recovery is possible even after the most radical surgical excision (Figures 8 to 18).

FIGURE 15:

Approximately 3 months post operatively, there is distal growth of the dorsal hoof wall with a healthy bed of granulation tissue filling the defect.

FIGURE 16:

The heartbar shoe is used to provide support for the foot in conjunction with the hospital plate. Originally a standard egg bar shoe had been used with the plate. The addition of a frog plate provided extra support to the foot and made the pony more comfortable.

FIGURE 17:

Complete regrowth of horn had occurred approximately 7 months post operatively.

Typically, lameness resolves rapidly following surgery. The period of convalescence required will depend on the size and site of the lesion. However it is usually many months before most horses can return to full exercise. The fitting of a hospital plate is essential to ensure optimal post operative management. In the longer term, a bar shoe with clips on either side of the defect should be applied. Filling the defect with composite material may allow a more rapid return to full exercise. This should only be carried out once keratinised cuticle has formed.

If the keratoma recurs, or if exuberant granulation tissue develops during the post operative phase, local debridement can usually be carried out with the horse standing under local analgesia and after a tourniquet has been applied. This is usually effective in resolving the lesion. It is surprising how well horses can cope with the loss of a significant proportion of foot and yet return to athletic activity.

Figures 19 to 24 illustrate the surgical removal of a spherical keratoma. The radiograph of this case is shown in Figure 2.

FIGURE 18:

Note the change in pigment of the solar horn.

FIGURE 19:

Parallel cuts in the dorsal hoof wall are made with an oscillating saw (water cooled by syringe).

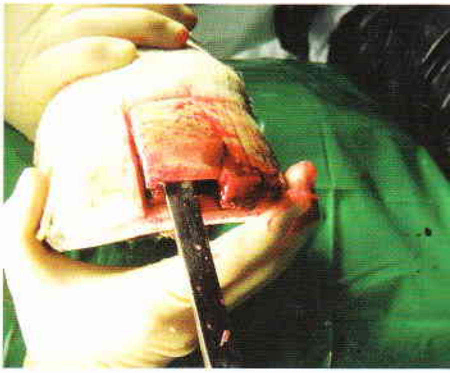


FIGURE 20:

The dorsal flap is elevated and then removed.

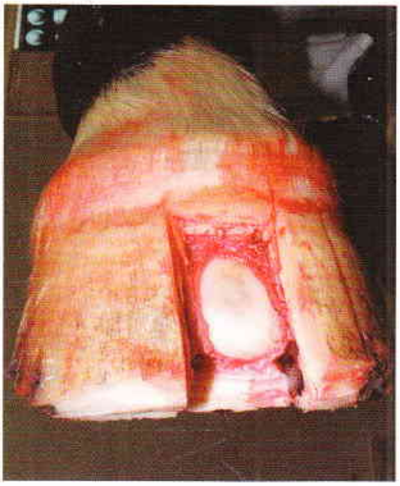


FIGURE 21:

A large spherical keratoma can be seen once the flap has been removed.

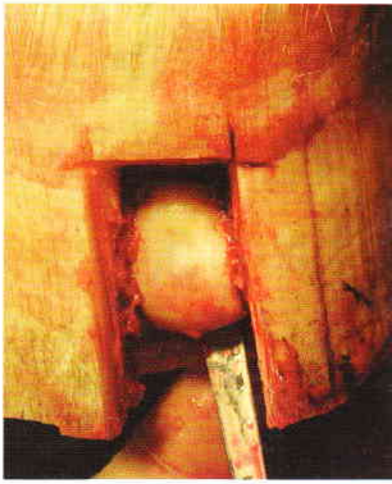


FIGURE 22:

The keratoma is elevated and removed.

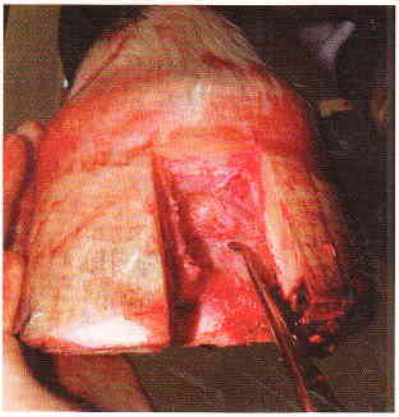


FIGURE 23:

Careful curettage of the underlying distal phalanx is carried out.

FIGURE 24:

The spherical keratoma after removal.

Chapter 11: Lesions of the hoof

Jonathan Lumsden

Corrective farriery
a textbook of remedial horseshoeing

The equine hoof is a uniquely structured adaptation of the integument, which performs admirably as the first line of defence between horse and terrain. Despite this, the hoof's role in locomotion, weight-bearing and the unpredictability of its environment frequently lends itself to injury. Minor wounds to the hoof are common and generally heal uneventfully with routine wound care; whereas deep extensive injuries are not common and require thorough evaluation and protracted treatment. Hoof lesions are classified according to the nature of the insult (abrasion, laceration, puncture, crack or avulsion) and the anatomical site(s) affected. A careful and systematic approach to wound evaluation is important, as treatment and outcome are largely dependent on the site and extent of the injury.

This chapter does not cover conventional hoof cracks such as sand and grass cracks. These are covered in depth in Volume II.

Wound healing of hoof lesions

Abrasions, lacerations and avulsion injuries of the hoof requir careful assessment in conjunction with a thorough appreciatio of the unique wound healing properties of the hoof. For th most part, the principles of wound healing of skin are common to th hoof. Despite this, there are several important factors unique to tissue of the hoof that influence the repair process significantly.

Clinical experience has shown that healing times for hoof lesions ar generally protracted compared with wounds at other sites. As hoo wounds are not amenable to suturing, and frequently result in tissu loss, healing occurs by second intention. For this reason, healing i reliant on the formation of granulation tissue from the corium, subcut or bone and subsequent migration of germinal epithelium. In addition the repair process is retarded further by the absence of active wounc contraction. All components of the corium have the ability to migrat and cover a defect provided that a healthy bed of granulation tissue ha been established. However, epithelialisation is almost impossible in th presence of infection. With this in mind, as hoof wounds are typicall heavily contaminated with dirt and faecal material, there is a hig likelihood of infection and extended healing times.

The hoof is subject to considerable movement compared with man other sites in the horse. The inherent constant weight-bearing an dynamics of loading and unloading of the foot, even in the confine horse, are associated with continual movement of tissues of the hoo This movement impedes wound healing and represents a significan factor contributing to extended healing times. Despite the rich bloo supply to the foot, vascular injury occurs commonly with deep hoo injuries and may result in local ischaemia predisposing to infection an impaired healing. These factors coupled with the normal slow rate o horny tissue regeneration result in prolonged healing times of hoo lesions that are typically in the order of 3–5 months. Furthermore, th clinician should bear in mind the potential involvement of vit structures occurring simultaneously with injury to the hoof. Injury t vital structures adjacent and deep to the hoof may result in infectio or instability causing career or life-threatening complications.

The sole

Full thickness wounds of the sole extend through the keratinised an germinal epithelium, corium and subcutis. During the initial woun healing process the wound margins do not retract and there is no swelling of adjacent soft tissues due to the confines of the hoof capsule. Conversely, swelling associated with the inflammatory and repair phases of wound healing results in tissue protrusion at the wound that impedes epithelialisation. As active wound contraction does not occur, granulation tissue forms to cover the exposed bone or corium. Wounds resulting in exposure of the distal phalanx are associated with prolonged healing times, as granulation tissue formation from bone is significantly slower than from the vascular rich corium. Subsequently, migration from the surrounding germinal epithelium occurs in a centripetal manner over the granulation bed. The remaining defect is then filled by the proliferation of keratinised solar epithelium.

The hoof wall

Full thickness injuries of the hoof wall repair in a manner similar to solar wounds except that epithelial migration from surrounding laminar epithelium is limited to replacing the stratum internum. The residual defect in the stratum medium persists until normal hoof wall growth proximal to the lesion reaches the solar margin. Furthermore epithelial tissue covering hoof wall defects may proliferate from various adjacent tissues, including laminar, coronary, solar or dermal epithelium, depending on the location of the wound. Epithelial cells migrating from adjacent tissues will assume the characteristics of their origins.

The coronary band

Small full thickness defects in the coronary band are capable of complete regeneration by coronary epithelial migration from wound margins without permanent hoof wall defects. Larger defects, unable to be bridged by coronary epithelium, are replaced by adjacent laminar or dermal epithelium. The hoof wall growth produced by the non-coronary epithelium often results in crack formation and does not produce a normal stratum medium. Despite this, the abnormal hoof wall tissue is commonly satisfactory to maintain normal hoof function.

Where coronary band injury is associated with full thickness loss of pastern skin, laminar or coronary epithelium migrates proximal to the coronary band and horny tissue grows on the pastern.

Evaluation of hoof lesions

Evaluation of hoof injury should initially involve classification of the wound in relation to the nature of the trauma, depth, location and

FIGURE 1:

A deep abrasion to the coronary band and skin of the pastern which was associated with profuse haemorrhage. Hoof injuries often incorporate injury to the coronary plexus or digital arteries that may result in substantial blood loss.

duration. It is important that the wound is assessed in conjunction with evaluation of the degree and type of lameness. Wounds of the hoof, coronary band and pastern which appear minor but are associated with severe lameness may indicate involvement of deeper vital structures, infection or structural instability. A complete physical examination should always be performed to evaluate any secondary systemic effects, such as cardiovascular compromise due to blood loss (Figure 1). Similarly, detection of additional abnormalities or injuries should not be overlooked as they may require specific treatment and affect the prognosis. Prior to a detailed wound examination, initial therapy may include confinement, pressure bandaging, intravenous fluids, antibiotics, analgesia, tetanus prophylaxis and anti-inflammatory therapy.

A systematic approach to wound evaluation should be adopted. Where possible the wound should be assessed in a clean dry environment. In the case of acute, deep or infected wounds, hoof manipulation is generally associated with a marked pain response and sedation and perineural anaesthesia are often required to facilitate evaluation. When wounding is extensive or the temperament of the horse limits a thorough evaluation, general anaesthesia may be necessary. The exposed sensitive tissues should be covered in sterile gel (Surgi-Gel or Intrasite Gel), the surrounding skin clipped, superficial hoof rasped and the sole pared. The tissue surrounding the wound should be cleaned with an antiseptic scrub and then both are rinsed with a dilute antiseptic solution. Using sterile gloves the wound should be palpated to determine the hoof and foot structures involved and to detect the presence of foreign bodies. A sterile probe can be used to assess deeper tissue openings. Careful consideration should be given to the possible involvement in synovial structures, particularly in relation to wounds involving the coronary band, pastern and heel bulbs. The integrity of the synovial structure (distal and proximal interphalangeal joint, digital flexor sheath and podotrochlear bursa) should be assessed by aspiration of fluid, synovial fluid analysis, bacterial culture and distension with sterile isotonic fluid. Injecting 10–30 ml of sterile isotonic fluid into the synovial cavity and observing for leakage from the wound assesses communication between a synovial structure and the wound. Centesis of the synovial cavity should be performed at a site remote from the wound under aseptic conditions (Figure 2). If the injury precludes a dorsal approach to arthrocentesis of the distal and proximal interphalangeal joints a palmar/plantar approach should be used. Similarly, digital flexor tendon sheath centesis may be achieved at the level of the sesamoid bones when palmar/plantar pastern injuries are extensive.

FIGURE 2:

Injury to the hoof wall, coronary band and pastern skin may extend to involve the underlying synovial cavity. The integrity of the distal interphalangeal joint is assessed by joint distension with sterile isotonic fluid and observation of leakage from the wound. Arthrocentesis is performed under aseptic conditions at a site remote from the injury.

Assessment of other deeper structures such as corium, germinal tissue, neurovascular bundle(s), digital cushion, flexor tendons, collateral ligaments and cartilage can be difficult. Evaluation may need to be delayed until haemorrhage is controlled by pressure bandaging (12–24 h) or performed under general anaesthesia. Wounds involving the corium and coronary band should be examined closely. Careful inspection of coronary band wounds is important particularly when hair is long, to eliminate the possibility of a foreign body. Substantial loss of coronary tissue will result in compromised hoof integrity, whereas the effect on hoof structure from partial thickness wounding may be difficult to assess until there is hoof regrowth. The foot has the propensity to develop adequate collateral circulation following unilateral insult of digital vessels to allow tissue repair. The possibility of subsequent thrombosis of digital vessels following trauma should also be kept in mind. Denervation may occur in conjunction with digital vessel laceration. Although generally of minimal clinical significance, subsequent loss of bone mass and strength has been reported following denervation.

Damage to the periosteum of the middle and distal phalanges and collateral ligaments of the proximal and distal interphalangeal joints may result in chronic lameness. Deeper injuries may cause infection of the

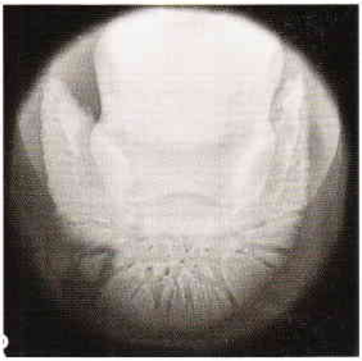


FIGURE 3:

Upright radiographic view of the third phalanx of a mare that kicked a piece of sheet metal resulting in a full thickness laceration of the hoof wall and a non-weight-bearing lameness. Radiographs revealed a corresponding linear lytic bony defect in the distal phalanx. A septic osteitis developed in the distal phalanx that was subsequently curetted in conjunction with hoof wall debridement.

navicular bone, middle and distal phalanges or the collateral cartilag For this reason, radiographic examination should be performed on a cases where there is severe lameness, deep injury or where draining trac are present (Figure 3). Radiographic assessment should be supplemente with contrast studies of draining tracts for a greater appreciation of th structures involved. Sequential radiographs at 7–10 day intervals ma reveal the development of septic osteitis, osteomyelitis or periosteal ne bone production secondary to the original trauma. Ultrasoun evaluation of soft tissues and draining tracts may be performed t establish integrity of tendons and ligaments, the origins of draining trac and to identify deeply embedded foreign bodies.

Neglecting to undertake a thorough evaluation of vital structures i association with hoof wounds may result in inadequate treatment, a inaccurate prognosis and a poor outcome. Prior to embarking o treatment of severe hoof injuries, owners must be made aware of th protracted and complex nature of the treatment, the considerab expense, possible complications and likely prognosis for restoration o form and function.

Management of hoof lesions

Optimum management of hoof injuries requires an appreciation of th specific wound healing properties of the hoof and the factors th affect wound healing. The principal goal of treatment is to create healthy environment for wound healing and to obtain the best possib cosmetic and functional results. Prior to surgery all 4 feet should b trimmed because, often, the non-operated feet tend to be neglecte during the healing process, especially if the operated foot remai painful for an extended period of time. Preparation of the hoof fo surgery should be performed the day before surgery if possible. Th periople, outer hoof wall and superficial horn of the sole and frog a pared. The entire foot is then scrubbed with povidone-iodin detergent, rinsed in alcohol and allowed to dry. The foot is the wrapped in a povidone-iodine solution soaked bandage and covere with an impermeable layer. Similarly, the skin around the pastern clipped and cleaned with an antiseptic scrub, after the wound covered in sterile wound gel or antiseptic ointment. A tourniqu applied at the level of fetlock reduces intra-operative haemorrhage ar reduces surgery times. Haemostasis can be achieved by simp wrapping a roll of elastic bandage (Vetwrap) firmly around the fetloc to compress and occlude the digital arteries. When the vascular tissu of the foot are incised, bleeding will ensue until the pooled blood in the foot and pastern has diminished. Alternatively, a rubber tourniquet can be applied from the coronary band to the fetlock, which will provide more complete haemostasis. Despite this, low grade oozing is likely to continue throughout the procedure. The pastern and hoof are then prepared for aseptic surgery. The remainder of the hoof not to be operated on is covered with an autoclaved Vetwrap.

The single most important factor in the management of hoof wounds is debridement of devitalised tissues and foreign material and complete wound excision is the most effective method. However, debridement of special tissues such as the germinal epithelium, corium, nerves, tendons and synovial cavities should be conservative. The viability of these tissues and the wound margins may not be apparent immediately. Wounds with tissues of questionable viability are best managed by bandaging with moist dilute antiseptic adherent dressings and delayed surgical excision if necessary at 2–3 day intervals. Surgical debridement should be combined with large volume irrigation of a wound. Lavage with sterile physiological solutions using a 30 ml syringe and 18 g needle or a pulsatile pump is effective at debriding loose blood, foreign material and bacteria from lightly contaminated wounds. For most hoof injuries, contamination is heavy and deeply embedded. Therefore sharp dissection followed by large volume (3–6 litres) lavage is more effective and not as tedious as pressure lavage systems. Following debridement the integrity of adjacent synovial structures should be assessed, as outlined above. The intimate association between the hoof and the remaining structures of the foot and pastern predisposes these structures to injury in concert with hoof lesions. For this reason, management of hoof lesions is incomplete without consideration of treatment of the adjacent structures. Open joints should be managed with large volume lavage with sterile physiological solution and treated with intra-articular and systemic antibiotics. Infected and devitalised tissue of the distal phalanx, its collateral cartilage and tendons should be excised.

The value of topical antibiotic preparations in treating and preventing wound infection is questionable. The topical application of antiseptic ointments and solutions should avoid high concentrations (chlorhexidine >0.05% and iodine >0.2%) which impair wound healing. Similarly, astringents such as white lotion, 2% formalin or 2–7% tincture of iodine are deleterious to fibroplasia and epithelialisation. Systemic antibiotics are indicated when injury extends deep to the dermis and where vital structures such as synovial cavities are involved. Broad-spectrum antibiotic therapy such a penicillin and gentamycin is appropriate for hoof wounds based on th likely presence of mixed bacterial populations including anaerobes Topical and systemic metronidazole may be indicated in cases wher anaerobes are resistant to penicillin. Local administration of hig concentrations of antibiotics by intra-osseous and intravenous infusio of the distal limb may be beneficial when treating infection of vit structures.

Wound bandaging limits further trauma and contamination, applie pressure, aids in debridement and prevents dessication. Application c moist adherent dressings, such as gauze sponges, are indicated to assi further wound debridement and prevent dessication. Subsequentl non-adherent semi-occlusive wound dressings should be applied t facilitate granulation tissue formation and enhance epithelialisatio Firm packing of hoof and sole defects with a contact dressing backe with gauze sponges helps prevent swelling and tissue protrusion fro the wound. The secondary layer of roll cotton is applied to absor wound exudate and distribute pressure evenly. Although this layer often omitted when bandaging wounds of the sole and distal wall, it beneficial in contaminated wounds and helps to wick away exce moisture. The outer layer of the foot bandage should be waterproo and may consist of a disposable nappy and adhesive tape, several laye of duct tape, impermeable elastic wrap (Vetwrap), incorporation of rubber inner tube or a commercial waterproof boot. It is important t avoid excessive pressure or direct contact with adhesive tape on th coronary band as the coronary epithelium may become macerated.

Stable hoof wounds may be managed adequately with bandaging an corrective shoeing. Large and unstable wounds are best protected an stabilised by a cast. Initially, wound management may require repeate debridement and regular bandage changes until infection is controlle prior to application of a cast. A distal limb cast provides stability t facilitate neovascularisation of damaged tissue, prevents furth contamination and restricts formation of granulation tissue. Castin should incorporate the hoof and pastern (phalangeal, foot or 'slippe cast) to below the fetlock, and may be applied to the standing hor with the aid of light sedation. The use of cast foam, ending the ca well below the level of the fetlock and rolling the proximal rim of th cast distally before the material sets, reduces the incidence of cast sor (Figure 4). As the phalanges are cast in extension, without restrictin the range of motion of the fetlock, a raised heel is rarely require Acrylic cement (Technovit 6091) is applied to the toe and heel of th cast to prevent premature wearing. The cement is applied by pouring it on a sheet of aluminium foil and taping it to the bottom of the cast. The phalangeal cast is less expensive, easier to apply and has a lower complication rate than a half-limb cast, which may also be used.

Coronary band

Superficial abrasions to the coronary band are common and epithelialisation occurs rapidly without gross evidence of scarring. Typically, treatment is not required for superficial abrasions other than maintaining the horse in a dry and hygienic environment. Deeper abrasions are often associated with considerable haemorrhage from the coronary plexus and variable degrees of pastern skin and coronary tissue loss. Initial management requires pressure bandaging to control haemorrhage, systemic antibiotic cover and tetanus prophylaxis until assessment of involvement of deeper structures (distal interphalangeal joint and collateral cartilages) is performed. Small stable wounds may be managed initially by cleansing with dilute antiseptic agents, debridement with wet-dry bandaging for several days and stall confinement. Subsequently, the wound is managed with semi-occlusive dressings such as Melolin or Telfa, which are backed by gauze sponges and secured with roll gauze. Topical antibiotic or low concentration antiseptic ointments may be beneficial early in wound healing. A secondary layer of roll cotton is applied, which is then covered by a waterproof layer. Non-steroidal anti-inflammatory drugs

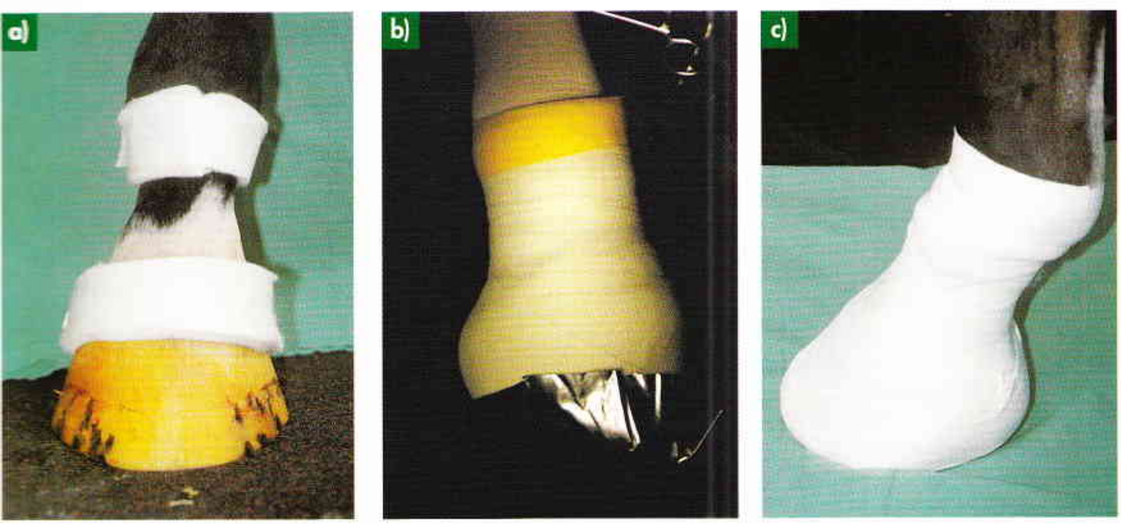


FIGURE 4:

Application of a phalangeal or 'slipper' cast is a key element in the successful treatment of unstable foot wounds. a) Orthopaedic felt is applied to protect the coronary band and proximal pastern. b) Cast foam applied over the stockinet minimises cast sores and acrylic cement is applied to the toe and heel of the cast to prevent wearing. c) The cast ends distal to the fetlock to avoid rubbing during fetlock extension and flexion. The top of the cast is sealed with adhesive tape to prevent contamination.

FIGURE 5:

a) Partial thickness abrasion to the coronary band involving the hoof wall and pastern skin 5 days after injury following treatment with moist adherent dressings and bandaging. b) Wound appearance after a phalangeal cast was applied for 3 weeks showing formation of healthy granulation tissue and displacement of the coronary band. c) Appearance at 12 weeks, showing hoof wall growth indicative of a satisfactory function of the coronary band.

are administered for the first 3–5 days and broad-spectrum systemi antibiotics are indicated when injury extends deep to the dermis.

Larger and more mobile wounds are managed as above for the first fev days until establishment of infection is ruled out. At this point woun healing and restoration of the coronary tissue is best promoted by ca immobilisation for 2–3 weeks. Coronary germinal tissue ha remarkable regenerative capacity if sepsis, instability and ischaemia ar prevented. With adequate debridement, proper wound managemer and casting a major coronary injury may be converted into a minc coronary defect. Accurate assessment of the extent of loss of germin coronary epithelium at the time of injury and subsequent compromis to hoof wall integrity is difficult. In many cases the effect of corona tissue damage requires time for healing and regrowth to assess hoo integrity (Figure 5). Coronary defects lead to permanent hoof crack or defects in the hoof wall, although not all cause function impairment or lameness. Preventative measures such as regular hoo trimming, corrective shoeing and acrylic repair may reduce o eliminate the consequences of the coronary defect and will be detaile in Volume II.

Full thickness coronary band lacerations inevitably involve the ho wall and distal pastern region to varying degrees. Where possib wound management should be enhanced by debridement and preci apposition of wound margins. Repair of lacerations should follo basic wound management principles with emphasis on creating a healthy environment, preserving coronary tissue and providing adequate stability for optimal healing. Tissue is apposed using non-absorbable monofilament suture on a cutting needle in a verticle mattress pattern (see Figure 12d). Stability is best achieved by applying a phalangeal cast for 2–3 weeks. Lacerations that result in minimal loss of coronary band tissue following suturing or by second intention healing rarely result in a hoof wall defect. Lacerated coronary band tissue may be unsuitable for debridement and suturing, particularly when treatment is delayed. Therefore, tissue resection is necessary to prevent infection and to allow formation of a healthy granulation bed. In this instance there will be substantial loss of coronary band tissue, and a permanent defect of sub-optimal, though often functional, hoof wall will result. Long term complications following coronary band injury may include hoof wall cracks, defects, keratomatous growths and horny spurs, which may require surgical reconstruction and long term corrective farriery.

Hoof wall

Full thickness lacerations, punctures and avulsions of the hoof wall are not common. Such injuries may follow debridement of a hoof crack, direct injury from a sharp solid object or surgically created defects. Whenever trauma has resulted in a full thickness defect, radiographic evaluation of the foot should be performed to determine if there is underlying bone involvement. In the majority of cases wound management is possible with the use of sedation and regional

FIGURE 6:

Use of a Dremel power burr and 'loop knife' allows precise removal of damaged hoof wall while minimising damage to healthy adjacent laminar tissue.

FIGURE 7:

Large, unstable full thickness hoof wall defects may be stabilised with contoured metal bands and screws placed in the hoof wall.

anaesthesia. Initial treatment of traumatic wounds involves paring o any under-run hoof wall back to margins of healthy hoof wall anc laminar tissue. Use of a 'loop knife' or power burr (Dremel; Figure 6 to remove damaged hoof wall minimises damage to adjacent health laminar tissue. Necrotic laminar tissue is debrided carefully, lavaged anc the wound examined for embedded foreign bodies or involvement o the underlying distal phalanx. If there is involvement of underlyin bone the defect should be curetted back to healthy bone, which is firm bleeds and is not discoloured. Broad-spectrum systemic antibiotic should be administered if there is bone involvement until health granulation tissue forms over the defect. Exposed dermal tissues ar then covered with a non-adherent semi-occlusive dressing (Sofra-tull or Jelonet) in conjunction with topical dilute antiseptics. The contac dressing is backed with moist gauze sponges firmly packed into th defect. An absorbent layer is usually unnecessary and a waterproof laye is then applied. Once granulation tissue forms, semi-occlusive dressings which promote epithelialisation such as Telfa or Melolin, are used. Th wound should be bandaged until the defect is covered with cornifie epithelial tissue. If the hoof wall defect is considered likely to affect th structural integrity of the hoof, a bar shoe in combination with sid clips or rigid fixation across the defect may be necessary (Figure 7 Once epithelial cornification has occurred the defect may be filled wit hoof acrylic (Equilox or Flex 'n' Bond) to allow earlier return t competition. Application of acrylic repair compounds should b delayed until a sufficient thickness of keratinised tissue has formed t prevent heat from the curing process damaging sensitive lamina (2– months). The reader is referred to Volume II for a detailed descriptio of hoof acrylic compound application.

Avulsion injuries

Hoof wall avulsion injuries may extend to involve the coronary ban and adjacent skin as well as the sole and third phalanx. The avulsio may be complete, incomplete, acute or chronic. Avulsion injurie typically involve fracture of the hoof wall with proximal displacemen extending into the coronary band as a result of the downward force c the limb striking a fixed object.

Complete avulsion occurs when tissue is lost from the foot or whe tissue of an incomplete avulsion is resected due to compromised bloo supply. The avulsion may be confined to the hoof wall althoug involvement of the coronary band and pastern tissues is common.

the wound is stable during movement it may be managed by debridement, lavage and bandaging. If there is sufficient loss of tissue a corrective bar shoe should be applied (Figure 8). Unstable or large defects are best treated by casting for 3 weeks following debridement and lavage. The stability provided by casting improves the chances of complete reformation of the hoof wall. Casting should be delayed until infection is resolved or its development ruled out. Similarly, casting is postponed until ischaemic tissues are debrided and potentially ischaemic tissue is evaluated. Sequential wound debridement over several days may be necessary to create a healthy environment for casting. Assessment and resolution of infection of synovial structures is paramount to a successful outcome. Broad-spectrum antibiotics and sterile bandaging are maintained until healthy granulation tissue forms.

Chronic complete avulsions may develop a keratomatous growth that extends proximal to the coronary band (Figure 9). The horny tissue may cause lameness with pastern movement and require periodic removal to render the horse pain free. Surgical treatment is possible by excising the keratinous material, undermining and reapposing adjacent soft tissue. Such repair must be accompanied by casting for 3 weeks and bandaging for a further 4–6 weeks. Keratomas are covered in detail in Chapter 10: Keratoma of the Hoof Capsule.

Incomplete avulsions may occur anywhere in the foot. The avulsed segment of hoof is generally attached at or above the coronary band. Hoof wall fracture and separation occurs commonly at the heel and quarter and extend to the coronary band. Where there is no or minimal coronary band involvement the undermined hoof wall is peeled away carefully with 'pull-offs' from its coronary attachment to create a complete avulsion. The solar and heel attachment of the hoof wall is separated at the white line and angle of the bars with a hoof knife or Dremel tool. The undermined wall is separated from the healthy attached dorsal margin using a Dremel tool or oscillating saw, rather than hoof knife and nippers, to prevent tearing of healthy hoof wall from the dermal laminae. The dorsal attachment of the hoof wall is then bevelled flush to the wound. The resultant hoof defect is treated as for full thickness hoof wall defects, changing the bandages every 2–4 days until the tissue is keratinised (Figure 10). A full bar support shoe (egg-heartbar shoe) is applied to provide hoof wall stability and hoof acrylic can be used to fill the deficit after 2–3 months. The resultant hoof growth typically does not compromise function of the foot.

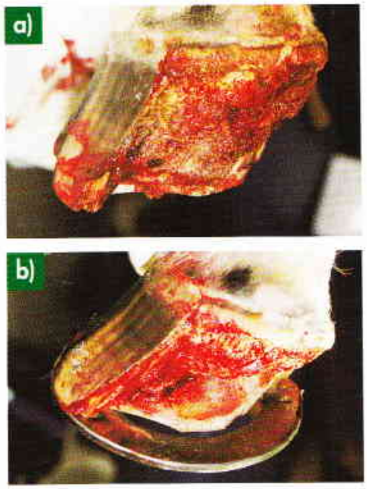


FIGURE 8:

a) Complete hoof wall avulsion involving the sole and the solar margin of the distal phalanx, confirmed by radiographs. This avulsion is associated with minimal damage to the coronary band. b) The avulsion was managed by surgical debridement, bandaging and supported by a full bar shoe.

FIGURE 9:

Chronic complete avulsions may develop a keratomatous growth that extends proximal to the coronary band. The rigid horny tissue may cause lameness with pastern movement and require periodic thinning to render the horse pain free.

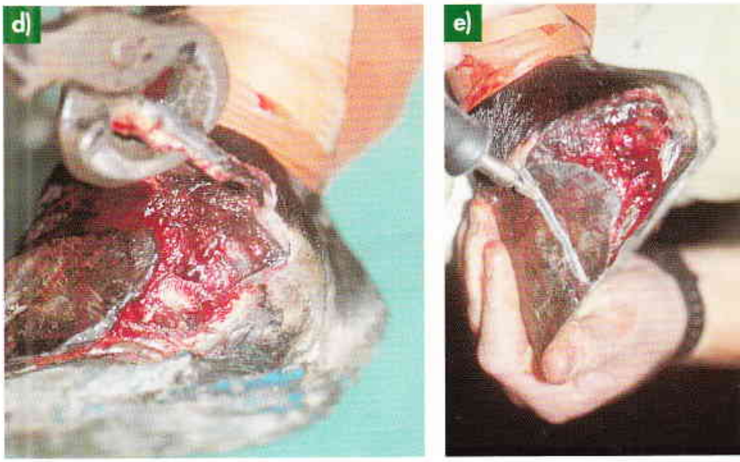


FIGURE 10:

a) Incomplete avulsion of the hoof wall at the quarter, following blunt trauma. Closer evaluation reveals near complete separation of the hoof from the underlying laminar tissue and minimal disruption to the coronary band. b) Following perineural anaesthesia of the palmar nerves a tourniquet is applied. c) The solar and heel attachment of the hoof wall is separated at the white line and angle of the bars. d) The undermined hoof wall is carefully peeled with 'pull-offs' in a proximal and caudal direction to separate the wall from its coronary attachment. e) The remaining undermined wall is separated from the healthy attached dorsal margin using a Dremel tool or oscillating saw. f) The resulting complete avulsion is then bandaged and a bar shoe applied.

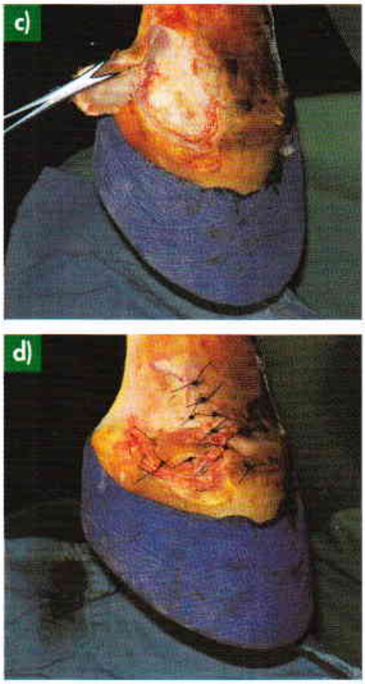
FIGURE 11:

Conservative management of avulsion injuries often results in upward displacement of the coronary band and spur formation. These chronic protruding avulsions are susceptible to further trauma and may cause lameness.

Incomplete avulsions may be acute or chronic. Acute injuries, which incorporate the coronary band, are assessed for tissue viability and degree of contamination. If the coronary band is obviously devitalised and tissues are heavily contaminated, resection of the avulsed tissue and healing by secondary intention is recommended. Where larger sections of the hoof wall and coronary band are involved, and there is an adequate blood supply, reconstruction of the coronary band is recommended. Cosmetic and functional expectations and treatment costs should be discussed with the owner prior to embarking on reconstructive surgery, as protracted post operative care is likely to be necessary.

Acute avulsions where coronary tissue is viable are best treated promptly by reconstruction and stabilisation. Partial avulsions left untreated result in elevated coronary tissue that produces a horny spur. The underlying tissue becomes fibrotic and epithelialises above the hoof and skin surface.

Chronic hoof wall avulsions may be associated with persistent lameness, non-healing wounds or aberrant growth of a hoof wall spur (Figure 11). Horny spurs may contribute to lameness as movement causes irritation to the underlying sensitive corium or the spur may be frequently traumatised. Furthermore, attempted reconstruction of scarred and misshapen wounds is more difficult and less cosmetically pleasing than management of acute wounds. A better long term prognosis for soundness and simplified long term hoof management is likely if defects are repaired in the acute stages of healing.



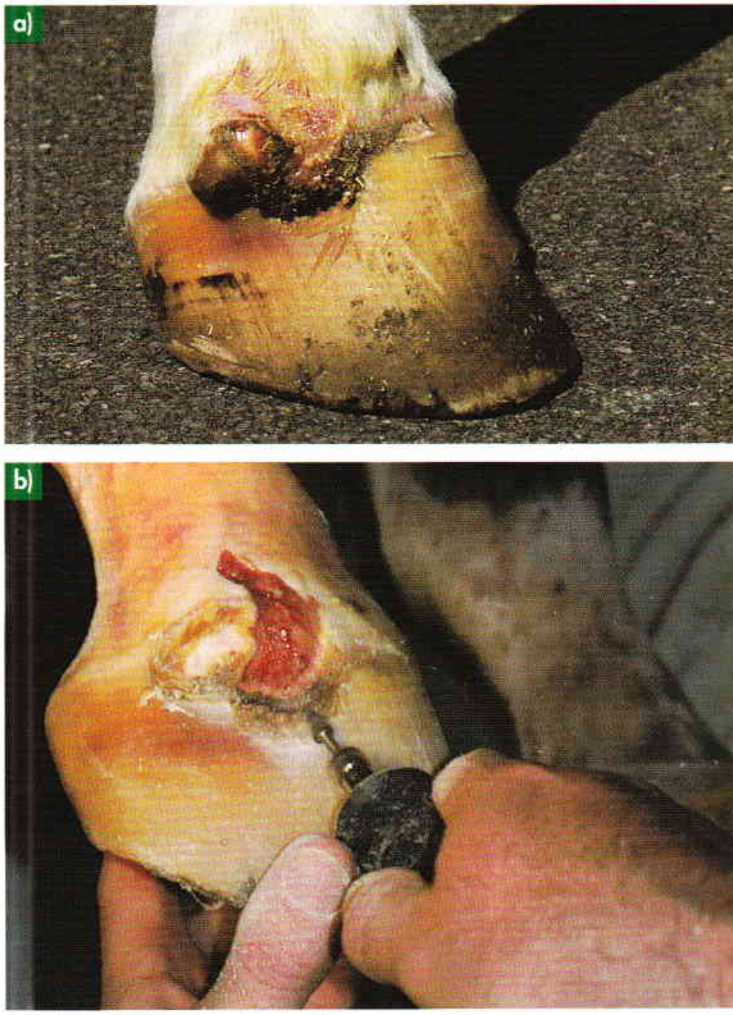


FIGURE 12:

a) Incomplete hoof wall avulsion involving the coronary band and pastern. b) The avulsed hoof wall is resected to approximately 1.5 cm below the coronary band and thinned using a Dremel tool so it may be sutured to the adjacent hoof wall which is also thinned. c) The wound is debrided, extended and adjacent skin undermined to allow re-apposition of the coronary band. d) The hoof wall is sutured using non-absorbable monofilament in a vertical mattress pattern, and then the skin and coronary tissues are apposed using simple interrupted sutures.

Repair of incomplete hoof avulsions is performed under general anaesthesia to facilitate aseptic technique, optimal tissue handling, haemostasis and complete evaluation of vital structures. Peri-operative broad-spectrum antibiotics are administered and, if deeper structures are involved, long term antibiotics may be required. The hoof wall and pastern skin are prepared as outlined previously. The avulsed hoof wall distal to the coronary band is resected to approximately 1.5 cm below the coronary band and thinned using a Dremel tool. The hoof wall adjacent to the defect is also thinned so that the avulsed hoof segment may be placed in the defect and sutured. All aspects of the wound are explored, dedrided and lavaged. Wound margins are apposed unless tissue viability is questionable or there is undue tension. Tension-relieving and skin-mobilisation procedures may be necessary to allow apposition of wound margins and accurate alignment of the coronary band. The hoof wall is sutured using Size 1 non-absorbable monofilament in a vertical mattress pattern with a cutting needle. Subsequently, the coronary band and skin are re-apposed using Size 0 or 2-0 vertical mattress or simple interrupted sutures. Accurate apposition with minimal tension is important to restore normal hoof growth (Figure 12). The distal hoof wall defect is left to heal by second intention and a phalangeal cast is applied for 3 weeks. After removal of the cast continued stall rest and foot bandaging occurs for a further 3 weeks. Once tissues keratinise, the sutured avulsed section of hoof wall may be stabilised with hoof acrylic (Figure 13).

Surgical treatment of chronic avulsions can be very rewarding and is approached as for acute repairs. In addition to preparation of the spur and adjacent hoof wall, the underlying scar and granulation tissue is excised sharply to allow the flap to lay flat. The edges of the pastern and coronary band are 'freshened' by resecting 1–2 mm of skin. Chronic non-healing wounds may require debridement of deeper infected or devitalised tissues. Scar revision and wound reconstruction techniques of the pastern and coronary band may be necessary to realign the coronary tissue without undue tension. Post operative care is as for acute repair.

Repair of hoof wall avulsion injuries may be associated with numerous complications including partial or complete wound dehiscence and the development of painful horny spurs, hoof defects and cracks. More extensive avulsions may result in permanent lameness due to fracture, infection or significant loss of the distal phalanx. Additional complications may arise from injury and infection to the digital cushion, collateral cartilages and the flexor sheath and distal interphalangeal joint.

In general, in the absence of such complications, the prognosis for restoring functional hoof growth and return to athletic soundness is good following reconstruction. Despite this, variable defects in hoof wall structure are commonly seen which may represent a cosmetic blemish only or may require ongoing corrective trimming and shoeing (Figure 14). Repair of chronic avulsions is more likely to result in partial hoof wall defects than acute repairs. Where infection or structural compromise of vital tissue of the foot occurs in conjunction with hoof injury, the prognosis for complete return of function is often guarded.

FIGURE 13:

Repair of incomplete avulsion after removal of the phalangeal cast. The sutured avulsed section of hoof wall has been filled and stabilised with hoof acrylic.

FIGURE 14:

Appearance of the hoof shown in Figure 12, 2 years after reconstructive surgery for an incomplete hoof avulsion. A good functional outcome was achieved with no evidence of lameness. The cosmetic outcome is satisfactory with good re-alignment and growth from the coronary band. Despite this, several superficial cracks persist.

Further reading

Blackford, J.T., Latimer, F.G., Wan, P.Y. and Shires, G.M.H. (1994) Treating pastern and foot lacerations with a phalangeal cast. *Proc. Am. Ass. equine Pract.* **40,** 97-98.

Hassel, D.M., Stover, S.M., Yarborough, T.B., Drake, C.M. and Taylor, K.T. (2000) Palmar-plantar axial sesamoidean approach to the digital flexor tendon sheath in horses. *J. Am. vet. med. Ass.* **21,** 1343-1347.

Hennig, G.E., Kraus, R., King, V.L., Steckle, R.R. and Kirker-Head, C.A. (2001) Comparison of two methods for presurgical disinfection of the equine hoof. *Vet. Surg.* **30,** 366-373.

Hogan, P.M. and Honnas, C.M. (1998) Diagnostic neural and articular anaesthesia. In: *Current Techniques in Equine Surgery and Lameness.* 2nd edn. Eds: N.A. White and J.N. Moore, W.B. Saunders, Philadelphia, pp 490-500.

Honnas, C.M. (2000) How to approach hoof wall surgery in the horse. *Proc. Am. Ass. equine Pract.* **46,** 153-155.

Honnas, C.M., Meagher, D.M. and Linford, R.L. (1989) Surgical management of difficult foot problems in the horse: current concepts. *Proc. Am. Ass. equine Pract.* **34,** 249-262.

Markel, M.D., Richardson, G.L., Peterson, P.R. and Meagher, D.M. (1987) Surgical reconstruction of chronic coronary band avulsions in three horses. *J. Am. med. vet. Ass.* **190,** 687-688.

Nickels, F.A. (1987) Hoof lacerations and avulsions. In: *Current Therapy in Equine Practice,* 2nd edn. Ed: N.E. Robinson. W.B. Saunders, Philadelphia, pp 275-277.

Parks, A.H. (1998) Chronic foot injury and deformity In: *Current Techniques in Equine Surgery and Lameness.* 2nd edn. Eds: N.A. White and J.N. Moore, W.B. Saunders, Philadelphia, pp 394-397.

Parks, A.H. (1997) Wounds of the equine foot: principles of healing and treatment. *Equine vet. Educ.* **9,** 317-327.

Parks, A.H. (1997) Hoof cracks and hoof wall avulsions. In: *Current Therapy in Equine Medicine IV.* Ed: N.E. Robinson. W.B. Saunders, Philadelphia, pp 73-77.

Riggs, C.M., Proudman, C.J., Hughes, I. and Caldwell, M. (1995) Management of traumatic, partial hoof avulsion in 2 horses. *Equine vet. Educ.* **7,** 140-144

Stashak, T.S. (1989) Management of lacerations and avulsion injuries of the foot and pastern region and hoof wall cracks. *Vet. Clin. North Am. equine Pract.* **5,** 195-220.

Steckel, R.R and Fessler, J.F. (1983) Surgical management of severe hoof wounds in the horse; a retrospective study of 30 cases. *Comp. cont. Educ pract. Vet.* **5,** s435-s443.

Turner, T.A. (1990) Hoof wall lacerations. In: *Current Practice of Equine Surgery,* Eds N.A. White and J.N. Moore. J.B. Lippincot Co., Philadelphia, pp 402-404.

Chapter 12: Hospital plate shoes

Stuart Marshall

Hospital plate shoes can be described as any horseshoe with a removable plate for the application of dressings to a hoof wound. There has always been a need for this type of shoe, especially within an equine veterinary practice where many injuries to horses' feet require protection. It has the advantage of putting pressure on the wound site, preventing excessive granulation tissue. Dressings can be applied more economically and with greater ease.

Hospital plates are well documented in many books and papers written by authors recognising the potential for improved management of foot wounds. A hospital plate shoe is described by Lungwitz in 'Horseshoeing', first published in 1884 (Figure 1). This book makes reference to 2 types: one uses splints of wood wedged between the shoe and the foot and is for hospital use; the other uses a cover plate held in place under a toe calk with 2 screw calks at the heels to be used for 'street–nail treatment'. The similarities between this shoe and those described in this chapter are remarkable; in fact the only differences with the modern versions are the additional use of modern materials. There are now several hospital plate shoe kits made of plastic that can be attached to the hoof using adhesives. This author believes that, as yet, their efficacy is unproven.

There are many uses for the hospital plate shoe, and these are covered in greater detail in other chapters and Volume II; eg abscess and canker, penetration injuries, sequestrum removal (see Volume II) and keratoma (see Chapter 10: Keratoma of the Hoof Capsule).

Care must be taken to ensure that any shoe is safe to use for both owner and horse. Some plates are inherently dangerous, one being the hinged plate. Once the fixing is undone, the foot cannot be dropped until the whole procedure of dressing has been completed. This is because the plate is permanently attached to the shoe; it may injure the horse were it to pull its foot away or damage the plate making it unusable.

The author has used, in a clinical situation, many hospital plates of varying designs; the 2 described in this chapter are his shoes of choice for all cases. They have a simplicity of manufacture and are practical to use. There are many elaborate designs for hospital plates, but it is the ease of use that is the most important aspect to the horse owner, veterinary surgeon and veterinary nurse. The 2 basic types described in this chapter are the 4-bolt plate and the 'Farley plate, plus variations that can be made to cover every eventuality (Figures 2 and 3).

The 4-bolt plate

Materials and tools

The requirements for the 4-bolt plate are:

- The bolts (correctly called set screws) for securing the plate to the shoe, chosen according to the size of the horse. M10 are an ideal choice for most progressing down to M8 or M6, for smaller shoes.

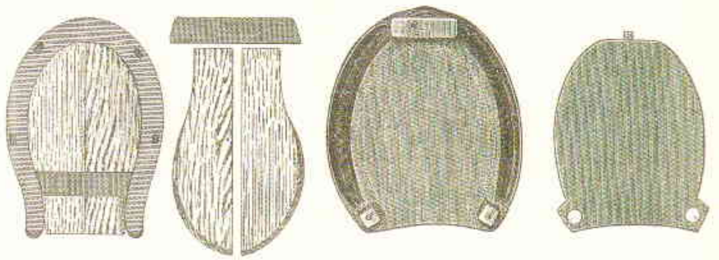


FIGURE 1:

Lungwitz described and illustrated 2 types of hospital plate in 1884.

FIGURE 3:

The Farley plate requires only one bolt at the heel, making changing dressings very simple and allowing exercise if required.

FIGURE 2:

The 4-bolt plate has many variations; this is made for a foal, the plate is attached with slotted pan head machine screws.

Most metric sizes of bolt do not have an imperial equivalent, however a $^3/_8$ Whitworth hole will accept an M10 bolt.

- The plate needs to be at least 6 inches (150 mm) wide, for most adult cases. The material used for the plate is aluminium, mild-steel or stainless steel chosen on each case's merits and with consideration of the tools and materials available. The thickness of the plate needs to be at least 5 mm ($^3/_{16}$ inch) for aluminium with thinner gauges being used for the stronger stainless or mild-steel.
- The tools required for these plates will include: 2 self locking pliers (Vise Grip Pliers or Stanley Mole Grip Pliers) hacksaw, jigsaw, electric drill or pillar drill, a selection of drill bits from 5–12 mm, lubricating/cutting fluid (Dormer Supercut), a centre punch, hand files and the usual hammers, tongs and other forging tools.
- The type of shoe is chosen bearing in mind the severity of the case. Eggbar shoes are the first choice, and heartbar shoes where the injury involves the hoof wall and frog support is needed (Figure 4). It should be remembered that this shoe makes wound management more difficult.

FIGURE 4:

Where there is less laminal attachment, frog support can be combined with a hospital plate by way of a heartbar.

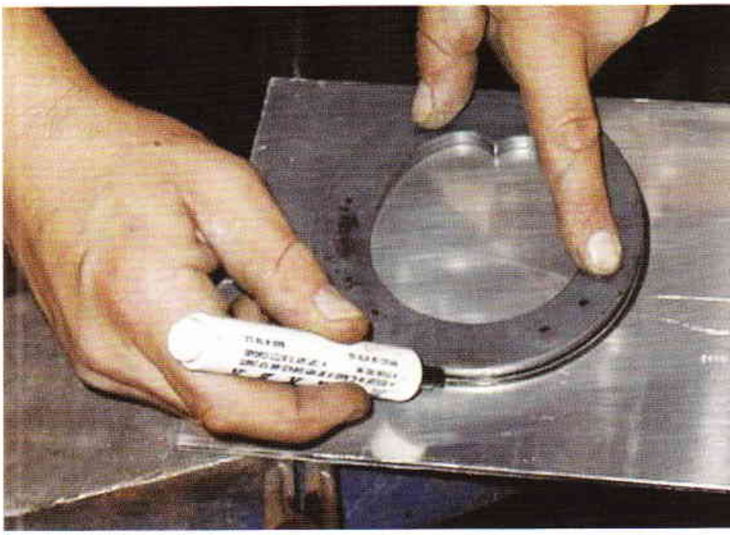


FIGURE 5:

After the eggbar has been fitted to the foot, the plate is marked with a pen or scribe.

Method

Step 1: The foot is trimmed and the shoe chosen and shaped to fit th foot before any surgery. Whilst the foot is being operated on the res of the hospital plate can be made. Co-ordination between the farrie and the hospital increases the efficiency of the process.

Step 2: The material is selected for the plate. Aluminium is softe and easier to work but will have to be a thicker gauge to resis deforming. Steel is a little harder to shape but can be drilled an ground to shape. It can also be heated and forged if necessar Stainless steel is a good choice as it is easier to keep clean and resist corrosion. However, it is harder to work. Care must be taken t make sure that all cutting tools are sharp as it will work harde making drilling and cutting practically impossible. Angle-grinder should not be used on stainless steel as the material hardens ver quickly.

FIGURE 6:

The plate is cut along the marked line. This can be done by a number of methods, including a powered jigsaw.

Step 3: The shoe is marked around with a pen or scribe and the plat cut out with a hacksaw or jigsaw keeping to the outside of the circl (Figures 5 and 6). Using a recommended lubricant will help th procedure. Slow speeds are recommended for cutting stainless stee using oil or a good pair of aviation snips or hand nibblers. The plate finished using a file to remove any sharp edges.

Step 4: Once the plate is cut out, it is clamped to the shoe in th correct position with self-locking pliers. The best position for th fixings, avoiding the nailing and wound areas, are marked for drillin

FIGURE 7:

The plate and shoe are locked together and 2 8.5 mm holes drilled diagonally oppposite.

FIGURE 8:

The holes are tapped to take a 10 mm bolt.

These are centre punched, if using either of the steel materials, as the drill bit will slip. The final position of the centre marks will resemble a square, with one bolt either side of the toe and one in each heel.

Step 5: The toe of the plate is marked with a centre punch, making a series of dots resembling a 'T'. This will help anyone removing and refitting the plate with the correct orientation. The holes can now be drilled taking care to centre them in the web of the shoe. The shoe and plate are clamped together and the shoe placed uppermost on the pillar drill table (Figure 7). All 4 of the positions marked can be drilled but this can complicate positioning of the plate, making changing the plate a longer process. To speed up the process of removal and refitting, only 2 holes, diagonally opposite, are drilled through the shoe and plate (Figure 8). Four bolts are a good alternative for either large breed horses or shoes with smaller bolts.

Step 6: Once the plate and shoe have been drilled, they should be separated and another 2 holes drilled in the plate at the additional 2 centre marks. These then have 'false' bolts rivetted in.

The plate holes are enlarged with a 10 mm drill to allow the bolts through. If the holes do not line up exactly, the holes can be increased to 11 or 12 mm until they do. It should be noted that the bigger the holes, the less stable the plate when fixed.

Step 7: The shoe's holes are tapped out to the desired size of M10 using a lubricant (Figure 9).

FIGURE 9:

Care must be taken when tapping to facilitate ease of use.

FIGURE 10:

The bolts are inserted and cut flush with the foot surface of the shoe.

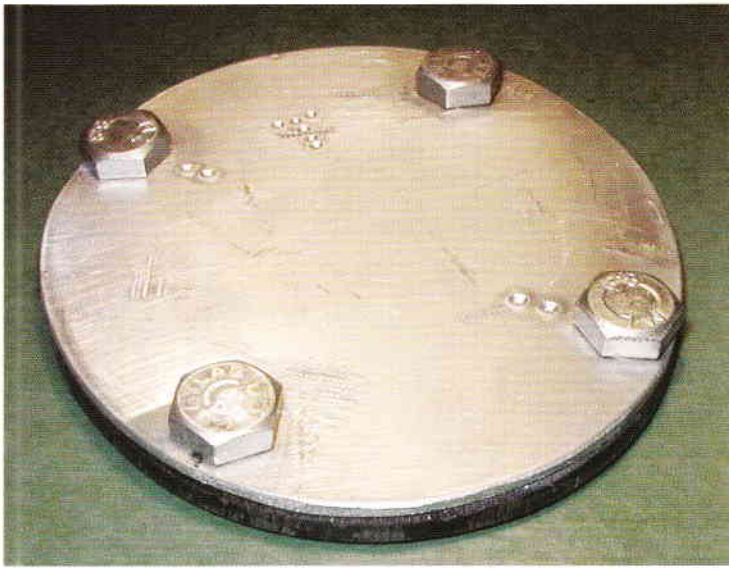


FIGURE 11:

The finished 4-bolt plate. Note that it has 2 'false bolts' rivetted to form a stable base. The removable bol have been marked, as has the toe.

The plate and shoe are bolted together with 2 x M10 bolts with th 'T' at the toe. Removing the excess bolt length with a hacksaw, th threaded end is unscrewed and filed at an angle all round to remov burrs (Figure 10).

The ease of fit is checked and the bolts inserted with fingertips. It i important that this is possible and that only the final tightenin requires a spanner as it speeds up the fitting for those who would b using this shoe the most, ie the veterinary surgeon, veterinary nurs and horse owner.

Step 8: The finished 4-bolt plate (Figure 11) can be nailed to th horse's foot, after which any nail heads that protrude above the shoe ar filed level. This will enable the plate to be bolted down squarel without distortion. The area within the shoe is flushed well to remov any debris, prior to filling with swabs. This void, especially the woun site, is packed with swabs level with the shoe. Some more swabs ar then added evenly so that the plate will pressurise the wound site.

This pressure is very important as it prevents exuberent granulation o the raw area and enables the veterinary surgeon to keep track of an infection underneath the granulation of the wound.

FIGURE 12:

The flange plate is a variation of the 4-bolt where some wall has been removed to access the lesion. The flange is cut out at the same time as the plate and bent up to the required angle and radius.

Variations on the 4-bolt plate

There are many variations of the basic 4-bolt plate, including flanges for the cover of hoof wall avulsions or where access to an infection has required the removal of some hoof wall. Flanges help hoof wall wounds to be dressed easily with swabs and, if pressure is needed on them, the flange can be pulled away from the hoof, the swabs applied and the flange allowed to spring back onto the dressings (Figure 12).

Step 1: A rectangular shape is added to the outline of the shoe drawn onto the plate. This represents the flange. The length of this flange should be made to cover the wall wound including the thickness of the shoe, eg if the wound is 2 inches high (50 mm) and the shoe thickness is $^5/_{16}$ inches (8 mm), then the flange needs to be at least $2^1/_2$ inches long (63 mm). The width of this flange should overlap the margins of the wound by at least $^1/_4$–$^1/_2$ inch (6–13 mm).

Step 2: The plate including the flange, is cut as marked. Once the plate is cut and finished and all the holes drilled, the shoe and plate are bolted together and inserted into a gas forge. More direct heat can be utilised using a gas torch. Heating makes forming the flange-bend

FIGURE 13:

The flange plate in Figure 12 seen from below. Because it is for a foal, a very light section was used and nuts were welded to accept the 6 mm bolts.

FIGURE 14:

Dental impression material (DIM) can be moulded inside the shoe to improve sealing and wound pressur

FIGURE 15:

A variation of the 4-bolt plate is the three-quarter plate shoe, where the shoe webb interferes with access to the lesion.

FIGURE 16:

The three-quarter plate shoe has a low flange to cover th area of shoe removed.

FIGURE 17:

The finished Farley plate from below. Note how the tongue fits under the toe and the heel is tipped up to protect the bolt from wear.

FIGURE 18:

The slot for the rostral tongue can be indented i aluminium using a tool made for the purpose.

easier. The time of heating is gauged so as not to melt the aluminium plate. NB If steel is used this is not a concern, however, stainless steel is difficult to forge.

Step 3: Once the flange is hot, the shoe and plate are removed from the forge and placed in a vice with the flange uppermost. Using a hammer, the flange is bent inwards at its base and formed into a curve around the shoe and along its length to match the hoof wall angle.

Step 4: The shoe and plate are checked to ensure that forming this flange has not made the fitting too tight.

Other variations of the simple 4-bolt plate include: foal size plates using small M6 bolts (Figure 13), the inclusion of a frog support riveted to the plate, the use of dental impression material to provide support within the shoe void (Figure 14) and a three-quarter shoe (Figures 15 and 16) applied where the injury is too close to the wall and the shoe would cover the site making wound dressing impossible. In the case of three-quarter shoes, the plate can be made with a flange the same height as the thickness of the shoe and then bent to cover the opening in the shoe.

The Farley plate

The 'Farley' plate was first designed and made by D. Farley of Ohio and was published in The Horse magazine in 1998. It is a good choice for many different solar problems and it is easy to use as it has only one bolt (Figures 3 and 17).

Materials and tools

- Aluminium or steel eggbar shoes.
- Stainless steel or aluminium plate, at least 6 inches wide, to accommodate most sizes.
- A square stamp, at least 19 mm ($^{3}/_{4}$ inches) wide, for the rostral tongue insertion.
- Tools remain the same as for previous plates. However drilling stainless steel is made far easier with alloy HSS including cobolt, which maintain hardness near red heat, drill-bits.

Method

The method needs to be followed closely in order to gain maximum benefit from the shoe.

FIGURE 19:

The eggbar is bent away from the ground surface immediately after the point of buttress. It must not impinge on the heels but needs to be of sufficient angle to remove the bolt from ground contact.

Step 1: An eggbar shoe must be selected for this type of plate. It needs to be oversize by one or more sizes.

Step 2: Once the shoe is fitted to the width of the foot, a square slot is forged centrally in the toe taking care not to distort the inner web of the shoe; any bulges are removed with a half round file. This slot can also be made by cutting each side with a hacksaw and then filing it out with a square file or can be made with a special tool (Figure 18). This section must closely match the rostral tongue for a tight fit.

Step 3: The heel section of the shoe is bent upwards just after the heel buttress. This can be done over the edge of the anvil or preferably in a vice. Care must be taken with this step to maintain a certain gap between the shoe and the heel bulbs (Figure 19).

Step 4: The outline of the shoe is drawn onto the plate and cut out. The shoe and plate are placed together and clamped with a pair of self-locking pliers. They are placed in a vice with the heel bend level with the top of the vice jaws and the plate is bent to conform the shoe.

Step 5: Without removing the self locking pliers, a hole is drilled centrally in the heel, through both shoe and plate. The plate is removed and the hole opened out to 10 mm.

Step 6: The plate and shoe are fitted together using a M10 bolt. They are positioned centrally, and a line scribed around the inside of the shoe at the toe. Removing the plate once more, 2 scribed lines are made from the outer edge towards the scribed mark at the toe. These 2 marks need to match the width of the toe recess. The lines are cut towards the centre of the plate and stop past the scribe line at a distance equal to half the thickness of the shoe or depth of the recess.

FIGURE 20:

The finished plate is bent at the correct angle at the heel and the rostral tongue fits the indent into the shoe.

FIGURE 21:

A 4-bolt hospital plate shoe raises the foot a considerable amount.

Step 7: Using a pair of locking pliers, the tongue is bent upwards and the plate bolted to the shoe again. The tongue is filed and hammered down into the toe recess. Any amount of the tongue that is not level with the foot surface of the shoe is removed. The tongue will now be slightly tapered but the plate will slide more easily into the toe recess (Figure 20). Finally, the ease of removal and refitting is checked as the tongue can become quite tight.

Step 8: When the shoe is offered up to the foot, particular attention should be paid to the area of sole at the toe. This may need to be eased with a knife to allow easy access of the plate. The fit should be tried before nailing on.

Step 9: After nailing on the shoe, the nail heads are filed off so that the plate lays flat and does not distort once the bolt is tightened.

Step 10: The area within the shoe needs to be flushed with dilute Povidone-iodine, to remove any debris, and Povidone-iodine swabs inserted to exert pressure once the plate is fitted.

The 2 plates described do have draw-backs, but with care these can be reduced. First, the 'Farley plate' has no means of grip and can be slippery on mud and grass surfaces. The rivetting of steel strips across the plate, use of checker plate aluminium instead of stainless steel or application of studs are all means of improving grip. The bent heel can cause excess pressure on the heel bulbs and subsequent lameness may be more acute than the original injury or surgery. Accurate fitting to avoid heel bulb pressure is essential to avoid this. Care needs to be applied to make sure there is a small clearance between the shoe and foot in this area. Flat footed horses will suffer from this problem more than a horse with an upright heel conformation.

Wear of the plate at the toe can sometimes be excessive and prolonged use of this shoe may result in a new plate having to be made. Both types of plate will deform over time due to uneven ground, concaving the plate upwards into the void. This is corrected by flattening the plate with each shoeing.

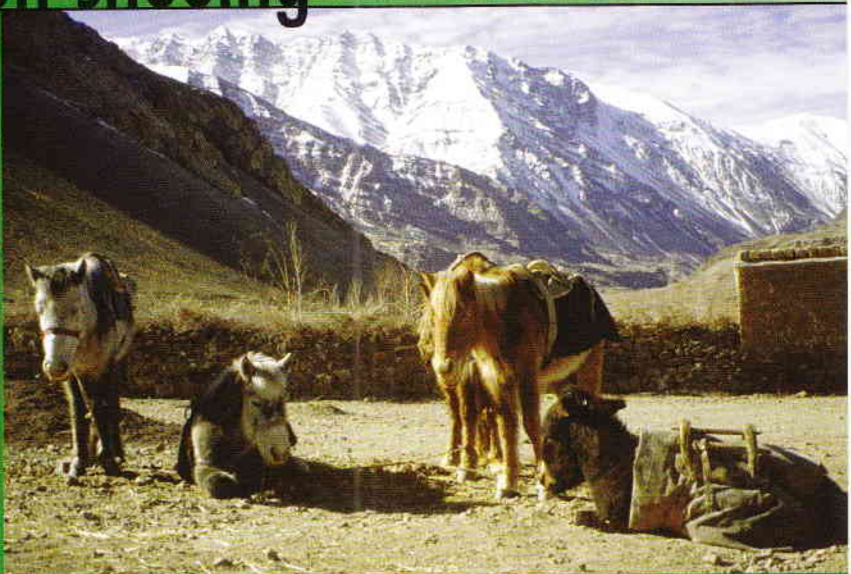
The 4-bolt plate has few problems, but the most evident is the thickness of the combined pieces; shoe, plate and bolts (Figure 21). Fitting a thicker shoe on the opposite foot will help the horse to feel more evenly balanced. However, the author has not really found this to be a problem over the short time during which the shoe is normally used. Most of the cases requiring a hospital plate are usually put on box rest and are not exercised at all during the time of convalescence. The bolts often wear heavily at the toe and may need to be replaced.

Further reading

Lungwitz, A. (1913) Horseshoeing. 11th edn., Oregon State University Press, Corvallis, Oregon.

Martinelli, M.J. and Ferrie, J.W. (1997) Farrier primer for the student and practising veterinarian. *Equine vet. Educ.* **9**, 89-97.

Chapter 13: Geographical influences upon shoeing



Dan Bradley, Bernard Duvernay
Sergio Muelle Goldstein and
Chris Pardoe

Despite being a success in its natural environment, the equine foot becomes susceptible to disease and injury when subjected to the demands of domestication.

The adaptation of animal species is highly dependent upon the environment and upon the climatic changes that our planet has sustained over time. The evolution of different horse species and the development of their present morphology bear witness to this fact. The earth displays pronounced climatic differences between the arctic and antarctic, also from the very arid to the humid regions of Asia or other continents. Some regions enjoy constant climates, but others have seasonal changes in which living conditions vary from extremes of cold to hot or from drought to flood. These characteristics affect all people, plant life and animals which are native to these regions and force them to adapt (Figure 1).

INTRODUCTION

Through the ages, man has shown himself capable of adapting to changing conditions, adjusting his life rhythm, diet, habitat, garments and shoes to the harshness of his surroundings. Flora develops and adapts as a function of the climate and of available insects, mammals and fish which complete the life chain of the region. For eons, a natural balance existed on our planet.

It is only relatively recently that people, animals and flora have shifted and been implanted into foreign zones. Today, new disorders, diseases and phenomena of species proliferation or eradication can be observed. Adapting to these huge changes requires a lot of time.

Horses have also been subjected to such changes, first with the migration of their wild herds, then with colonisation of the continents, and today for business or sport purposes. Just like man, the horse suffers from these upheavals: diseases, breeding and growth disorders can result when the animal is removed from its native environment.

At the start of domestication, the horse travelled over open ground, trails and generally within the environment into which they were born. Used as a means of hauling materials and goods, and for human transportation, they received no specific hoof care. As populations grew, the horse became a valuable farm animal and a means of carrying armies into battle. The need for hoof care then became paramount. The science of farriery had its fledgling beginnings, as populations became less nomadic and settled in cities, Horses were then used not

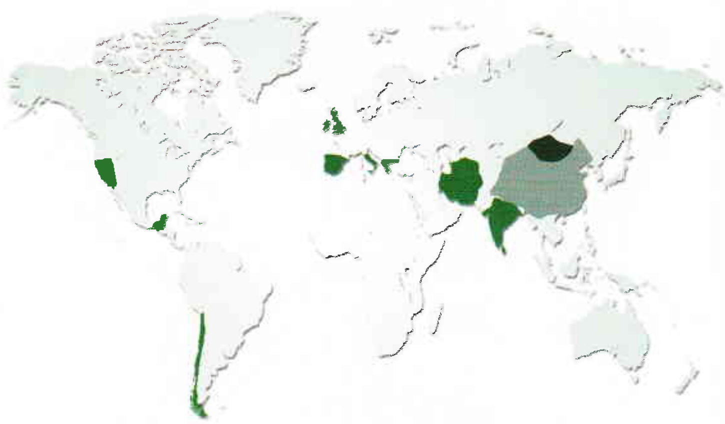


FIGURE 1:

The horse has a geographical spread across the whole globe. This chapter looks at factors affecting farriery in the marked areas.

FIGURE 2:

Pune, India: Nomadic shepherd women with their ponies before leaving the night camp.

only for farming and military purposes, but for every form of transportation, light to heavy (Figure 2). As a result, different types of horse were bred for specific tasks. During the 20th century the work load for the horse in developed countries was replaced by recreational use .The advent of surfaced roads, and the change from an open herd environment to confinement in stables, created additional hoof problems.

Horses in confined spaces may be subjected to wet, dry or soiled bedding. Wet conditions can produce an over abundance of moisture and subsequent loss of hoof wall integrity. Dry conditions can produce a hard constricting hoof wall and contraction of the hoof. Soiled bedding can produce hoof diseases as a result of bacteria and fungal growth. The health of horses living outside can also be influence by ground composition. A high alkaline content can cause a breakdown of the inner hoof wall. Rocks and hard ground can cause sole bruising, hoof wall avulsions and heel soreness. Wet and muddy conditions can cause lamenesses associated with abscesses, scratches, fungal and bacterial infections. Paddocks that are too lush in the spring or autumn can cause an increased incidence of laminitis (Figure 3). A lack of exercise also adds to the overall hoof problems that farriers encounter, including a lack of circulation in the foot. Horses that are exercised daily are more likely to have healthy hooves.

Farriers must always be aware of the effect of changes in environment on horses' feet. The diversity of conditions in which horses must exist represent a challenge with must be met by an increased knowledge and level of skill.

FIGURE 3:

Killing them with kindness: in many climates, lush green grazing leads to conditions such as laminitis.

CLIMATIC EFFECTS AND THE IMPORTANCE OF EDUCATION

Bernard Duvernay

Climate is one of the major factors which affect the hoof; other important factors include the standards of farriery and the education of those in charge of the horses' care.

Usually, the farrier is directly responsible for hoof care and prevention of foot problems. He should therefore be the key person in advising owners, riders and grooms on everyday treatment methods and routine care.

Farriery, as a profession, has made considerable gains as a result of advances in veterinary medicine and technology. Today, the focus is on specific disorders and diagnostic accuracy. Technological developments - such as new plastics and glues, aluminium alloys, entire new ranges of factory-made shoes and appropriate tools - have all helped farriers work with much more specificity and precision. Unfortunately, these advantages are still mostly in the hands of farriers from the wealthy parts of the world. In countries where equine sport activities are not well developed, the cost of these products is still far too high relative to the cost of living and, consequently, hard to obtain locally (Figure 4).

FIGURE 4:

Honduras, Central America: Farriers working with very simple tools manufactured locally and limited knowledge.

In this author's opinion, the secret to success in underdeveloped countries is to keep goals simple and modest. Prime importance should be given to skill over technology. It is always possible to improvise and find a solution. Only by striving for standards of excellence in farriery education will we help raise practice to reasonable levels. In this, the disciplines of anatomy and physiology constitute the basis of our knowledge. Without this solid base, we are not likely to be in a position to perform trimming and shoeing, to deal effectively with the daily problems of the horse's feet that we encounter everywhere.

Breeds and horse displacement today

There are 5 recognised equidae in the world. They are:

1. Equus caballus (domestic horse).
2. Equus asinus (donkey).
3. Equus quagga burchelli (Common or Burchell's zebra).
4. Equus zebra (Mountain zebra).
5. Equus grevyi (Grevy's zebra).

FIGURE 5:

Many local breeds are adapted to their local situation. The Marwari of Rajasthan, India, seen here at a water point, is suited to its arid environment. Note the ears, peculiar to this breed.

Today there are a great number of equine breeds around the world. Many are specific to their isolated regions and, therefore, not generally well known. All these horses, mules and donkeys have their own distinctive morphological features; they are incredibly well adapted to the harshness of the climate and to the efforts that are required of them. This can easily be observed in the robust familiar breeds around us, such as the Irish or British Cob, the Welsh pony, the Swiss Franches Montagnes, the French Baudet du Poitou or the Sicilian donkey. But there are less well-known breeds, such as the Criollo of Latin America, the Marwari of Rajasthan in India (Figure 5), the Akhal Teké of Turkmenistan and the Mongolian pony (Figure 6). All these breeds went through the ages as faithful helpers in tasks that man could not accomplish alone. Since their domestication around 3,000 BC, horses have been bound to man in his great conquests and in his urban and rural pursuits. Some breeds were more adapted to heavy work, others to work requiring speed. This is why, in the past, Persian horse dealers sold their Arabian horses to the Indian Maharajas; in the same way, Sicilian or Catalan donkeys were exported to the USA, where they went on to produce the huge mules seen in the agricultural farms of the American great plains. By losing their identity and adapting to different conditions in their new environment and their new occupations, some species have also contributed to substantial changes within their breed. History is full of such cases.

Today machines have taken over most of the heavy jobs that horses once did: this has become a tragic situation for the draft-horse whose

FIGURE 6:

Hohhot Inner-Mongolia, China: Mongolian horses with traditional riders at a breeders' meeting.

FIGURE 7:

Ladak, Himalayas: Native ponies with their saddle packs.

role in society has disappeared. In countries such as France, draft-horse breeding has had to be subsidised to prevent the species from total extinction.

Sport and leisure activities have helped to develop new potential for professions dependent on the horse. New breeds or cross breeds have been developed to fit the needs of all these activities. Now that horses travel by air, and distances are not an obstacle, horses are often moved to environments far from their homeland.

Influence of climate on the horse's foot condition

As a result of climatic and topographic conditions, the changes observed in the characteristics of the horse's foot bear witness very visibly to this adaptation, even to its evolution over time. An example of this is the ability of small horse breeds such as the 'Criollo' in South America to endure and adapt to very hard labour. These, and others such as the ponies and donkeys of Ladak, are sometimes obliged to work in extreme conditions of heat or cold, in icy winters and on difficult rocky paths (Figure 7).

These conditions are hard on the horses, but even more so on people who, in these circumstances, are unlikely to be moved by feelings of pity for the labouring conditions of their work companions. In general these little horses have very solid hooves which are often damaged by irregular care and poor shoeing. However, sport horses imported from the other side of the world, often suffer from the radical climatic and dietary changes when they are brought up in conditions so different from those of their native region. These situations, imposed upn the sport horse, seem less acceptable because they result from the whims of the rich. Many owners are insufficiently aware of the care these fragile horses require when they are removed from their natural habitat. Sport horses have often been weakened by the selection of breeding stock being based upon performance rather than conformational strength.

The most striking consequences of a changed environment is the effect on the horse's foot; growth disorders, poor horn quality and foot shape, growth rings (Figure 8) and thrush are all common sequelae.

FIGURE 8:

Honduras, Central America: Growth rings and deformities of the foot, poor hoofcare and farriery.

Horses that remain in a feral environment have been less affected by these changes. They are able to mate on the basis of natural selection, without human intervention. Generally these breeds have very strong feet which adapt either to wet lands or to arid, hard ground.

In humid conditions, foot size is appears to be greater because the hoof walls have a tendency to flare. Humidity makes the feet more tender and more vulnerable to abrasion from the ground and hard surfaces such as rocks, tree-stumps or foreign bodies. Horses working on soft ground usually require shoes to protect their feet and to increase their grip and traction. In dry and very hot conditions, horses develop incredibly tough horn capable of resisting wear and providing a high level of protection.

Physiologically, horses' feet appear to be better adapted to dry, hot conditions than to moisture. Arabian horses in their native region are a perfect example of optimum adaptation to a hot, dry climate. The need to shoe these horses will be dependent upon the intensity of work to which they are subjected.

In countries where traditional farriery methods are somewhat basic, the most severe problems tend to occur in imported horses. The local farriers have not been trained to manage the type of hoof problems are common in sport horses. This is not surprising given that, even in the west and in the hands of competent professionals, these horses require very meticulous farriery, with no margin for error.

SHOEING HORSES IN ASIA AND LATIN AMERICA

Bernard Duvernay

Dry climates

Horn dehydration and its consequences lead to severe problem for many sport horses imported to hot countries such as Iran India, China or Mexico. It is difficult to give temperatur ranges, humidity and rainfall values for these countries because the are so vast that the climate varies a lot from one part to another. Bu for example, the highest temperatures are 38°C in Teheran, 40°C i Chennai, 32°C in Beijing, 36°C in Mexico. The humidity is very lo in these areas, except Chennai due to the proximity of the sea. Th percentage of air humidity during this high peak of temperatur tends to create a variation in hoof condition which can lead to hoo damage unless day to day preventive care is implemented. Man warm blooded breeds suffer from the heat because of lack o appropriate care. Dehydration of the horn weakens the walls an renders shoeing, and in particular nailing, difficult. The wall ver often disintegrates, reducing the surface in contact with the shoe an making a secure attachment of the shoe more difficult.

Flat feet, soles with poor or no concavity, quickly become ver difficult to manage. Feet that are in contact with hard ground suffe from excessive pressure on the sole. Irreversible situations arise rapidl if farriers lack the knowledge and/or materials for adequate sol protection.

Cracks, consequences of trimming mistakes (long toe, low heels interference injuries (from studs or the shoe), transport accidents o even poor shoe fitting, indicate the beginning of very traumatisin effects on the feet. Small injuries, neglected trimming or shoeing, lac of good care or incorrect modification of the hoof shape are often th origin of lameness. These can limit or interrupt the career of th athletic horse (Figure 9).

FIGURE 9:

Guatemala, Central America: A heel crack caused by a coronet injury on a very dry foot.

Here again, a lack of adequate knowledge of these disorders, of th physiology of the hoof and of all the farriery possibilities will be handicap to prevention and treatment of the problem. Cracks als occur on barefoot horses when the horn is dry and lacking elasticit for the same reasons as stated above.

FIGURE 10:

Iran: An Arabian horse with contracted feet and high heels. These feet are a result of the environment and lack of farriery care.

On imported sport horses especially, the feet require specific daily care to prevent the evaporation of horn moisture and thus maintain greater elasticity. Applying oil on the wall offers good protection. An animal or vegetable oil will help reinforce the periople effect. The following ointment formula is cheap, efficient and easy to prepare: wax + liquid paraffin or pig fat or honey + mustard oil or coconut oil or laurel oil or olive oil in equal proportions. One should beware of all synthetic oil products, old engine oil causes a drastic caustic effect to the hoof.

If there is a deficiency of horn quality or of speed of growth, massaging the coronet twice a day (5 to 10 min each coronet) with a soft cream offers effective treatment. Several creams specifically mixed for this purpose are available on the market, but if nothing else is available, one can give a vigorous massage using ordinary hand-cream mixed with some laurel oil. Plenty of exercise is also very important for conditioning the feet; it stimulates blood circulation and the hoof capsule expands and contracts with each step. Diet must also be managed and should contain all the ingredients necessary to ensure healthy horn growth.

Contraction of the hoof is observed on narrow feet, which tend to grow mostly in the heel. This foot shape tends to grow straight and too high in the heels, with a consequent loss of good physiological movement. Poor trimming and a lack of extension of the shoe

FIGURE 11:

Morning exercise on Pune racecourse, India, during the Monsoon. The rains arrive in early June and continue without break until the end of September.

branches, as well as a lack of exercise, will favour the development of this poor conformation. Once again adequate attention by the farrier is the only chance to change the foot shape or at least to prevent a painful and irreversible situation developing (Figure 10).

Long dry periods followed by wet (monsoon)

In countries affected by monsoon cycles, eg India, alternating dry and humid seasons will affect the horses feet; indeed it is during the monsoon season that most cases of lameness occur (Figure 11).

FIGURE 12:

Beijing, China: Mule feet with shoes made from lorry tyres. Farriers in third world countries often adapt materials found locally.

Feet which have become dry and hard in intense heat are suddenly plunged into muddy paddocks. This excess of moisture will rapidly make the hoof soft and vulnerable to the abrasion of the ground. At this time, many feet punctures, sole cuts and hoof abscesses have to be treated. It is sometimes very difficult to estimate the origins of these incidents which are not related to routine foot care. Foals, yearlings or adult horses are equally vulnerable.

Moisture also gives rise to thrush, white line disease and fungus, even to foot cankers. We know that humidity is a very favourable ground for bacterial or fungal proliferation. Many commercial products are available for these diseases, but wood tar, copper sulphate, iodine, iodine crystal + turpentine oil are still very good alternatives (Figure 12).

SHOEING HORSES IN SOUTHERN EUROPE

Sergio Muelle Goldstein

The environment

The environment of Mediterranean Europe is, in general, a dry one. Compared to the rest of Europe, the annual rainfall is significantly less and therefore the average relative air humidity levels are low. In summer this relative humidity can be less than 50%. The temperature can range from -10°C or below in winter to 48°C or higher in July.

This dry environment means that there is little available moisture for absorption by the hoof wall. Grass fields in summer can only be sustained at a considerable cost in terms of effort and money (Figure 13). Paddocks are often merely dry plots of compact earth. Making mud puddles next to the water troughs is not advisable, for this does not help maintain healthier hooves. As soon as the horse walks away, the mud on its feet dries and remains caked on the hooves, drawing moisture from the hoof wall. When this process is repeated a few times a day, the hooves harden ever more and become extremely brittle.

Types of breed

There are 2 main categories of horses to consider with reference to shoeing: a) Horses born and bred in Mediterranean Europe, whether native to the area or not; and b) Imported horses, born and bred in more humid climates.

FIGURE 13:

Arab horses 30 km north of Madrid. Sometimes, even as early as April, temperatures reach 34°C. They pass 40°C by August, after a long summer that begins in April. Any meagre shade is most welcome through the afternoon.

FIGURE 14:

A Spanish Andalusian. The hoof on the right has been trimmed showing the amount of growth removed in comparison with the untrimmed foot on the left. Despite the 30 mm growth, the shoe was not embedded in the sole.

a) The native horses, many of which have common ancestors, include breeds such as the Spanish Andalusian, the Skyros and Pindos ponies of Greece, the Portugese Lusitano and Alter, the Camargue in France, the Neapolitano and Calabrese breeds of Italy or the Bosnian pony of the Balkans. All are very different horses, with many different uses, but all have a very similar hoof type: thick soles, thick walls and a tight, contracted look to the whole foot.

In the heavier breeds, eg the Andalusian, we would expect to find bigger feet, more capable of supporting the large, often excessively heavy body, but the feet always seem to be one size too small. The quarters of the hooves are straighter than the ideal described in farriery literature. This is already pointing at a very limited capacity to expand on weight bearing (perhaps contributing to their characteristic high action; Figure 14).

The Arabian horse, probably the common ancestor to most, if not all, breeds is also bred in southern Europe. Although it shares all the hoof characteristics mentioned before, its feet are more in proportion to its body size. However, the quarters are still in general, straighter than the 'ideal'.

Due to the strong hoof quality of these breeds, when properly trimmed for balance, the hooves do not deform or easily develop collapsed heels which would alter the hoof-pastern angle, even after an 8 week shoeing interval. Neither does the hoof spread at the quarters, although a good 10–15 mm ($^3/_8$–$^5/_8$ inches) of wall may need to be trimmed off.

Recently in Spain, it has become quite common to see Thoroughbreds used not only on the racetrack and for show jumping, but also in Doma Vaquera competitions, which are comprised of a series of exercises similar to those seen in western riding, or even in bull-fighting from horseback. Despite this change in environment, their feet appear to remain sound.

Shoeing native horses

In general the sole is full, and the first layer is removed more easily with the hoof cutters, or a toeing knife, after paring the frog. When summer dryness is extreme, the excessive hoof growth becomes rock-hard and starting the trim is difficult. Under these conditions, it is easier to begin trimming the edge of the hoof wall with the cutters at an angle to the outside of the foot, from heel to heel. Once this first

FIGURE 15:

It is easier to begin trimming the edge of the hoof wall with the hoof cutters at an angle to the outside of the hoof, the sole will then be left slightly higher than the wall.

FIGURE 16:

The toeing-knife can be wedged under the sole and struck with the nylon hammer to drive it from heel to heel. These are excellent Spanish Andalusian horses. Note the contraction of the foot.

FIGURE 17:

Using the toeing-knife, the sole often comes off in one piece. Note the thickness of the hoof wall.

FIGURE 18:

This Spanish Andalusian was long overdue for a re-shoeing, yet its feet remain healthy and balanced. If we can imagine lines from the coronary band to ground surface at the quarters, we can visualise how the foot is more tube shaped than cone shaped.

rim has been removed, the sole will be slightly higher than the wall and the toeing knife can be wedged under it and struck with the nylon hammer. The external layer of sole comes off, sometimes in one piece, leaving a sole of a softer consistency, which can then be pared more easily with a drawing knife. This, in turn, exposes more excess hoof wall which can again be trimmed with the cutters. The hard outer surface of the frog will also be removed more easily by starting with the cutters rather than a knife (Figures 15 to 18).

In most circumstances, an all-purpose three-quarter fullered and clipped shoe of 20 x 8 mm ($^3/_4$ x $^5/_{16}$ inches), 22 x 8 mm ($^7/_8$ x $^5/_{16}$ inches) or 22 x 10 mm ($^7/_8$ x $^5/_8$ inches), is adequate. Natural hoof expansion is less on strong hooves with straight, upright quarters, yet shoeing with plenty of width is advisable to compensate for the relative narrowness of the foot. This should not cause any interference. Hot shoeing is also recommended, as it seems to help maintain a healthy hoof quality, this is probably by sealing the ends of the horn tubules (Figure 19).

Shoeing imported horses

Horses that travel to Mediterranean Europe from a more humid climate undergo an adaptation process which can be quite traumatic, depending on the breed, the time of year and the stabling conditions. The main concern is the rapid loss of moisture in the summer, which makes the hoof hard and brittle. This will cause the horse to feel the impact of its hooves on the ground much more intensely. This impact will not be dissipated by the foot's shock absorbance mechanisms to the necessary degree. The horse will tend to shorten its stride, and its movement will become more stilted.

Frequent shoeing is recommended, as excessive hoof growth will encourage cracks to develop. The application of hoof conditioners can help in maintaining the suppleness of the hoof wall. Many such conditioners are available in Northern Europe where they help keep moisture out of the hoof. Care should be taken to select one which is rich in natural oils (laurel, cod liver oil, etc). Feed supplements may also play a key role in aiding healthy hoof growth.

The shoes used should be as light as possible, as these will take lighter nails. Most shock absorbing pads do not have the expected positive effect; in fact they may even encourage the contraction of the foot and produce weaker quarters.

Regular exercise appears to keep the hoof healthier and more elastic. This can reduce the period of adaptation to the new environment.

Depending on the surrounding conditions, and the individual horse's adaptability, it can take from 6–12 months before a change in the hoof quality is apparent. Hoof walls will eventually strengthen to cope with

FIGURE 19:

A wide fit is always recommended to compensate for the relative narrowness of the hooves.

the environment, although occasionally some horses, particularly Thoroughbreds, adapt very poorly.

Hooves are sensitive to changes. The adaptation process begins at the coronary band and has to grow out. The negative effects on the hoof wall to a different environment, also have to grow out and the hoof effectively substituted by new horn developed in this different situation.

Under drought conditions, which can occur periodically, even native horses have difficulty in adapting to the increased summer, and decreased winter temperatures, with no true spring or autumn to act as a buffer. Quarter cracks can appear and are often very persistent, even multiple cracks are observed. These can be helped temporarily using patches (see Volume II), but usually recur and will only clear up completely when the climatic conditions return to normal and a new hoof has grown.

SHOEING HORSES IN WESTERN STATES OF AMERICA

Dan Bradley

The professional farrier of this age has many different products at his disposal. These include a large assortment of ready-made shoes, different types of pad, hoof fillers, sole protectors, etc. All of these materials enable farriers to service their clients more efficiently. One factor that does not change is the horse's ability to adapt to its environment. No better example of this can be found than in the desert regions of the western United States (Figures 20 and 21). The feral horses can have completely different hooves from one corner of a state to the next. In one area which is steep and hilly, horses' hooves tend to be more upright whereas, in another area with flat sandy regions, hooves may be broader with a lower angle. When these horses are brought into captivity, their hooves change dramatically. They are no longer travelling miles to feed and water or travelling up and down rocky hills or across sandy desert lands. Their environment may now be in a barn with a few hours of turnout each day. They may carry 100 lb (45 kg) or more on their backs. If they have a poor conformation in the wild, this will only deteriorate in captivity and present an even greater challenge for the farrier.

When we are confronted with a lameness case, we should ask "Does the environment where this horse lives cause or contribute to the lameness?" If so, the hoof care programme must be adjusted to

FIGURE 20:

Dry high desert region with little in the way of forage. Many of the feral horses of the southwest United States reside in these areas. These horses tend to have a more upright, boxy hoof.

FIGURE 21:

Southwest grass plains area in the spring.

FIGURE 22:

A working cow horse training farm. Irrigated pastures, dry dirt holding pens and sand surface working arena.

ompensate for the environment. This same principle applies to the ound horse. Is the total environment where this horse resides onducive to the job asked of it? Is the trimming/shoeing schedule dequate to maintain the horse in a sound condition?

The desert regions of the south west United States provide harsh living onditions for the feral horse. These 'wild' horses are actually classified s 'feral' because they escaped from domestic stock and are not native o North America.

The humidity of the region throughout the year is extremely low xcept in the south west region in the state of Arizona. This has a rainy eason during July and August. The humidity will be on the high side luring afternoon hours. The temperature range for the desert will wing from lows of -18°C to highs of 30–40°C.

Horses in the high mountainous regions will have fairly upright hooves those in the plains/sandy areas (Figure 22) will have a more xpanded hoof. The hooves of feral horses will be short with strong walls. In the high alkaline areas, hooves tend to disintegrate in a nanner similar to white line disease.

For farriers in these desert regions, the only real problem that is ncountered are hard brittle hooves. This problem occurs in the lomestic horses, confined in small areas. In these conditions, horses vould benefit from increased exercise and the application of noisturisers to the hoof wall.

SHOEING HORSES IN NOTHERN EUROPE

Chris Pardoe

It is now generally accepted that global warming is beginning t affect the world's climate and weather patterns are becoming mor extreme and liable to sudden changes. In Britain, seasonality i becoming less distinctive. Winters are wetter and warmer with th incidence of prolonged heavy frosts and snow diminishing, replaced b more heavy rainfall. Likewise, the incidence of protracted heat wave and droughts in summer months is increasing. Not only do thes changes affect the local hoof environment (ie temperature, humidit and ground conditions) but they also have an effect on the animal dietary intake as grazing conditions change. These changes ar occurring at rates greater than that at which equine hoof evolutio and structural adaptation can keep pace (Figure 23).

FIGURE 23:

In the UK and Ireland, hooves are frequently subjected to long periods stood in muddy paddocks.

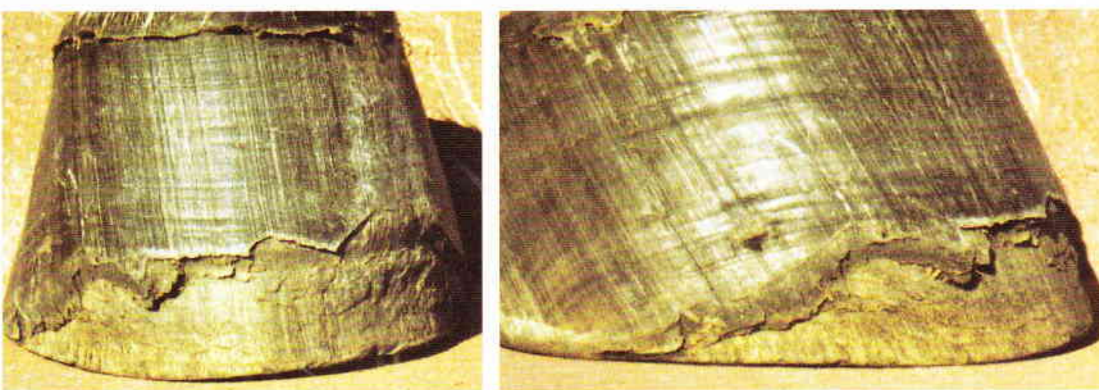
The mechanical properties of hoof horn are dependent on their wate content so extremes of heat or humidity will cause large fluctuation in the mechanical strength. These sharp changes increase the stresse within the horn capsule and, under load, can cause cracks to appea (Figure 24).

Dry brittle horn can break away with disastrous consequences an softened weak horn can collapse under load, leading to collapsed hee and laminar tearing.

In order to combat broken hoof walls the farrier can punch extra na holes in the shoe to allow better choice of placement or materials t re-build the hoof can be employed.

FIGURE 24:

Dry and brittle horn peels away, making secure nailing difficult.



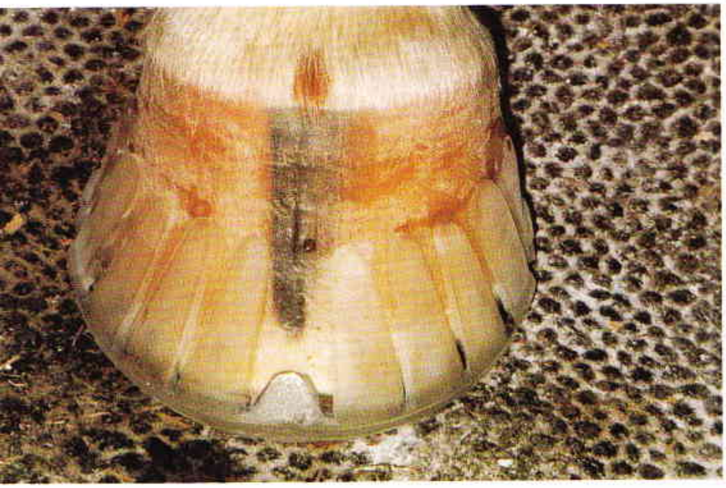


FIGURE 25:

Nail-less shoeing has been available in different forms for some years. This shoe is attached with cyno-acrylate glue.

/Iodern adhesives also offer today's farrier the opportunity to attach a hoe without the use of nails (Figure 25). Attention to the nanufacturer's preparation requirements must be followed closely to nsure success.

The incidence of onychomycosis or white line disease appears to be ncreasing. This may be related to the bacteria that lodge in the soil not eing diminished in the upper layers by frost. Consequently, with a varmer wetter winter environment, they are able to multiply and nvade the softened horn tissues earlier and gain a stronghold before he hotter dry spells reduce their efficacy. This is emphasised in the case of the donkey, originally brought to Britain from the Mediterranean n Roman times. It has a different horn density to that of the horse nd, in its natural environment, its hooves are dry and tough. However, n the cooler but wetter weather of the British Isles, its hooves are very usceptible to ingress by horn digesting bacterium (Figure 26 a,b).

Because the seasons are becoming less well defined, dietary management s gaining significance. Certain types of laminitis that were 'seasonal' are now being diagnosed throughout the year. Horses are routinely having heir diet supplemented in one form or another. Although this may be beneficial, over supplementation or under supplementation can cause problems. Imbalanced diets can lead to horn qualities that are favourable o sulphur reducing bacteria. Many supplements contain trace elements hat the animal needs for normal everyday function. Excessive upplementation may overload the system and, although excesses of ome elements may do no harm and be excreted easily, others may emain and build up to toxic levels, eg selenium.

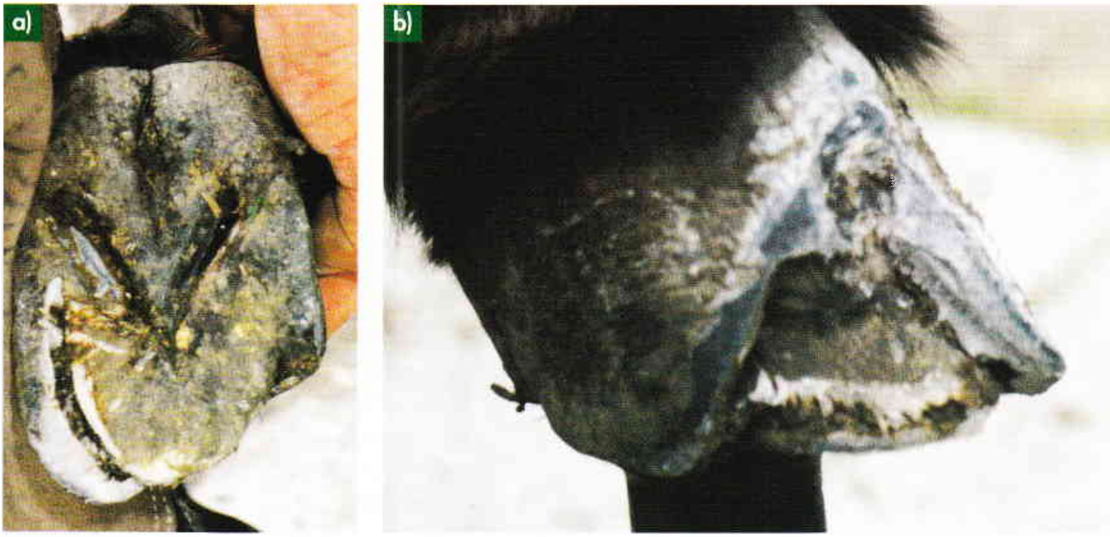


FIGURE 26:

A donkey has hooves that are adapted to arid and stoney conditions. In a damp north european climate they become very susceptible to horn digesting bacteri and fungi (seedy toe). a) Shows the loss of bearing surface; b) Shows the area of hoof wall undermined.

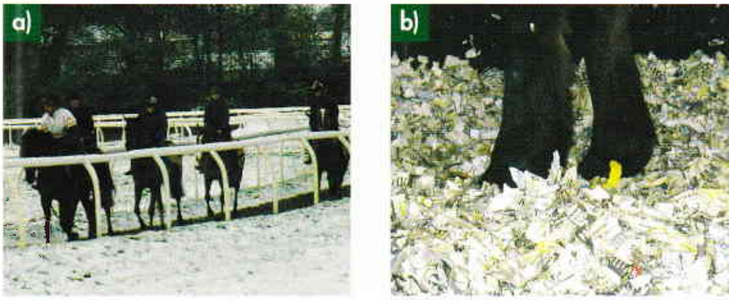


FIGURE 27:

Some artificial exercise arenas (a) and bedding surfaces (b) create conditions favourable to bacteria that are detrimental to the horn. Paper bedding should not be allowed to become wet and soiled. Woodchip has become a very popular bedding material but is very drying to the hoof. Straw still appears to be the most horn friendly.

Some modern artificial exercise arena surfaces and bedding material are also creating unnatural microclimates for horses' hooves. Som surfaces utilise materials that, in damp environments, release metalli ions creating favourable conditions for some horn-digesting bacteri (Figure 27 a,b).

As the world's climate changes become more significant, today's farrie must become even more aware of environmental conditions and th problems that may ensue.

Further reading

Bertram, J.E.A. and Gosline, J.M. (1987) Functional design of horse hoof keratin: the modulation of mechanical properties through hydration effects. *J. expt. Biol.* **130,** 121-136.

Budras, K.-D., Schiel, C. and Mulling C. (1998) Horn tubules of the white line: an insufficient barrier against ascending bacterial invasion. *Equine vet. Educ. Manual No* **4,** *The Equine Hoof.* 11-18.

Butler, K.D. (1985) *The Principles of Horseshoeing II.* Butler Publishing, Maryville.

Compendio de Albeytaria (1729) Fernando de Sande y Lago, Joseph Gonçalez. Madrid, Facsimila, Edicios Do Castro, Galicia Espana.

Curtis, S.J. (1999) *Farriery - Foal to Racehorse.* Newmarket Farriery Consultancy, England.

Précis de Marechalerie D'Autheville, P., Fromond, P., 2nd Edition. Maloire, S.A., Editeur, Paris, France. Portugese edition by Organização Andrei Editora Ltda.

Turner, T.A. (1998) White Line Disease. *Equine vet. Educ. Manual No* **4,** *The Equine Hoof.* 73-76.

Rolph, C. and Woodall, P. (2001) The biology of white line disease: New findings and implications for the future. Presentation: *1st UK Farriery Convention, Preston, UK.*

Semiologia Clinica de las Cojeras y su diagnostico diferencial, Olhagaray, N., Editor Hemisferio sur, Montevideo, Urugaay.

Summula Da Alveitavia (1694) Antonio Pereira, Lisboa, Portugal.

Stashak, T.S. (Ed) (1987) *Adams' Lameness in Horses.* 4th edn. Lea and Febiger

Warren Evans, J., Borton, A., Hintz, H.F., Dale van Vleck, L. (1977) *The Horse,* W.H. Freeman, N. A., San Francisco and London.

Chapter 14: Laminitis

Robert Eustace, David Nicholls and Simon Curtis

INTRODUCTION

Laminitis is a common cause of lameness in horses and ponies in th 'developed' world. It was first recognised in 350 bc when it wa known as Barley Disease, which gives us a clue as to the commo cause in those days. Barley Disease is now known in various parts of th world as laminitis or founder. These terms are often used synonymousl but this is incorrect. Laminitis is the condition and founder one of th effects.

Laminitis is the term used to describe a typical heel-loading lameness c variable severity. Sequelae to laminitis include acute founder and sinkin which involve a dislocation of the distal phalanx relative to the hoo capsule. Recovered acute founder cases are termed chronic founde cases (Figure 1). While the aetiopathogenesis of laminitis is still no clearly understood, the bio-mechanics are more evident.

This chapter defines the terms used in describing laminitis, the commo causes, and many of the treatment options. In the sections dealing wit treatment, various alternatives are given. Although there is a theme c improving break-over and using the palmar (plantar) parts of the foo (especially the frog) to reduce laminal stress, some of the advice may b considered by the reader to be conflicting, ie the use of polystyrene foar and heel elevation. The 3 authors are specific as to their preference leaving the reader to select their own chosen method of treatment.

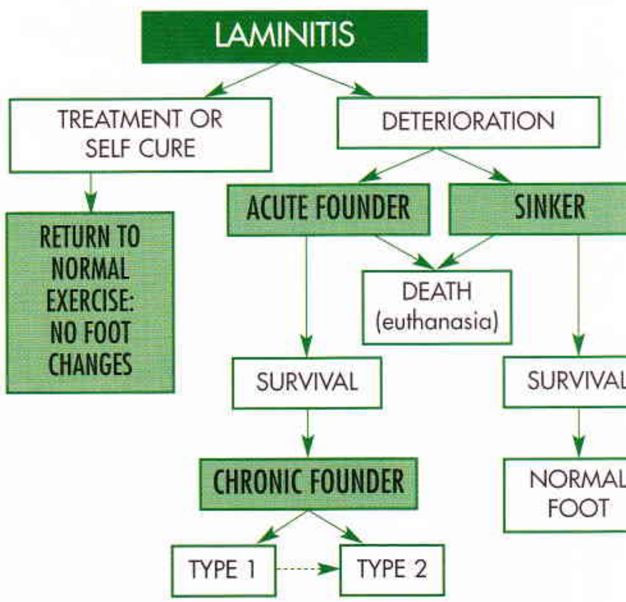


FIGURE 1:

Laminitis, if treated in its early stages, may not preclude the horse's return to normal use. However, in many cases the disease progresses to acute founder and/or sinking syndrome which may lead to death. In relatively mild cases, or those successfully treated, the horse survives with chronic changes to the distal phalanx and compromised hoof growth ('chronic founder'). Recovered sinkers have few changes to the feet.

LAMINITIS: DISEASE MECHANISMS, HIGH RISK SITUATIONS, PREVENTION, DIAGNOSIS, PROGNOSIS AND TREATMENTS

Robert Eustace

It causes intense pain, and if the disease progresses to the acute founder stage, can result in crippling changes within the horse's feet. Such changes may preclude the animal from participating in anything but the lightest athletic work. The most severe form of laminitis, sinking syndrome, is life threatening and in 80% of cases, necessitates humane destruction of the horse. Given that approximately 80% of laminitis cases are due to inappropriate management and feeding (Figure 2), it is clear that there is a substantial welfare issue.

Disease mechanisms

Presently there are 4 main theories attempting to explain the mechanism of equine laminitis.

Vascular theory

This is supported by the greatest amount of experimental evidence. The theory suggests that the initial events affecting the foot are those of vasoconstriction. Mediators, whether they be directly from the gut in dietary laminitis, or an infected focus in cases of sepsis, or via an intermediary organ such as the liver, are thought to initiate a constriction in the arteries and veins supplying the hoof. Alternatively, vasoconstriction could originate from activation of receptors on the blood vessels under nervous control. Vasoconstriction affects the veins more than the arteries. This increases pressure within the blood capillaries, increasing the tendency for fluid to leave the vessel and enter the surrounding tissues. This increase in tissue pressure causes pain. The vasoconstriction and increased tissue fluid pressure impedes the flow of blood within the foot. At the same time factors increase the permeability of the capillaries, increasing fluid leakage. In addition, the endothelial cells lining the capillaries and veins become attractive to platelets, which aggregate and form clots which further impede blood flow. As the systemic blood pressure has also increased, the afferent blood is diverted through the rich network of arteriovenous anastomoses (AVA's) directly into the veins. Thus there is an increased systemic blood pressure, increased blood flow to the foot but restricted (or no) perfusion of the tissues supplied by the affected blood vessels. The aim of treatment for those supporting the vascular theory is to achieve vasodilation, inhibit blood clot formation and improve or restore perfusion of the digital tissues.

Toxic theory

This theory proposes that many of the above alterations in blood flow and perfusion do occur but are secondary phenomena. The initial

FIGURE 2:

An obese pony is at high risk of suffering laminitis.

insult is thought to be damage to the basement membrane, whicl separates the dermis from the epidermis. This membrane is extremel convoluted within the foot, mirroring the anatomy of primary anc secondary laminae. This theory suggests that a toxin (the exotoxin o *Streptococcus bovis* has been implicated by Dr Pollitt) is responsible fo the damage to the basement membrane. It is proposed that this i achieved by the toxin reacting with a group of enzymes within th basement membrane, the matix-metalloproteinases, resulting ir splitting of the basement membrane and separation of the epidermi from the dermis. The severity of the damage is presumably related tc the dose of toxin delivered to the basement membrane. The treatmen for those following this theory involves promotion of vasoconstrictior or diversion of blood containing toxin away from the laminae.

Metabolic theory

This is much the same as the toxic theory but rather than the damag to the basement membrane being due to a toxin, this theory states tha the damage is caused by altered metabolism. In particular, depletion o glucose in *in vitro* hoof tissue explants has resulted in separation o dermal and epidermal laminae. Supporters of this theory treat cases b improving blood perfusion of the affected tissues by vasodilation closing of AVA's and perhaps the administration of insulin.

Mechanical theory

This relates to road founder, traumatic laminitis and weight-bearin founder and sinking. It states that in certain circumstances the weigh or repeated trauma inflicted on the laminae is sufficient to overcom

FIGURE 3:

The same pony (Figure 2) 3 months later after gradual weight loss. He is now at low risk and did not suffer from laminitis again during the remaining 8 years of his life.

the cohesion between the 2 sets of laminae. The other interesting finding in relation to weight-bearing founder and sinking is that, when the horse bears full weight on a limb, no blood can enter the foot. This could lend support to the metabolic or the vascular theory.

To compound these theories further, anecdotal reports by experienced practitioners report excellent success rates with diametrically opposing treatments, eg the use of ergonovine and cooling the feet versus acepromazine and poultices!

This author suspects that there are narrow time windows during which both of these treatments may be useful. The problem is that much of the damage to the horse's foot occurs before the owner/vet can see any lameness, so the chances of utilising these windows are slight.

The problem for researchers is either to find one unifying theory that explains how all the 'causes' happen or to give a proven mechanism for each 'cause'.

Preventing laminitis

It is more helpful to consider circumstances which render the animal susceptible to laminitis, rather than causes. An animal, which can be described by one of the following sets of circumstances, should be regarded as being very likely to develop laminitis. The term 'prone to laminitis' is often used. Being 'prone to' infers that it is an irreversible situation, to which the horse will always be subjected. This is not the case with obesity/dietary related laminitis, which make up 80% of the cases seen by this author. By correct management, these animals car be brought out of the high risk group (Figure 3). Only those animals with chronic untreatable systemic disease remain 'prone to' laminitis.

Diet and obesity

This author has encouraged all horse owners over the last 20 years not to allow their horses to become obese, as this puts them at high risk o laminitis. Although we are not sure exactly why this occurs, we dc know that many fat horses show insulin resistance, in other words they do not show a lowering of blood sugar concentrations when injectec with insulin. Recently, Dr P. Johnson at the University of Missouri has suggested a possible explanation.

The suggestion is that fat horses and ponies may be suffering from a syndrome which has been well recognised in human medicine, that o Omental Cushing's disease. In people, the omentum, a fatty sheet that covers the intestines, becomes an abnormal site for the production o the hormone cortisol. The omentum in these individuals contains ar aberrant set of enzymes which convert the person's own inactive 'cortisone' into the active form 'cortisol'. This increased amount o circulating cortisol has an adverse effect on the carbohydrate metabolism causing increased blood glucose and insulin.

A similar situation may be occurring in fat horses, which show high concentrations of circulating cortisol, insulin and glucose, are hard to diet and often suffer from laminitis. This syndrome in horses has beer referred to as 'peripheral Cushing's disease'; not a very good name as the extra cortisol is not coming from the adrenal gland as it does ir pituitary-dependent Cushing's disease. Similarly, these animals do no show the changes in hair coat so typical of pituitary-dependen Cushing's disease. Unfortunately, at the time of writing, there is nc specific treatment for obesity related laminitis. Nevertheless such animals can be kept free of the disease by strict dietary anc management methods. The secret is to prevent the animal becoming obese and then to keep it on a high fibre, low calorie diet. If the anima is obese it must be gradually dieted down to a condition score of 2.5 to 3 and then kept at that weight. The horse must not carry any fa depots and you should be able to feel its ribs easily when you run you hand along its side. However it should not be so lean that you can see its ribs.

Animals which are recognised as 'good doers' or 'easy keepers' may well be suffering from either peripheral Cushing's disease o hypothyroidism. Laboratory analysis of blood samples are necessary to distinguish the 2 conditions.

Toxaemia

Any animal suffering from toxaemia, the presence of toxins in the circulating blood stream, is at high risk of laminitis. It may become clearer, with further research, which toxins are most dangerous but in the meantime it is safer to assume that all toxaemic horses are at high risk. The common toxaemic conditions, which precede laminitis and founder, are retained placenta giving rise to a septic metritis in mares, intestinal infections, colic (particularly those animals requiring surgical correction of colic in which there may be localised peritonitis) and ingestion of plant toxins.

Drug related laminitis

Some horses suffer laminitis following the administration of various drugs or vaccines. Certainly vaccination of animals suffering from sub-clinical disease is likely to make the horse ill; this is why veterinary surgeons examine horses before vaccination. Similarly, some horses react adversely to wormers, and it is not known whether this is due to the drug itself or to intermediary compounds released and absorbed from dying worm larvae. Some drug treatments seem to precede the onset of laminitis more frequently than others, eg a double dose of pyrantel for tapeworms.

The corticosteroid group of drugs is the most dangerous. The administration of corticosteroids to horses already in a high-risk situation should be avoided if at all possible. These drugs do not cause laminitis every time they are used but, when they do initiate laminitis, it is usually severe and results in the horse foundering. This author takes a very conservative view of corticosteroids in horses and would only use them as a last resort, ie in horses with a life threatening condition which is likely to improve with a corticosteroid. When long acting corticosteroids are administered to obese ponies the risk of founder must be explained to the owner. Even injecting one joint with a small dose can result in founder in horses in training!

Excess strain on the laminae

Conditions referred to as weight-bearing laminitis and road founder result from repeated trauma or prolonged force applied to the laminae overcoming their inherent cohesion. For example, if a horse is severely

FIGURE 4:

Laminitis and the consequent acute founder was caused to the left hind of this horse from continual weight-bearing due to the fracture of the right hind pastern.

lame in the right hind leg from a fracture or infected synovia structure, it takes all its weight on the left hind which often founder or sinks. The tendency is to give the injured leg attention but neglec the weight-bearing leg (Figure 4). Similarly horses undergoing fast o prolonged exercise on hard ground, particularly if not sufficiently fit may suffer founder in both front feet.

Hormonal laminitis

Some fillies and mares repeatedly suffer from laminitis, usually mildly when they are in oestrus. The mechanism for this is as yet unexplaine and treatments are similarly thin on the ground.

However, pituitary-dependent Cushing's disease is the most commonly recognised form of laminitis related to endocrine dysfunction. This wa originally described by Cushing, as a syndrome in which the adrena gland produces more than a normal amount of cortiso (hyperadrenocorticism). In horses, hyperadrenocorticism is nearly always secondary to an abnormality in the pituitary gland. Whether th pituitary abnormality is a true benign tumour or a hyperplasia is a moo point being argued by histopathologists. Cushing's disease causes th horse to fail to shed its winter coat; the coat becomes thick, long matted and curly. The animals tend to drink excessively, sweat mor than normal and lose weight despite an increased appetite. In additio they tend to change shape (Figure 5). There is a redistribution of fa depots on the horse with fat pads being laid down around the sheat or udder, the tail head, over the loins and crest and in the supra-orbita fossae. From the side they look rather square or 'blockier' than normal

FIGURE 5:

The typically hairy appearance of a pituitary-dependent Cushing's disease case. Note the 'square' blocky appearance. Clinicians should look for fat depots above the eyes.

Not all Cushing's cases show all of these signs at the same time but the longer the animal survives the more signs tend to appear.

Cold weather

Very few animals suffer from laminitis in cold conditions but this author believes that the condition exists. It seems to be prevented easily by turning the horse out in warm woollen leg bandages so it is presumably an individual sensitivity of the digital blood vessels to cold weather. This should not be confused with horses which become foot sore in the snow as this is more likely to be due to balling of snow in the soles of the feet leading to direct bruising.

Inadequate or irregular foot dressing in chronic founder cases

All chronic founder cases tend, to a variable extent, to develop misshapen feet. The toes become long, the heels high, the soles flat and the white lines widened (Figure 6). If the farrier does not keep the feet in as normal a shape as possible or is not called back at least every 5 weeks, many of the animals will a) become lame from sole pressure from the ground, increased pressure on the dorsal laminae or joint pain in the coffin joint as the heels become too high or b) suffer from repeated attacks of laminitis following all of the above.

FIGURE 6:

The typically distorted feet of a chronic founder case; these belong to a donkey.

Stress related laminitis

Stress related laminitis does occur infrequently, eg in horses (and particularly donkeys) which have lost a long term companion, or

FIGURE 7:

The digital pulse can be felt beneath the finger and thumb in these positions.

animals subjected to long and tiring journeys. However this possibility leads many people to think that their horse has stress related laminitis which is, in fact, usually due to inappropriate feeding and management.

Diagnosing laminitis

Laminitis is not a difficult lameness to diagnose. However it does present in a range of severities. For example mild laminitis is seen commonly in racehorses in training where there is a loss of action on hard going or on a trot-up in the yard. These horses are often described as being unable to trot but able to gallop. They are usually suffering from an excess of cereal in the diet leading to chronic low hindgut pH. This causes unwanted changes in temperament, such as box walking, aggression, colic and laminitis. The feet show a gradual widening of the dorsal white lines; sometimes evidence of haemorrhage is seen in the white line horn.

At the other end of the scale of severity, horses which are found at pasture recumbent, blowing and covered in sweat are often misdiagnosed as colic, azoturia or fracture cases. It should be remembered that laminitis does not only affect the front feet, it may affect the hind feet which gives a different stance. The horse tries to stand with all its feet on the same spot under its belly. The other condition which can be confused with laminitis is acquired deep digital flexor contracture in adult horses. Although these cases tend to try to land and stand on their toes, at first glance they do adopt a stance with the affected limbs stretched out in front of them, particularly when they first rise.

It is a mistake to confuse the terms laminitis and founder. Use of the following classification system will help us remember what is happening in the horse's foot and more importantly give us an accurate guide to prognosis.

The following 4 types of 'laminitis' are easily recognised without the need for radiography or other specialised techniques. A clinical examination will enable allocation into one of the following groups.

Laminitis

All cases of laminitis are lame, have an increased strength or force of their digital pulses (Figure 7) and tend to stand on their heels and try to take the weight off their toes (Figure 8). These are the characteristic

FIGURE 8:

The typical 'laminitic' stance of an animal affected in both front feet.

FIGURE 9:

A finger tip is run down to feel for the coronary band depression, which is characteristic of acute founder.

features of laminitis. The degree of lameness they show can be extremely variable, ranging from a mild lameness in one foot to an animal down, covered in sweat and groaning. Laminitis cases shift weight from one foot to another. Although the digital pulses are increased in rate, primarily due to pain, it is the change in nature of the pulse, which can be felt at the back of the pastern, which is the diagnostic sign. The digital pulse can be felt in most normal horses, it is easier to feel in fine skinned animals than those with thicker skin and subcutaneous tissues. In the normal horse the pulse has a relatively gentle rise and fall whereas, in horses with laminitis, the pulse has a sharper, hammer like quality.

Recognising laminitis and the sequelae

Acute founder: These cases show all the signs of a laminitis case, ie lameness, stance and pulse character, and also have depressions which can be palpated just above the coronary bands (Figure 9). If a finger is run down the pastern, over the coronary band and onto the hoof wall of a normal horse there is no resistance to this movement. In a case of acute founder, the finger tends to lodge in a dip or depression in the skin just above the coronary band. Acute founder cases are more severely affected than laminitis cases. The depression indicates that the laminae within the foot are pulling apart and the distal phalanx is moving distally within the foot. The deeper the depression, and the greater its collateral extent, the worse the founder. In other words the

FIGURE 10:

In sinkers the coronary band depression extends back to above the bulbs of both heels.

FIGURE 11:

Front foot of a Thoroughbred mare with chronic founder. The divergent growth rings are arrowed. Negligence is clearly a factor in this case.

deeper the depression the farther down within the foot the distal phalanx has displaced.

Sinkers: These animals are the most severe manifestation of the group. They do not show the heel loading and toe-relieving stance of the laminitis or acute founder case. Rather, they stand square but immobile and are extremely reluctant to move. If forced to walk they will rush forward in an incoordinated manner. Sinkers will run into anything which happens to be in their path. This author has seen 2 horses kill themselves this way. The other characteristic feature of a sinker is that they have depressions above the coronary bands, which extend the full length of the coronet; from one heel, around the toe to the other heel (Figure 10). Sinkers also have an increased strength of the digital pulses as in laminitis and acute founder cases. However, animals which have sunk for some hours, may also have stone cold feet as the normal circulation has been cut off. Sinkers which have been given analgesics retain the square motionless stance but, if forced to move, will walk like cases of cervical maladjustment syndrome (wobblers) in that they slap their feet down as they move.

Chronic founder: Chronic founder cases have all experienced one or more episodes of acute founder in the past and are left with characteristic changes in their feet. The feet become misshapen with high heels, long toes, flattened soles and have growth rings on the hoof walls which are more widely spaced at the heel than at the toe (Figure 11).

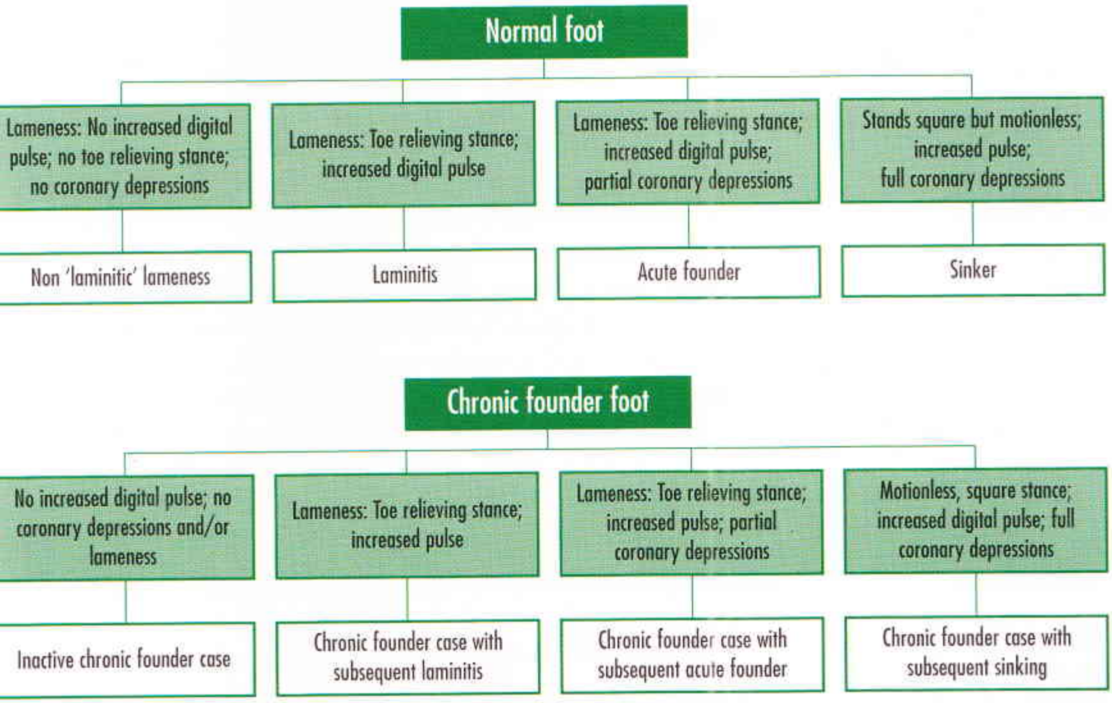


FIGURE 12:

Flow chart to aid in 'grouping' suspect cases.

Additionally, the white line in the dorsal part of the foot, around the toe, becomes wider than normal and often shows discoloration with orange serum staining or evidence of haemorrhage into the horn. This area of stretched white line is commonly infected and results in seedy toe. These changes all indicate the occurrence of foundering; the feet will be abnormal, the structural integrity of the laminae will have been compromised and the horse will be walking on inherently weakened structures.

It is possible for chronic founder cases to suffer subsequent attacks of laminitis and acute founder. Theoretically it is possible for chronic founder cases to become sinkers although this author has never experienced this.

To summarise, when approaching a new case of 'laminitis' the diagnostic protocol recommended is as follows: examine the feet in order to identify the changes characteristic of chronic founder; determine whether the horse shows toe relieving stance, increased digital pulses and coronary depressions then follow the chart to determine the type of 'laminitis' case with which you are presented (Figure 12).

Further examinations

It is important to obtain a good history from the owner so that an opinion may be formed as to the likely cause. In many cases the cause is only too obvious such as when presented with an overweight animal having received a high-calorie diet. In other cases the 'cause' is not so obvious and it may require examinations of blood and urine help to establish the underlying cause. For example laminitis in a thin horse nearly always indicates underlying systemic disease, eg pituitary-dependent Cushing's disease, chronic liver or kidney disease. Laminitis in thin horses is rarely the result of an inappropriate diet. This author uses a routine equine haematology and biochemistry profile and the analysis of creatinine and 6 electrolytes in blood and urine samples. In addition it may be necessary to measure endogenous ACTH, insulin and cortisol in blood to aid diagnosis of pituitary-dependent Cushing's disease and obesity related laminitis. Dynamic hormone response tests, such as a TRH response test, can provide useful information on both the thyroid and pituitary/adrenal axis status of the horse.

Although it is not necessary to radiograph the feet of all laminitis cases, doing so can provide valuable data in terms of radiological measurements should the animal deteriorate to acute founder.

Treatments

It must be accepted that, until the medical problems associated with a case of laminitis can be controlled or removed, it is unlikely that the animal's lameness will improve. The veterinary surgeon is therefore the important professional at the early stage when laminitis is first diagnosed. The farrier comes into his own later on should the condition deteriorate to founder when corrective farriery work is vital. To achieve the best result the owner, farrier and veterinary surgeon must work together. First, the intended use of the horse should be established. If faced with a moderately talented horse in training, there is a serious question as to whether any treatment should be attempted if that is the only potential role for the horse. The veterinary surgeon must be able to control the diet, stable management and regular treatments given to the horse. If this cannot be achieved at home then it is probably better to hospitalise the animal. The caveat to hospitalisation is that many equine hospitals are busy places with large throughputs of horses and staff. Laminitis and founder cases need a quiet comfortable environment where they can rest for long periods without interruption.

Co-operation

It is vital that the farrier and veterinary surgeon are both taking the same approach. If one uses heartbar shoes, complete box rest and vasodilators and the other prefers sole supports an agreement must be reached before treatment commences.

This section describes the treatments that this author has used most successfully over the last 15 years. The results obtained using these treatments are published in the Equine Veterinary Journal and to date represent the highest success rates published in a scrutineered veterinary journal.

Treatment protocols

Recommended treatment protocols are based on vasodilation, complete box rest on a deep full shavings bed, frog support, minimum analgesia, deep digital flexor tenotomy on contracted cases, dorsal wall drainage (acute founder) or dorsal wall resection (old and chronic founder cases), minimising pressure on the sole and monitoring the heel height (neither raising nor lowering). This author does not nail shoes onto acutely lame horses, the aim being to minimise the strain on the laminae.

Laminitis treatments

Laminitis is an emergency and should be dealt with by a veterinary surgeon that deals with horses routinely. The principle is to remove the 'cause' of laminitis. If this is diet, and in the UK the largest variable is grazing, the horse must be removed from its access to grass.

Treatment to the foot: Before the horse is walked, it is advisable to fit frog supports. This can be done cheaply by using a roll of soft bandage under the frog (Figures 13 a,b). If the horse is very lame, it may be necessary to wait until it has received analgesics in order to be able to lift a leg. If the horse is a long distance from its stable, it is advisable to move it in a low loading trailer rather than walk it. If the horse is shod, leave the shoes on; which will mean that thicker frog supports are necessary. Shoe removal at this time is unnecessary unless the feet have been neglected and are overgrown. In these cases the shoes should be removed and the feet trimmed to provide a firm pair of heels for the

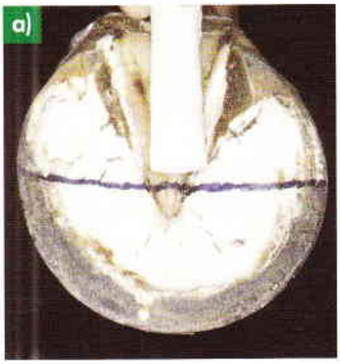


FIGURE 13a:

Fitting a bandage frog support: The bandage is unrolled until it is the correct thickness. The forward end of the bandage is placed about 1 cm behind the trimmed point of the frog.

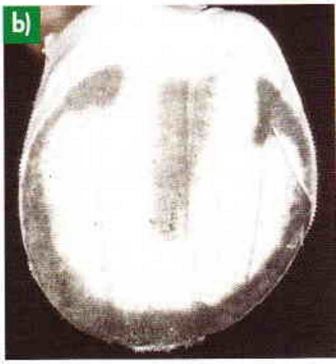


FIGURE 13b:

The frog support in place: Blackening indicates where weight-bearing is taking place. Note that none is on the sole, indicating that there is no direct pressure.

horse to stand on. When trimming the feet they should be dressed forwards not down, ie bring the toes back but do not remove the wall, which will force the horse to stand on its soles and increase the lameness.

Medical treatment: The veterinary surgeon is likely to administer a laxative saline (liquid paraffin and salt) by stomach tube and provide limited analgesics (phenylbutazone) and vasodilators (acepromazine). Collection of blood and urine samples is recommended at this time. It is common for laminitis cases to suffer from anaemia and an appropriate haematinic can be provided (Haemo 15; 10 ml iv every other day for 3 injections). Palpation of all coronary bands on all feet, preferably twice daily, is required as any depression which develops indicates that the horse is beginning to founder.

If the animal is sick (toxaemic) it is useful to use flunixin for its anti-endotoxic and anti platelet-aggregation properties (1 mg/kg daily) in combination with intravenous fluids. If the horse is sick due to a bacterial infection it may be useful to use a combination of antibiotics which give a broad spectrum of anti-bacterial activity. Blood cultures may be necessary prior to this, especially in cases of chest infections. In cases of retained placenta in mares vigorous efforts are needed to eliminate the infection. For example warm antiseptic uterine washes help to void the uterus and facilitate manual removal of the placenta. Oxytocin drips may be used. Both local and systemic antibiotic treatments are recommended.

Horses with gastro-intestinal disease need faecal cultures, systemic antibiotics and often massive volumes of intra-venous fluids if a successful treatment is to be achieved. Flunixin and hyperimmune sera have also been used with varying degrees of success.

If the veterinary surgeon is examining the animal within 48 hours of the onset of clinical lameness then heparin may be worthwhile using for its anticoagulant properties (100 units as a loading dose iv followed by 40 units every 6 h). This treatment is probably only worth persevering with for 48 or 72 h. If flunixin is not given then aspirin may be used (5 mg/kg every other day) as an anti platelet-aggregation drug in combination with another non-steroidal anti-inflammatory such as phenylbutazone. Although phenylbutazone is an old drug, it is the best for controlling the pain of laminitis. Meclofenamate (2.2 mg/kg daily) is a useful alternative. The aim is to control the horse's pain with sufficient acepromazine to keep the animal moderately tranquillised all the time and limited phenylbutazone to control, but not abolish pain. The horse should be able to feel its feet ie be in mild discomfort. To this end it should be rare to use more than 2 g of phenylbutazone daily. Additionally, using more analgesic than necessary will completely mask clinical signs of the horse starting to 'go up on its toes'. This is an indication of either deep digital flexor muscle contracture or an abscess in the palmar or plantar part of the foot.

The acepromazine dose is best given twice daily orally either in the feed as 25 mg tablets or as a paste. Failing that, intramuscular injection can be used. Tranquillisation reduces the horse's anxiety, reduces the systemic blood pressure and enables a lower dose of phenylbutazone to be used than would otherwise be the case. The dose of acepromazine should be regularly monitored, as horses with laminitis seem to become alternately sensitive and resistant to it. Strange as it may seem the weather will influence the dose needed; less is necessary to achieve the same degree of tranquillisation in hot than in cold weather. Giving too much acepromazine can result in the horse standing virtually immobile for hours, which is contraindicated. It is desirable for the horse to lay down and take the weight off the feet not stand up for long periods. In some animals is can be useful to cast the horse quietly with a sideline. This is usually only practical for ponies, which are afraid to lie down. Once they are down, they often stay there, when they realise it is more comfortable. This is acceptable and provided the horse will roll itself over, one only wants it to get up a few time daily to urinate and pass droppings. Acepromazine

FIGURE 14:

A deep clean dry whitewood shavings bed is recommended. The animal is encouraged to lie down and remain quiet.

medication should be used until the digital pulses return to normal i laminitis cases; this is usually within 72 h.

The author has no theoretical problem with the use of glycery trinitrate patches and creams but has never seen any advantage ove using acepromazine as a peripheral vasodilator.

Bedding: Clean dry whitewood shavings are the most suitable beddin for laminitis cases. It is not as cold or dirty as peat, nor as abrasive a sand. It is absorbent, warm and cushioning (Figure 14). If the bed laid to a depth of at least 40 cm over the entire stable floor area, allows the standing horse to set its heels at whatever height it finc most comfortable by digging its toes into the bed.

Frog support: Frog supports, if correctly fitted, improve the comfort c 80% of laminitis cases immediately. This is indicated by a reduction i their anxiety and the adoption of a more normal stance. The aim of frog support is to thicken the frog artificially allowing it to take proportion of the horse's weight through the frog and thus reliev some of the strain on the laminae. The frog support should not be s thick that the horse is forced to take most of its weight through th frog as this will cause an uneven bearing surface under the foot ar will soon make the horse lamer. Bandage frog supports can be kept i place for 48 h and, if necessary, replaced at that time as they hav usually flattened and their effect has reduced.

Foam pads: The use of various types of foam pad under the horse's fo has become popular recently. In this author's experience, these on improve the horse's comfort if the foam under the sole is remov before the pad is fitted. By choice this author would always use bandage frog support. A pad may be beneficial in an unshod chron founder case suffering an attack of laminitis. If the pad is trimmed to the shape of the foot, and all sole support removed, it can provide frog support while preventing the sole from pressing on the ground. This author does not condone the principle of using crushable foam pads because the sensitive solar corium is used to crush the pad.

Box rest: It is recommended that laminitis cases be confined to stable rest for 30 days, ie 30 days after the pulses have reduced and the horse shows no lameness in the stable without analgesics. This not only gives the damaged laminae time to recover but also enables a weight reduction diet to be instituted. Experience has shown that some horses diagnosed as laminitis cases are in fact mild acute founder cases and, when exercised too soon, can gradually deteriorate. It is surprising to find that if horses are given free exercise, not even forced or ridden exercise without the 30 day rest period, they often develop solar prolapse. This usually occurs 6 weeks after the initial laminitis attack. During these 6 weeks the horse is not sound but often does not show serious lameness.

Diet: In addition to appropriate medical and stable management, diet is very important if a successful treatment is to be achieved. Laminitis cases should receive a high fibre, low calorie diet, with supplementation of specific nutrients. In the UK, the Laminitis Trust has developed a Feed Approval Mark scheme to identify feeds which the Scientific Committee of the Trust regards as suitable for laminitis cases. The scheme also provides suggested feeding rates for approved feeds and the weights of other forages necessary to complete the diet.

In thin or anaemic horses, or those with blood results indicating parasitism, a larvicidal dose of anthelmintic is appropriate. In a very few horses with a gross upset of hind gut bacteria it may be necessary to seed the gut by using either a probiotic or a faecal filtrate from a normal horse.

Supplementation should provide a reliable supply of nutrients in a form the horse can absorb (Farriers' Forumla). The use of supplements that include chelated minerals or bioplexes should be avoided as they remove the horse's in-built intestinal selectivity and unbalance the diet; bioplexes force the horse to absorb whatever minerals or elements have been chelated. Supplements should contain the micronutrients necessary for correct horn formation, particularly in foundered horses; as the part of their hoof capsules (at the front of the foot has detached) the back part of the hoof needs to be as strong as possible. Hoof treatments designed

FIGURE 15:

A true latero-medial weight-bearing radiographic projection is the most useful when dealing with 'laminitis'. A bicycle spoke has been embedded in the block to produce a baseline. Chapter 3: Imaging the Foot and Leg shows this in more detail.

FIGURE 16:

A drawing pin with a shortened point is placed about 1 cm back from the true point of the frog to highlight a known position on the frog. The pen line across the foo provides an indelible mark to show where the pin wa positioned.

to toughen horn should be avoided. The hoof needs to be strong an pliable, not hard and brittle. This is particularly important when there i any risk of these chemicals coming into contact with corium, skin o bone. As many horses with laminitis are toxaemic to some degree, supplement should provide the 3 nutrients needed by the liver t perform its metabolic detoxification. Similarly many horses ar marginally hypothyroid so a supplement should contain a balance supply of L-tyrosine and iodine, which are necessary for thyroxin formation. In animals with Cushing's disease the supplement shoul contain adequate amounts of L-tyrosine and phenylalanine, which ar used to form the transmitter substance Dopamine.

Acute founder treatment

In acute founder, the characteristic depressions above the coronar bands indicate that the distal phalanx has moved within the foot. I such cases, 6 months off athletic work is required. All the examination and medical treatments apply for acute founder cases and further wor is necessary to try and minimise any further laminar detachment. It i important that all the feet of acute founder cases are radiographed a soon as practicable using a repeatable technique. This will enable th veterinary surgeon to measure the founder distance in each foot an provide a prognosis.

X-ray technique: A few simple preliminaries will make the differenc between an X-ray that is some use for diagnostic and prognosti purposes and one which is not. A wooden block, about 2 inches hig and wide enough for the horse to stand on, is needed. To highlight th ground surface, a shortened bicycle spoke is embedded into the top c the block (Figure 15). The horse's foot is picked and brushed out an any overgrown frog horn trimmed away. The frog is trimmed so th the collateral sulci can be seen to their depths on both sides of the fro and around the true point of frog. A drawing pin with a shortened point, (so as not to puncture the frog corium), is placed about 1 cm behind the point of frog (Figure 16).The position of the pin is marked by drawing a line across the sole and frog with a felt tipped pen. A dorsal wall marker is made as follows and kept in the X-ray machine box. Another piece of bicycle spoke is cut off and checked for straightness by rolling it. Each end is squared so that the wire measures 50 mm long.

The dorsal hoof wall is lightly rasped, just below the coronary band, to remove flaking or excessive perioplic horn. The top of the dorsal hoof wall is palpated with a finger to find the ridge where the horn changes from hard to soft. This place is marked with a felt tipped pen line, or lightly rasped to mark in the horn. The wire marker is taped (radiolucent adhesive office tape) straight up the dorsal wall with the top of the wire at the pen line (Figure 17). The X-ray is taken with the beam parallel to the top of the wooden block and to the long axis of the navicular bone. Using a rather lighter exposure than normal; detail is sought around the dorsal coronary groove rather than osseous changes. If the horse is shod it is not possible to use the frog marker. However all other steps in the protocol are used and should provide a film from which an accurate founder distance can be calculated.

The developed film is placed on a horizontal viewing box. With a parallel (expanding or nautical) ruler, 2 lines are drawn parallel to the ground line. One line goes across the proximal limit of the extensor process; the other goes across the proximal end of the dorsal wall wire marker (Figure 18). The distance between these lines is the apparent or measured founder distance. To correct for magnification:

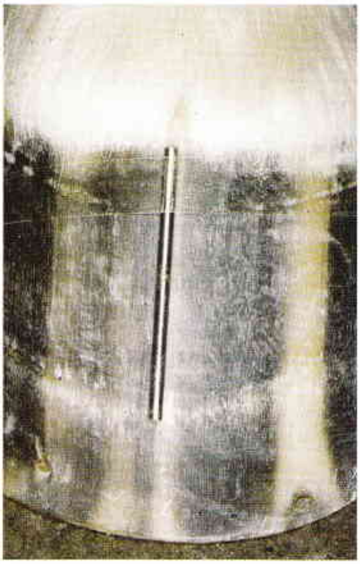


FIGURE 17:

A piece of straight, stiff wire of known length is positioned with the top at the junction between mature and juvenile dorsal hoof horn. This is determined by digital palpation.

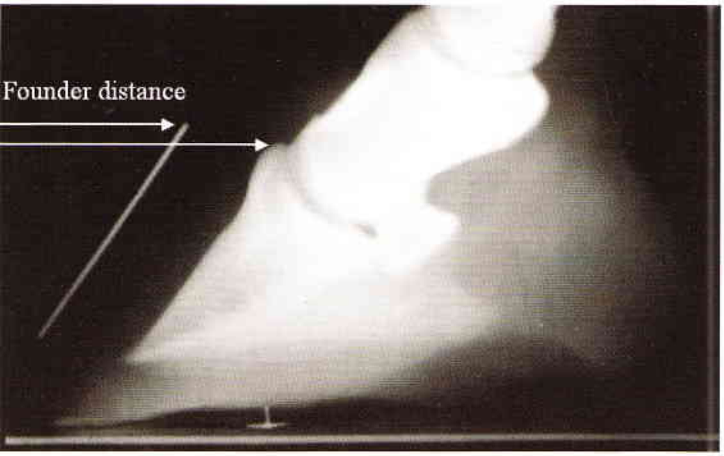


FIGURE 18:

A latero-medial radiograph showing the markers and how to measure founder distance, the vertical distance between the 2 arrowed lines. The spoke wires shown in Figures 16 and 17 can also be seen.

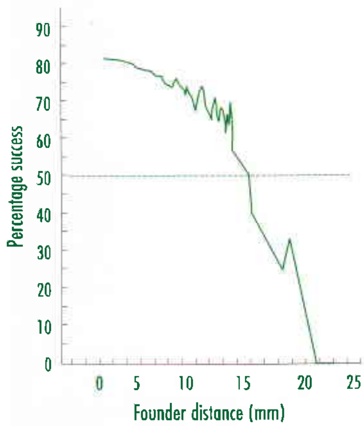


FIGURE 19:

This graph shows the anticipated success rate plotted against the founder distance in acute founder cases.

True founder distance = Apparent founder distance X Real wir length (50 mm) / Apparent wire length (as measured from the X-ray film).

The expected success rate, provided the same treatment protocol i followed, can be read from Figure 19. Further advice on prognosis i given later in this chapter.

When the horse deteriorates to acute founder, it is necessary t provide a firmer and more durable form of frog support than bandage roll. There are a variety of commercially available product which will fulfil this task without the need for nailing shoes to th foot. Any of these may be used in line with principles of avoiding sol pressure, not altering heel height and providing sufficient shoe at th heels to give a solid platform on which the horse can stand securel This author has used a plastic and steel adjustable heartbar shoe at hi clinic since 1990 but it is appreciated that it is not the easiest shoe t fabricate under field conditions.

A caveat when using frog supports is never to use them if the frog i already painful to thumb pressure. This usually is due to an over-thic frog support having been fitted recently, or to an abscess or serom under the frog or sole. The latter may be drained through a dorsal wa drainage procedure if it is possible to extend the resection to open th junction between the dorsal laminae and the dorsal horny sol Abscesses in foundered horses should not be drained by opening th sole from beneath, ie distally from the ground surface. This usuall results in a mass of swollen solar corium prolapsing through th drainage hole; such prolapses can take many weeks to re-epithelialis If it is not possible to use a frog support shoe, the horse can be le barefoot in the deep shavings bed until the frogs are no longer sensitiv and can stand a frog support device.

Fabricating the Eustace Shoe: Three thicknesses of pad are used (12 mm, 1 mm and 20 mm), all of which are 20 cm in diameter. This means th the shoe cannot be used on horses with feet wider than 20 cm. Th thicker pads are used not so much in proportion to the height of th horse, or the size of its feet, but in response to the flatness or convexit of the soles. A thicker pad is necessary on a convex sole in order t achieve clearance between the steel quarter bar and the sole of the foo

First the foot should be radiographed with markers, as describe earlier, to decide where to fit the apex of the heartbar. The horse's fo should be dressed forward if necessary.

The frog should be trimmed to bevel its sides so that the depth of the collateral frog sulci can be seen, ensuring that the horn is trimmed to reveal the true point of the frog. Failure to do this is one of the commonest faults in heartbar shoeing. If the tip of the frog is bound to the solar horn, pressure from the heartbar will transmit to the solar corium, which will cause pain and bruising.

The wall should be smoothed with the rasp and sandpaper with the horse standing on the pad, or his foot rested on the pad on the knee if he won't bear weight. The horse should be kept still while the outline of his foot is drawn on the pad using a waterproof indelible medium tipped felt pen. Enough pad must be left to give the foot sufficient length behind the heels.

The outline of the frog is drawn around (if the frog is in contact with the pad, the mark of the frog in sweat can be seen in an oblique light). If there is no frog mark, the position of the frog is estimated (it is best to be generous as there is nothing worse than finding the tip of the frog plate has been thrown away).

Using an electric jigsaw held in a vice, the foot outline is cut around. A hole is drilled through a part of the pad which will be discarded; this enables the cut to continue around the inside of the shoe and frog plate. The fit of the shoe is checked against the foot and altered if necessary until it is a perfect fit. Using an abrasive burr in an electric drill, the shoe is seated out and boxed off.

A length of gauge plate is cut to fit accurately across the shoe so that the front edge of the steel lies a few millimeters behind the apex of the plastic frog plate and the drilled and tapped hole lies centrally over the frog plate centrally. Two slots are drilled through the branches of the sole pad (these should be closer to the ground surface of the shoe than the foot surface, making it easier to keep the feet picked out later on) to accept the ends of the steel bar.

Using nippers, enough plastic is cut out on the ground surface of the frog plate to receive the steel quarter bar. Failure to do so makes the frog plate stick up in the air at too acute an angle to the frog. The fit of the shoe on the foot is checked so there is no frog support when the shoe is glued on. According to the height of the frog in relation to the wall of the foot, it may be necessary either to pare horn from the frog, or conversely, to glue an additional plastic thickener to the foot surface of the frog plate.

Using a hot air gun, the tabs are welded around the branches of the shoe. The 2 tabs which cover each end of the steel bar are welded first.

FIGURE 20:

The plastic and steel glue-on adjustable heartbar shoe (Eustace Shoe).

A plastic tab is held by the tip in artery forceps and the other end is heated with the corresponding surface of the shoe. When the surfaces look wet, or develop tiny bubbles, heating is stopped and the surfaces pressed together using a screw driver. If the polyurethane is overheated, it will start to brown and burn and it will not weld (Figure 20).

The wall is de-greased with a cotton wool swab soaked in acetone or trichlorethylene. It is blown dry and the shoe is then glued to the foot. An assistant should hold the other leg up. Only 2 drops of the cyanoacrylate glue should be put on the wall where the tab is to be stuck; using more glue worsens the bond. Some extra glue can be run around the edges of the tabs once they are stuck to the wall. A grub screw of a suitable length is fitted (not so long that it hits the ground when the horse walks) into the hole in the quarter bar. This is turned with the Allen key until it comes into contact with the frog, (it will get harder to turn), then it is turned another quarter turn. This screw adjustment is checked twice daily for the next 4 days (it may be necessary to fit a longer screw as the frog compresses), after which check daily to make sure the screw has not loosened. The foot surface of the steel bar must not contact the sole, neither must the inside edge of the 'branches' of the shoe other than at the very periphery (Figure 21).

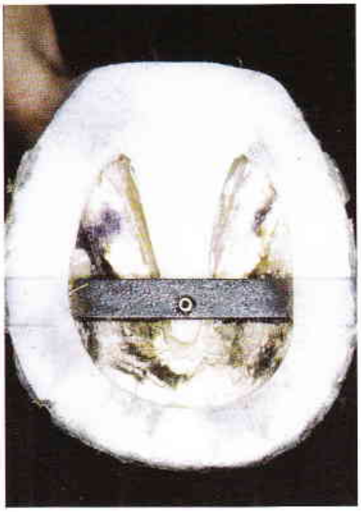


FIGURE 21:

The Eustace Shoe in position on the foot: Turning the grub screw with an Allen key allows adjustment of the frog support.

In some chronic founder cases suffering a current attack of acute founder, it may be advisable to dress the distal part of the dorsal wall of the foot, thereby helping to improve ease of break-over but not removing any surviving laminal attachments. This appearance

FIGURE 22:

A mini (partial) dorsal wall resection in an acute founder case. This procedure allows drainage of sub-mural fluids without loss of laminar attachment.

resembles 'dumping' the toe. In addition, the toe of the shoe can be squared if necessary and set under the remaining toe of the foot.

In addition to providing a durable and preferably adjustable form of frog support, it is recommended at the acute founder stage to perform a dorsal wall drainage (Figure 22) and a coronary grooving procedure. By removing a part of the dorso-distal hoof wall, drainage can be achieved from all the dorsal laminae without compromising surviving laminae. The need to retain surviving laminae cannot be over-emphasised. The inter-laminar bonding is all that suspends the horse within its hooves. Premature removal of the dorsal wall will increase the founder distance and may reduce a salvageable case into one with little or no chance of a successful outcome.

Coronary grooving: Coronary grooving procedures are designed to reduce the compression on the parts of the coronary groove, above which a depression has appeared. Coronary grooving, partial and full dorsal wall resections do not require the horse to be nerve blocked or otherwise desensitised, as these techniques, performed correctly, do not invade live tissue and are therefore non-painful. They are best performed using a high-speed milling tool such as a Dremel. Occasionally the horse may need to be tranquillised more heavily than the acepromazine dosage it is already receiving if it is of a nervous disposition. In removing the stratum medium and thinning the stratum internum it is hoped to remove upward force on the coronary groove and improve the chances of the distorted coronary papillae remodelling. The horn can be seen to become whiter when the limit of the groove is appearing and any haemorrhage indicates that part of

FIGURE 23:

An extension of the mini resection can be carried out once sub-mural radiolucencies are visible at the old founder stage. This should be no earlier than 6 weeks after foundering.

either the coronary or proximal laminar corium has been invaded and that the resection should be made no deeper (Figure 23).

Provided the bedding is kept clean and dry there is no indication to bandage the feet. This author anoints the laminar horn within the resections with Hoof Disinfectant and then leaves the area exposed to the air. Bandaging feet not only hides the tissues from view but also traps evaporated moisture which weakens the wall horn and predisposes to horn infections. Dry horn is stronger than wet horn.

Dorsal wall resection: This author only extends the small dorsal wall drainage area into a full resection once a distinct sub-mural radiolucency is visible radiologically (old founder stage, Figures 24 and 25). As a general rule this procedure is not performed sooner than 6 weeks after the horse foundered. A dorsal wall resection removes detached dorsal wall, allows drainage of sub mural abscesses, removes upward pressure on the dorsal coronary corium and allows access under the dorsal horny sole, again to achieve drainage. Usually at this time the coronary depressions are remodelling, ie the horse has stopped foundering, is much more comfortable and can cope with having nailed on shoes applied. If a dorsal wall resection is to be made, the foot must be shod first. On no account should horses with dorsal wall resections be left unshod.

Deep digital flexor muscle contracture: Deep digital flexor muscle contracture seems to occur in a minority of acute founder cases as an exaggerated

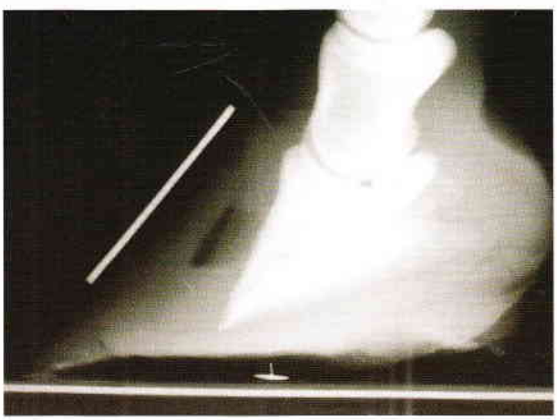


FIGURE 24:

An obvious radiolucency under the dorsal hoof wall.

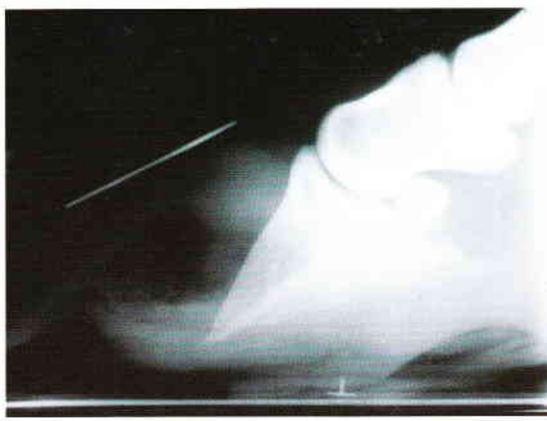


FIGURE 25:

A much larger radiolucency which extends from quarter to quarter around the front of the foot in a neglected case at the old founder stage.

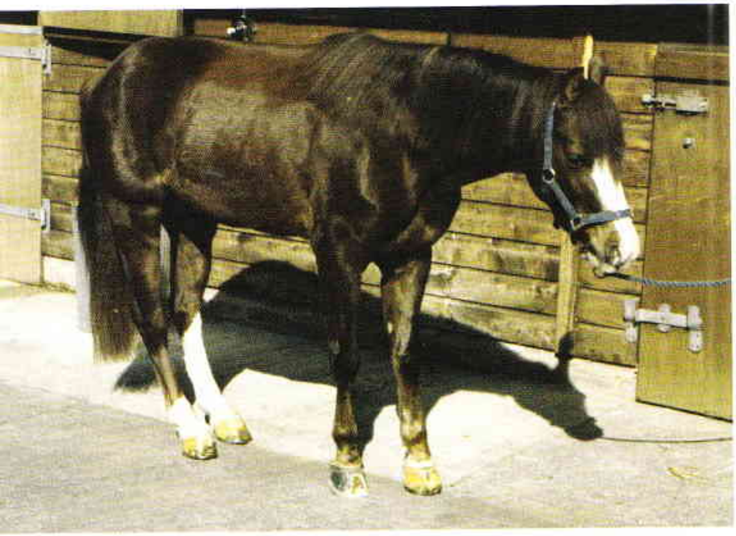


FIGURE 26:

The stance typical of an animal showing either: 1) bilateral abscesses in the palmar parts of both front feet; or 2) deep digital flexor muscle contracture affecting both front legs. In this mare it was the latter.

response to foot pain. The deep digital flexor muscle begins to pull the 'tip' of the distal phalanx down and around towards the horny sole. Clinically, the horse tends to put its toe down first when it moves (Figure 26). Analgesic drugs, such as phenylbutazone, will effectively mask this clinical sign, even at small doses and the clinician must decide whether to give more analgesic, in the hope that the muscle will stop pulling, or go straight for tenotomy surgery before more displacement occurs? As this author has only seen one horse respond to an increased dosage of analgesic and apparently stop contracting, he tends to opt for an early tenotomy. Given the recovery period of foundered horses is governed by the rate of growth of the hoof horn, which takes longer than a surgically divided tendon takes to heal, an early tenotomy does not result in a longer recovery period. In fact, if the surgery is necessary, the sooner it is done the better before the founder distance becomes unmanageable.

Surgical technique

This author prefers to perform the surgery at the mid-cannon site with the horse under tranquillisation and local anaesthesia (Figure 27). The surgery may be performed under general anaesthesia but carries increased risks. Also, it is difficul to estimate how much heel to remove during surgery, impossibile to dress feet flat and level when they are sideways on and there is a risk of hyperextension of the coffin joint during recovery, with damage to associated collateral and suspensory ligaments.

FIGURE 27:

A chronic founder case suffering from deep digital flexor muscle contracture. The left fore leg has undergone surgery and the foot is dressed. The right fore is as yet untreated. Note the difference in heel height.

Sinkers: Sinkers are cases in which there is a time window of only a few hours in which to apply effective hoof treatments if a hoof slough is to be avoided. This is because, in a true sinker, all the laminae have detached and the coronary depression extends around the entire coronary band. The distal phalanx is loose within the hooves of these cases and there is a limited period between detachment and laminar swelling during which an effective frog support shoe can be fitted. If this can be achieved the coronary depressions are less deep on palpation following shoe application and, provided the animal is not allowed to walk and there are nó further medical complications, these cases can make a full recovery without further treatments. Recovered sinkers show a single growth line on the hoof wall parallel to the coronary contour. It is still recommended that they are given 9 months of rest prior to any work.

If treatment is attempted after laminar swelling has occurred, results are generally bad. The pain these animals suffer can often preclude attempts at treatment. The principles of treatment are as for acute founder cases but the success rate is significantly lower. Many cases either injure themselves fatally or slough their hooves. Some animals have survived hoof sloughs but consideration must be given to whether it is humane to continue with treatment following a slough.

Chronic founder: In this sequel to laminitis; it is very useful to have pre-treatment radiographs so that cases can be divided into Type 1 and Type 2 (Figures 28 and 29). Type 1 cases can recover and return to work whereas Type 2 cases do not. Therefore, only treatment options for Type 1 cases are discussed here. Treatment is based on re-aligning the phalangeal column to a straight axis, restoring the distal aspect of the distal phalanx to approximately 7° to the ground and removing excess dorsal horn to restore the parallel relationship between the dorsal cortex of the distal phalanx and the remaining dorsal hoof wall (Figure 30). The feet need regular dressing, down more at at the heels than the toes at no longer than 5 week intervals. The extent to which this is done should be assed by observing the diverging growth rings on the lateral and medial hoof walls. In addition, any horn infections should be cleared up if possible and well seated out shoes with sufficient heel length may have to be fitted to cases with flat or convex soles.

Experienced farriers can restore the normal anatomical relationships in many cases without the need for radiographs; in fact many do this on a daily basis. However, there are again caveats; care should be

FIGURE 28:

A radiograph of a chronic founder Type 1 foot: Note the hoof distortion but minimal osseous change to the distal phalanx.

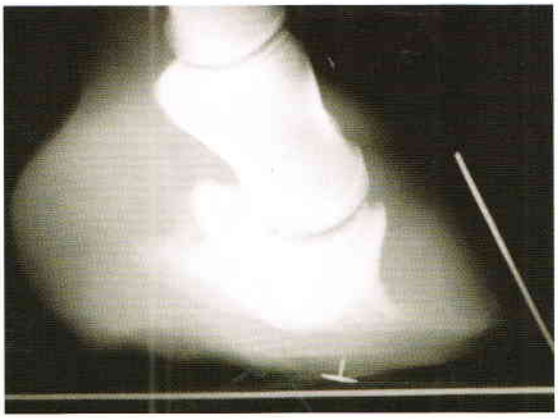


FIGURE 29:

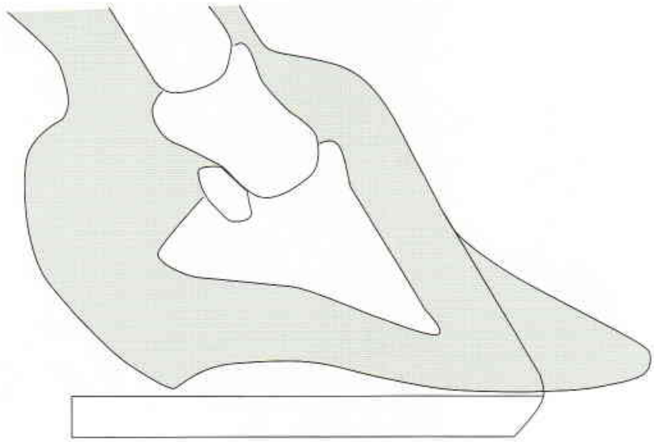
A radiograph of a chronic founder Type 2 foot: A solid wedge of dorsal horn with no reduction in wall thickness in the proximal wall combined with significant osteopaenia of the distal phalanx.

exercised when there is significant osteopaenia of the distal phalanx, often with remodelling of the dorsal cortex of the bone yet not bad enough to be regarded as a chronic founder Type 2. Such cases, with distorted feet and rather long toes yet sound enough to work, should be trimmed in a conservative fashion. Rather than removing a mass of toe horn and underlying laminar horn to restore the parallel relationship described above, trimming should be more gradual. Some cases, if much of the horn is removed at the toe, will destabilise and founder again. They seem to have adapted to accommodate a distorted foot.

The second caveat is to avoid removing excessive heel horn aggressively in a 'one-off' attempt at lowering the heels. Some of these animals have suffered deep digital muscle contracture and if their heels are removed they will not be able to stand up. It is necessary to either be gradual in trimming or perform a toe-wedge test first, and to ensure that the animal is not receiving analgesics when this test is made as this can mask contracture very effectively. The toe-wedge test mimics heel removal without the need for foot trimming. A graduated pad should be cut out to mimic the shape of the toe; more than one pad may be needed. The thickness of the pad at the toe should approximate to the height of heel being considered for removal. The wedge is placed under the toe of the foot and an assistant lifts the contra-lateral leg. The horse's behaviour is observed to see if it appears

FIGURE 30:

The principles involved in dressing chronically foundered horses' feet involve dressing the heels back (without radical over-lowering and dressing the dorsal wall parallel to the distal phalanx).



to resent this procedure. The tension in the deep flexor tendon of the tested leg is felt before and during the toe-wedge test. If the tendon feels like a taught hawser when the toe is raised and the limb is loaded, and the horse resents the test, it probably has suffered deep flexor contracture. The intended amount of heel should not be removed. Treatment options in these cases are either to remove a lesser amount of heel or have a deep digital flexor tenotomy performed. In the former case it is hoped that the animal will be reasonably comfortable even though the foot dressing results in a compromise between a perfectly fitting coffin joint and a straight phalangeal axis.

The third caveat relates to extensive horn infections in Connemara ponies, whether they be foundered or not. This author has experienced 3 cases which, despite intensive and aggressive treatment, failed to respond and had to be destroyed. Histological examination of their hooves showed that they all had an inability, presumably genetic, to incorporate lipid into their hoof horn.

The general principle when trimming chronic foundered horses' feet, without the benefit of radiographs, is to observe the affected foot from the side, determine the line of growth of the most recent dorsal horn and dress the foot forwards to remove all horn in front of this line. This will result in the remaining dorsal wall being within 2° of parallelism to the dorsal cortex of the distal phalanx.

Prognosis

It is important at the onset of dealing with a foundered horse's feet to try and provide as accurate a prognosis as possible. This enables owners to make an informed decision as to whether they wish to, or can afford to, pursue treatment. Additionally, it avoids prolonged suffering in animals in which there is little hope of recovery. A study, undertaken by the author, identified significant factors involved in the prognosis of founder cases. First, and perhaps surprisingly, grouping of cases into laminitis, acute founder, sinker and chronic founder is the most useful prognostic parameter. By examining the stance and the feet of the horse carefully, a prognosis based on scientific considerations can be made. Different treatments can be expected to give different success rates and 'successful' treatment must be defined. Unless the horse returns to work at his previous or a higher level of athletic function without the need for analgesics, the treatment may be considered to have failed, ie those which are sound enough only to act as pets or breeding stock, or those which suffer laminitis attacks in a 12 month follow up period, may be regarded as failures.

Acute founder

Acute founder is probably the group which causes the most difficult decisions to be made. This author has achieved a success rate in treating acute founder cases of 81%. The prognosis can be refined somewhat by measuring the founder distance from radiographs. The success rate declines rapidly for each mm increase in founder distance beyond 14 mm. This author rarely encourages owners to continue with treatment if the founder distance is 15 mm or greater (Figure 19).

Sinkers

Sinkers have the lowest success rate (20%). It is possible to find sinkers, which have small founder distances, ie within the range of normality (less than 10 mm). As a general rule these cases have a greater chance of success than those with higher founder distances. Most sinkers have founder distances greater than 15 mm and many over 20 mm. These cases have such a small chance of recovery that treatment is not recommended.

Chronic founder

It is imperative to use radiographs when prognosing on chronic founder cases. This allows the identification of chronic founder Type 2 cases, which have no chance of recovery. Overall, in the study referred to above, the success rate in chronic founder Type 1 cases was 79%.

FIGURE 31:

Solar prolapse may occur as a sequel to founder or sinking. Its presence is not always valid grounds for euthanasia.

FIGURE 32:

The difference between the angles of the dorsal wall and the dorsal cortex of the distal phalanx was found to be a significant prognostic parameter only in chronic founder cases.

Other factors affecting prognosis

Other factors may adversely affect prognosis. The inability to treat the underlying medical condition will make attempts at treatment futile. Animals that are affected in one foot only generally have half the anticipated success rate. The breed also influences the outcome, for example Arabs and Thoroughbreds have 3 times the likelihood of failure compared to all other breeds. This effect is independent of its classification or group.

Interestingly, the height of the animal, and therefore the weight, is not correlated with outcome and horses have the same prognosis as ponies. A higher ratio of solar prolapse cases fail than unprolapsed cases (Figure 31). Animals that suffer solar prolapse following a large increase in founder distance have a significantly greater failure rate than those animals with a smaller founder distance.

The severity of lameness is significantly associated with outcome. However, prognosis should not be based on this factor alone. The association relates directly to a trend towards more severe lameness in serious acute founder and sinker cases. Cases, with no physical displacement within the foot may show extreme lameness yet have an excellent prognosis. Additionally, the angle of rotation (Figure 32) was not found to be significantly related to outcome, except in chronic founder cases. In other words, the angle of rotation is not a significant prognostic indicator in acute founder and sinker cases.

SHOEING THE CHRONIC FOUNDER (Thoroughbred broodmare)

Simon Curtis

Chronic founder does not specifically afflict Thoroughbred broodmares but because of their economic value and continued use there is a high proportion, within the population, suffering from this condition. Causes for these large numbers are mentioned earlier in the chapter, including stress while a racehorse in training, hormonal factors relating to the oestrus cycle, annual pregnancy with the consequent weight-bearing, 'doing well' and metritis after foaling.

The principles involved in the trimming and shoeing of Thoroughbred broodmares suffering from chronic founder, may be equally applied to other surviving types and breeds. Ponies are renowned for their ability to suffer an attack of founder and later resume a useful life.

Diagnostic signs

The diagnostic signs of chronic founder are described earlier in this chapter. Because of the nature of the Thoroughbred's foot conformation, and the reluctance of owners to describe their mares in this way, many synonyms are used instead. They are frequently called 'flat footed, 'dropped soles' or just bad footed. Radiographs will almost always confirm the condition of chronic founder but, they are unnecessary in most instances. Depending on the severity of the condition there are a number of external recognisable signs (Figures 33 a,b and 34).

1. The sole is flat or convex.
2. The mare is uncomfortable without shoes.
3. The dorsal wall is concave.
4. The heels grow faster than the toe, often seen by the divergence of growth rings at the heel.

FIGURE 33a:

The sole of a mare with chronic founder is flat or convex (arrowed). The dorsal wall is concave and the heels are high.

FIGURE 33b:

A mare with chronic founder usually has growth rings which diverge towards the heel.

FIGURE 34:

Mares with chronic founder frequently suffer from abscesses. This mare has abscesses in both heels (bars) and at the toe.

FIGURE 35:

A lateral radiograph of a Type 1 chronic founder. Radiographs give additiona information which may affect the chosen shoeing regime.

5. The presence of a sand crack at the toe.
6. The white line is distended at the toe.
7. The hoof wall is of poor quality or missing around the toe fror quarter to quarter.
8. Cracks and abscesses occur midway down the bars.
9. Solar cracks and abscesses occur in front of the apex of the frog.
10. The lateral branches of the suspensory ligament are often taut an clearly seen.

Radiographs are useful in confirming diagnosis and also in confirmin deterioration or stabilisation of the condition (Figure 35). Latera views are the most useful and show:

1. The depth of the sole, ie the distance between ground and th distal phalanx (PIII).
2. The founder distance.
3. Skeletal rotation of PIII in relation to PII and PI.
4. Divergence of PIII from the dorsal wall (capsular rotation).
5. Remodelling and lytic changes to PIII including pathologica fractures of the distal margin (Figure 36).
6. Sub-solar and sub-mural abscesses.

FIGURE 36:

A post mortem specimen of a distal phalanx from a mare with chronic founder (see Figure 42) shows the erosion and remodelling at the distal border.

FIGURE 37:

A view of Figure 36 from above shows the demineralised distal border (pedal osteitis) causing a ragged appearance.

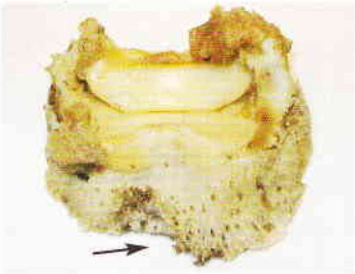


FIGURE 38:

This is the other front foot of Figures 36, 37 and 43. The cavity (arrowed) is caused by a pathological fracture. The mare was destroyed on humane grounds.

A dorsoproximal-palmarodistal oblique view with the foot on the x-ray plate is worth taking at the same time and may show:

1. Demineralisation of the distal border (Figure 37).
2. Pathological fractures (Figure 38).

Other diagnostic information includes the stance and gait of the mare, how she copes with various ground conditions and her state of pregnancy. The first sign of this condition in a young mare is often the need for shoes on hard ground in the summer or severe frosty ground in the winter. The mare is not clearly lame but is slow to lead, inactive in the paddock, and does not usually stand in the classic acute founder stance.

FIGURE 39:

The heels are trimmed back to a normal height.

FIGURE 40:

The dorsal wall is realigned and the toe rolled.

Sore-footed

Chronic founder mares should not be confused with mares that ar foot-sore due either to excessive trimming or having had their shoe removed after a training period, which often leaves youn Thoroughbreds (3–4 years) slightly 'footy'. The Thoroughbred has deserved reputation for thin horn of poor quality. Having bee subjected to the rigours of training and more nails than any othe sports horse, the hooves are often in a poor condition to support th horse shoeless. Nevertheless, every attempt should be made to ge them out of shoes as soon as possible. Most Thoroughbreds develop thicker and more robust hoof wall at 5–6 years of age.

Trimming

Usually the broodmare with chronic founder needs shoeing becaus of the flat or convex sole. However in low-grade cases, where there enough robust wall, trimming alone may suffice. The principles are follows:

1. Preserve the distance between the ground and the sole; therefor do not over-trim.

FIGURE 41:

Seating out (arrowed) the shoe removes direct contact between shoe and sole. Failure to do this may further impede blood circulation.

2. Improve the break-over, by rolling or squaring the toe if necessary (Figure 39).
3. Trim the heels back; thus increasing the bearing surface and reducing compression of the caudal foot (Figure 40).

Shoeing

The principles of shoeing for chronic founder are as for the trimming (this fact is frequently over-looked with an immediate concentration upon the horseshoe and its biomechanical effects). Additional benefits are gained by shoeing and the design of the shoe.

Shoeing should aim to raises the foot and sole from the ground, reducing direct trauma, and gives the hoof capsule increased rigidity. The design of the shoe may incorporate:

1. Seating out to reduce sole pressure (Figure 41).
2. Reduction in break-over by way of a rolled, rocker or square toe (Figure 42).
3. Frog support.
4. Caudal support.

The drawback to shoeing is that, unless sufficient attention is given to each shoeing, and is regular, the condition may deteriorate purely from poor or infrequent shoeing. The golden rule is 'toes back and heels back'. This does not necessarily mean dressing off the dorsal wall back to the shoe border (Figure 43), which can reduce the integrity of the wall and create additional problems. The biomechanics and comfort of

FIGURE 42:

A good shoe for chronic founder has a square/rolled toe to bring back the point of break-over and sufficient heel length.

FIGURE 43:

The front feet of a mare with chronic founder. The right fore (nearest) has been shod for one month and the left fore has been trimmed. The feet show the characteristics of long term chronic founder. Only radiographs allow differentiation of Type 1 and Type 2 chronic founder. The mare had led a successful and pain-free (apart from one episode of abscessing) life for some years prior to the fracture (see Figure 38) that led to her demise.

the horse are paramount; the aesthetics are secondary (Figures 44 anc 45 a,b).

Types of shoe

A good steel concave shoe section for Thoroughbred broodmares is 1$\times$ 8 mm ($^{3}/_{4} \times {}^{5}/_{16}$ inches). If the fullering is closed at the toe this wil bring back the break-over point. For the mildest cases these are ideal Seating out concave is not easy by hammer. Using a file or angl grinder is more practical.

An aluminium shoe of 20 $\times$ 8 mm or 22 $\times$ 10 mm ($^{3}/_{4} \times {}^{3}/_{8}$ inches o $^{7}/_{8} \times {}^{3}/_{8}$ inches) allows easier and deeper seating and will also create greater ground to sole distance. It is simple to alter the shoe cold making it into a square toe with a rolled toe and seating (Figures 4 and 42). This shoe and its application can be viewed as a similar bu less radical approach than the natural balance method described earlie in the chapter.

The heartbar shoe has a role in the shoeing of chronic founders However, this author has found that over the long term (12 month plus) its efficacy diminishes. The frog plate needs to be fitted with les length than for acute founder, ie at least 2 cm ($^{3}/_{4}$ inch) back from th trimmed apex of the frog. This may be because of the remodelling o the distal margin and the degree of rotation frequently seen in thes types of cases. The frog plate should be fitted with neutral pressure.

Frog pressure can also be gained by shoeing with a pad with a raise frog and under-filling with dental impression material (DIM). Th

FIGURE 44:

A radiograph of a Type 1 chronic founder shows some remodelling to the dorso-distal margin of PIII, excessive toe length (arrowed) and a shallow depth of sole.

FIGURE 45a:

The foot shown in Figure 43 is typical of many Thoroughbred mares. Changes to the PIII are compounded by allowing the toe to grow forward. Note the distance between the break-over point and the coronary band (arrowed).

FIGURE 45b:

After trimming, according to guidelines shown earlier in this section, the break-over is now closer to the coronary band (arrowed). Note that the dorsal wall is not rasped back to the shoe and the heels are supported caudally.

DIM fills the lateral sulci and sole from caudally to within 2 cm of the apex of the frog. The horse can make use of the rear half of the foot, where weight can be borne, thus reducing the loading on the sole and dorsal wall. This can be viewed as a variation of the Ovnicek technique for shoeing founder and is this author's method of choice for lame chronic founders.

Secondary conditions

The changes within the hoof capsule, primarily to the distal phalanx, and the resulting alteration in shape and increase of stress causes secondary effects that may cause acute lameness. Sometimes it is only at this point that the condition is recognised as such. It is essential that the primary condition is improved or stabilised while treating these

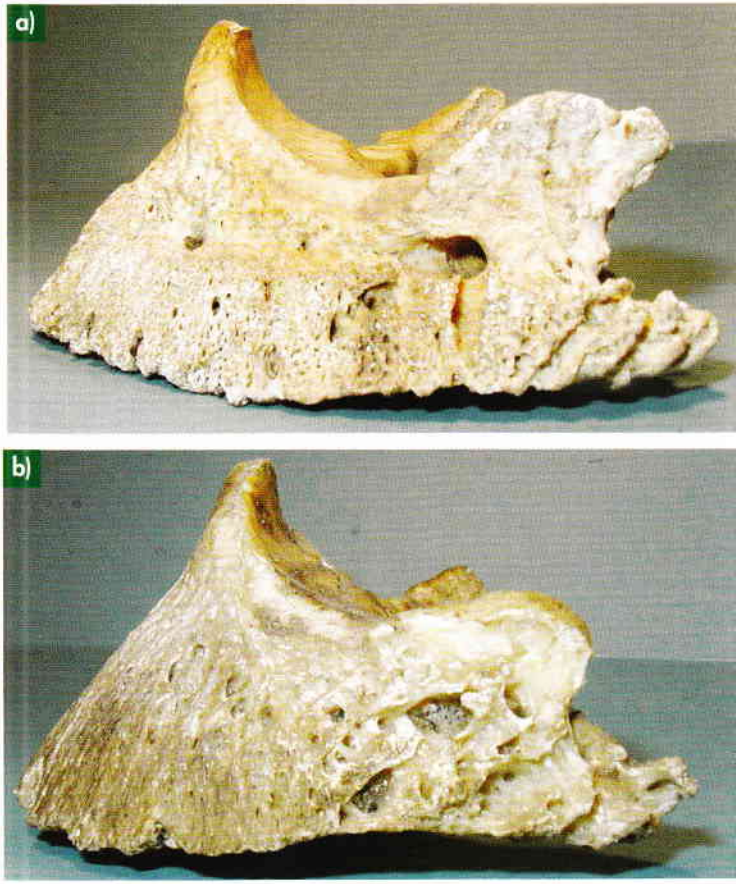


FIGURE 46:

In long term chronic founder cases, the distal phalanx is radically remodelled. Both bones are from horses of a similar age and size. Note how bone a) is not only eroded along the dorso-distal margin but also the shallow depth compared to b).

secondary lesions. It may be that the secondary conditions are signs o the progression from Type 1 to Type 2 (Figures 46 a,b).

Sand cracks

Sand cracks at the toe, especially where the wall is curved in, are a classic sign of chronic founder. It appears to be caused by a combination of the descent and rotation of PIII, the extended break-over point and, probably, a restricted blood supply to the dorsal wall Trimming and shoeing as described in this section will reduce the stresses and help immobilise the wall but, in many cases, patching i required. This is described in Volume II.

Abscesses

Excessive loading of the heels, under-run heels impinging on the palmar soft tissue and PIII rotation may cause sub-solar abscesses and sub-mural abscesses may occur under a sand crack. All abscesses should be opened with as little collateral damage to the horn as possible. Chronic founder cases usually have insufficient horn; growth and healing are slow. Opening directly into the sole usually creates a prolapse of sensitive tissue through the sole that is difficult to manage. Sub-solar abscesses can almost always be ventilated at the junction of the dorsal wall and the white line (Figure 34).

Pathological fractures

It appears that pathological fractures occur along the distal margin to some extent in a large number of chronic founder cases. Radiographs show minute fractures of the margins, which are continually reabsorbed. Occasionally, where there is severe demineralisation of the distal margin, a larger fracture will occur causing immediate pain and the danger of a sequestrum (Figure 38).

Mediolateral sinking

Occasionally a chronic founder is seen to have sunk further on one side of the foot. The sole is more dropped on one side and the distension of the white line is greater on that side. The coronary band and hoof wall also lack mediolateral symmetry (Figure 47). A radiograph will confirm mediolateral sinking (Figure 48). This leads to further complications when shoeing. It is difficult to nail the shoe symmetrical to the frog axis. Nevertheless this is a good example of where the long axis of the cannon gives the farrier a guideline in balancing the foot.

FIGURE 47:

An anterior view of a chronic founder that has sunk more on the medial side, causing considerable distortion to the hoof capsule. Distension of the laminae is greater on that side.

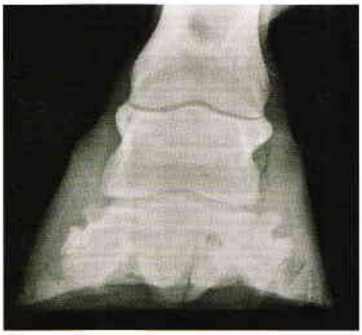


FIGURE 48:

A dorsopalmar x-ray of the above foot showing the bone column sinking medially.

The long term

Shoeing mares with chronic founder over a long period is inevitably disappointing. Although low-grade (Type 1) cases will often live a full life, moderate and severe cases (Type 2) almost always have their lives shortened by this condition. At some point an inexorable descent begins, punctuated by short-term improvement. This descent is characterised by some of the secondary conditions mentioned above, ie worsening sand cracks at the toe, abscessing and pathological fractures of the distal margin of PIII. Where a clear improvement of the condition is achieved by the techniques described above this should be viewed as a plateau and success measured by the number of years that the mare is maintained at that level of soundness.

The Styrofoam Support System is intended as part of a treatment regime at the onset of an attack of laminitis. Comfort is usually seen immediately and will improve further upon second block application. The Styrofoam Support System addresses natural weight-bearing issues by providing uniform support for the frog, caudal sole and bars all in the least painful areas of the foot and seeks to protect the more painful areas of the sole. This is accomplished without causing local ischaemia and pressure necrosis which often plagues systems reliant on frog support alone when applied inappropriately.

STYROFOAM SUPPORT SYSTEM

David Nicholls

It is important to use the correct type and grade of styrofoam so that, when compressed, it closely simulates sole material and does not offend the structures of the foot. Commercial styrofoam kits are available. Early correct application and management helps to restore and increase the blood supply to the foot and can reduce the damage to the basement membrane of the laminar bed by up to 30%.

Step 1: Only clean the foot of loose dirt and sole pieces that can be removed easily. It is helpful sometimes to leave some hoof wall growth as it will help to secure the support blocks. Rasp a rocker at the toe, as this will aid break-over (Figure 49).

Step 2: Before going to the foot place 2 pieces of duck tape on the ground side of the Styrofoam pad, in a cross pattern. Leave approximately 75–100 mm hanging over the sides and the toe of the pad. These will be the placement tabs (Figure 50).

Step 3: Place the pad on the foot leaving aproximatly 25 mm overhanging the toe. This will assist in pad compression. The pad must be large enough to extend to the back part of the frog. Apply duck

FIGURE 49:

The loose horn is removed and the toe rasped to aid break-over.

FIGURE 50:

The Styrofoam pad is prepared for attachment by sticking a cross pattern of tape to the bottom.

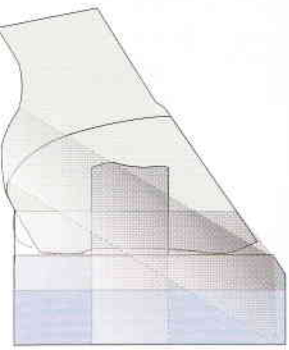


FIGURE 51:

The pad is attached securely to the hoof and over the bulbs of the heels.

FIGURE 52:

The first pad will soon compress with weight-bearing.

tape horizontally around the bottom of the pad and hoof wall at the same time. Make a minium of 2 wraps over the bulbs of the heels well onto the hair. Care must be taken not to twist the pads during taping (Figure 51).

Step 4: After 24–48 h, the pads should have compressed enough to proceed to the second block application (Figure 52). This is dependent on the surface on which the horse is kept and how ambulatory the horse is. An ideal environment is a 20–30 square metre area of firm ground with an area of soft ground, or bedding, where the horse can lay down. The best results have been achieved when the horse has had this this access to movement, with poorest results seen in box rested horses. The compressed pad should be removed from the foot and hoof

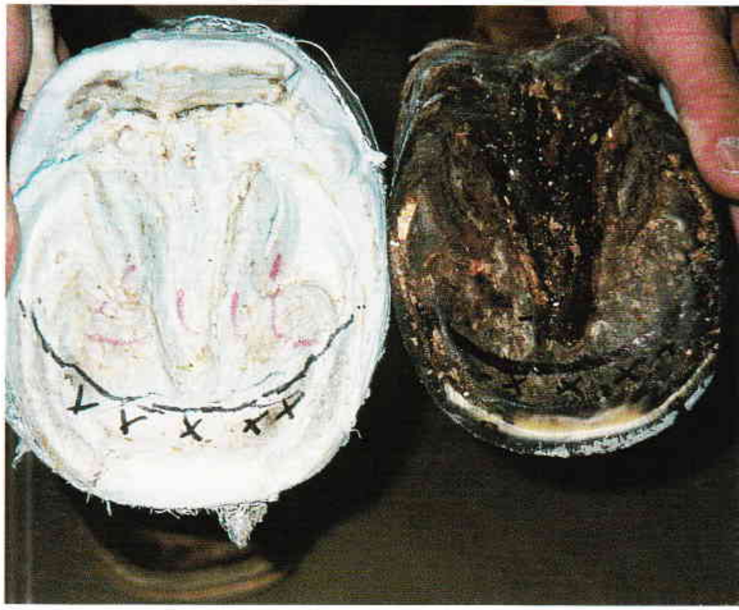


FIGURE 53:

The compressed pad is removed and the areas of pain on the corresponding sole are marked.

testers used to test the bottom of the hoof and mark the painful areas (Figure 53).

If the pad compresses more at the toe than at the heel, it will be important to de-rotate the trimmed, compressed pad. Remove the tape on the ground surface of the pad, begin at the middle of the pad and rasp towards the back (Figure 54).

Step 5: The remainder of the first pad should be taped back into the non-painful area, using 2 pieces of tape, and a new pad taped on top, remembering to make the wraps over the heel bulbs (Figure 55).

This second application should render the horse more comfortable but, in time, it may be necessary for a third application.

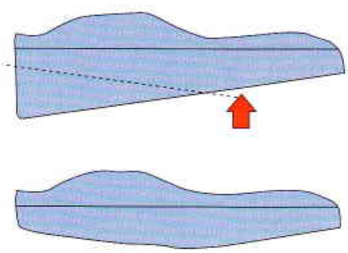


FIGURE 54:

The crushed pad is trimmed (arrowed), if necessary, ready to be re-attached.

Step 6: Carefully remove both compressed pads and de-rotate the second pad, only when necessary (Figure 54). The front part is trimmed away at the same place as the first layer. The 2 layers should be taped together making sure the tape does not get into the ridges or grooves left by the bars and frog clefts. The 2 pieces of pad are taped into the non-painful areas in the rear of the foot, using 2 pieces of tape, and a new pad added as before.

Once an acute case has stabilised and improved to Obel Grade 3 or better, the horse is ready for treatment using the Equine Digit Support System.

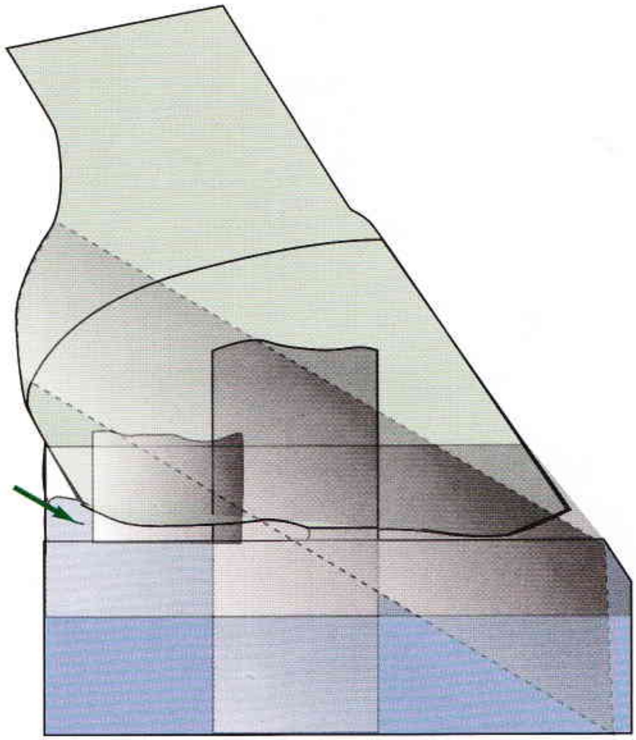


FIGURE 55:

The crushed pad (arrowed) is refitted and a new pad taped over it.

Trouble shooting

If it is noticed that the pads are crushing rapidly at the toe, remove the pad, turn it over and turn it round, placing the thick end at the toe, and re-apply the pad.

If the pads will not crush, it is possible that the horse is not ambulatory or is on deep or soft bedding. It may be possible to overcome this by taping a hard pad on the ground surface of the pads. This should only be left on long enough to start the pad compression process. Horses always become more comfortable following the removal of the hard pad.

If signs of pain become evident in the presence of a Styrofoam Support System, it may be due to an abscess. The pads should be removed until the horse has recovered from the abscess, and then re-applied.

The equine digital support system (EDSS) is a method of treating laminitis and founder. It was developed by G. Ovnicek. Its main principles are frog and caudal hoof support, radical reduction of break-over at the toe, allowing increased lateromedial movement and, where required, heel elevation.

This author's experiences have shown the use of the EDSS gives better results than many previously used methods. He believes the reason for this is due to the fact that it addresses the biomechanical needs of the foot for weight-bearing, circulation, physiology and pain response.

EQUINE DIGIT SUPPORT SYSTEM

David Nicholls

The EDSS system is made in a kit format, in 6 sizes (115–145 mm ($4^1/_2$–$5^3/_4$ inches), each kit containing shoes, pads and impression plates, 6 sizes of frog inserts and 3 heights of wedge rails. The kit also contains sufficient screws, bolts and impression material for the first shoeing and 2 re-sets. To obtain the greatest degree of success, the manufacturer's instructions must be followed carefully.

Step 1: When an acute case has stabilised to Obel Grade 3 or better, the horse is ready for treatment using EDSS. The foot should be cleaned of debris and loose sole material and hoof testers used to test the bottom of the hoof and mark the painful areas. The details should be recorded on the work up form.

Step 2: Trimming should be undertaken utilising natural balance guidelines. Excess sole is removed at the apex of the frog and caudally to the insertion of the bars into the sole. The chalky solar horn just inside the white line between the heels and quarters of the foot, should be removed down to the waxy lower layer. After measuring up from this layer 3 mm, the hoof wall is trimmed towards the heels. Each side should be trimmed to the same plane from the sole. Powdery

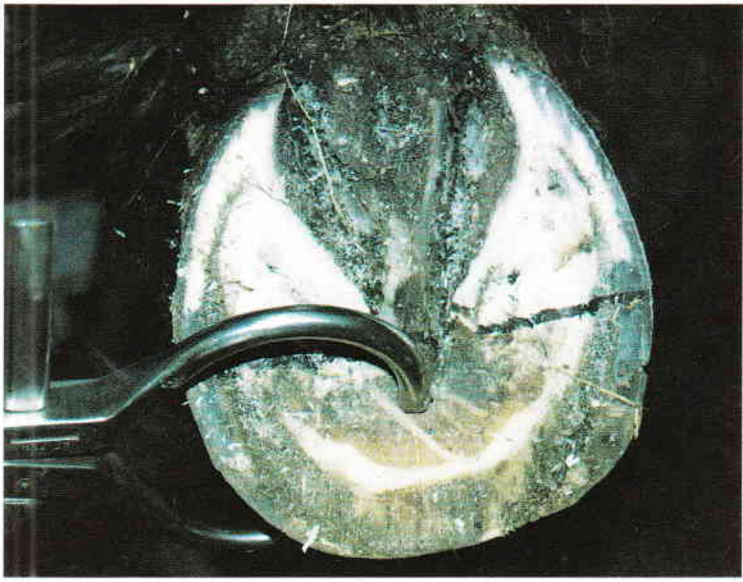


FIGURE 56:

Hoof testers are used to localise pain and a line is drawn 5 mm behind the last painful area. DIM is packed behind this line.

FIGURE 57:

The shoe is placed on the foot to check for fit. The inner border of the toe of the shoe is placed at the insertion of the frog apex to the sole.

FIGURE 58:

Equal amounts of DIM are mixed to produce the under-sole cushioning.

horn from the apex of the frog and any attached frog from the frog/sole buttress should be removed. This does not apply to any horn over the painful areas of the sole. The de-rotation caudal to the tip of the pedal bone reduces the pressure on the solar circulation.

Step 3: Using hoof testers to map out the painful areas of the sole, a line is drawn a few millimetres caudal to the last point of pain and another across the sole at the true apex of the frog, continued a short way up the hoof wall. This will assist later in correct shoe placement (Figure 56).

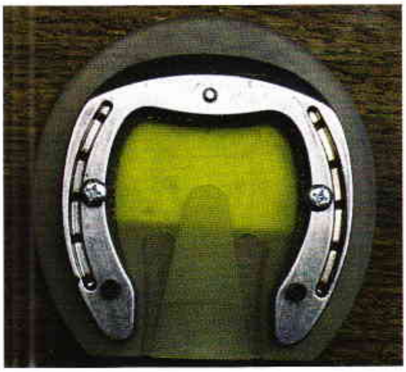


FIGURE 59:

Once the pad is positioned and attached, it can be cut around. The yellow area on the attached pad shows the area seated out.

FIGURE 60:

The set DIM is trimmed back behind the marked line. Compressed DIM is packed into the least painful areas of the foot.

Step 4: The shoe is placed with the inner border of the toe at the apex of the frog and shaped to fit. When altering these shoes, the whole branch of the shoe should be moved without distorting it, or the wedge rails will not fit the pre-drilled holes in the shoes (Figure 57).

Step 5: Two pieces of duck tape are placed on one of the impression pads, as for styrofoam application. Take enough of equal parts of the impression material to fill the foot behind the pain line. The impression material should be blended to an even colour and packed into the rear of the hoof. The impression pad is taped on, applying it to the hoof wall and pad together, with some wraps over the heel bulbs. The horse should be encouraged to stand on the pad to compress the impression material evenly (Figure 58).

Step 6: Using one of the screws supplied, the pad is attached to the shoe with the raised frog piece on the ground side. When the pad and shoe are screwed together the pad becomes seated out on the foot surface. This is to prevent any pressure on the painful sole beneath, while protecting the distal border of the pedal bone. Most surplus pad around the outer border of the shoe is cut away but it helps to leave some pad overhanging the toe of the shoe (Figure 59).

Step 7: The impression pad is removed carefully and the set impression material is trimmed so it is behind the pain line (Figure 60). Nail on the shoe and pad and clench up in the normal manner.

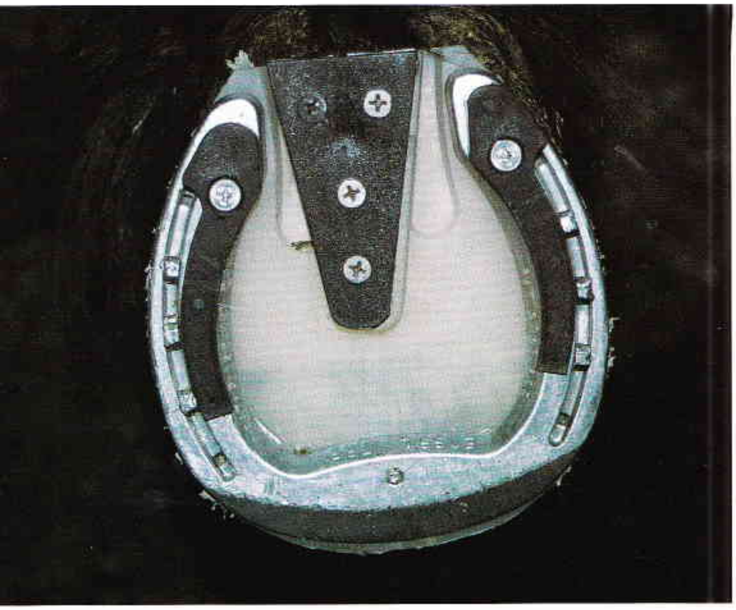


FIGURE 61:

The depth of frog support can be increased according to the horse's reaction. Rails (heel elevation) can also be added to assist in lateral movement.

FIGURE 62:

A rear view showing the DIM, pad and shoe, with the additional frog support and rails.

Step 8: With the horse walking in a straight line, the gait should be observed. It is important that the horse lands on the back part of the frog insert first, so it may take some time to select the correct frog insert.

Step 9: The horse should be trimmed in 2 metre circles to observe how it places its legs. As it turns, its outside leg should pass round and anterior to the contralateral limb. If this is not achieved, and the horse places the limb behind the contralateral limb or does not turn easily, rails can be added. After removing the protective bolts and screw on the rails that correspond to the frog inserts, the horse should be walked again to assess the horse's gait; further alterations of the frog inserts and rails may be necessary (Figures 61 and 62). Further adjustments can be made without removing the shoes. The frog inserts utilise the haemodynamics and soft tissue to support the bone column. The increased blood supply aids in the healing process. The adjustable frog inserts and rails provide support only during weight-bearing and release when the foot is unloaded. Correct shoe positioning ensures that the point of break-over is directly beneath the tip of the pedal bone, thus reducing the lever arm. The rails reduce the static tension on the deep digital flexor tendon and are positioned inside the nail groove. This facilitates easier turning as the leverage is removed from the edge of the shoe. In this author's experience, EDSS has consistently returned horses, failed by other forms of treatment, to pre-disease soundness.

Further reading

Butler, K.D. (1985) *The Principles of Horseshoeing II.* Butler Publishing Maryville.

Eustace, R.A. and Cripps, P.J. (1999) Factors involved in the prognosis of equine laminitis in the UK. *Equine vet. J.* **31,** 433-442.

Hickman, J. and Humphrey, M. (1988) In: *Hickman's Farriery.* 2nd Edn. J.A. Allen, London.

Ovnicek, G. (1997) *New Hope For Soundness.* Equine Digit Support System Inc.

Chapter 15:
Mediolateral limb deformities

Simon Curtis and
Sarah Stoneham

In many situations mediolateral deformities of the limbs are simply considered to be 'toe in' or 'toe out'. This may result in over simplification of the conformational defect and consequently the foot trimming may be inappropriate.

Early recognition of the type of deformity and its origin make attempts to correct the deformity more likely to succeed. It is important to be aware of the types of problem that may be corrected and those that cannot so that an appropriate prognosis can be given.

It should be remembered that limb conformation is dynamic until the individual is skeletally mature.

This chapter describes normal and abnormal development of the limbs, assessment of limb conformation, the types of deformity observed and techniques to allow optimal development of the limb for athletic soundness.

Normal limb growth and development

A foal is able to stand and follow its dam within hours of birth. It is useful to make an assessment of conformation during the first few days of life and then monitor this on a regular basis, usually monthly for foals without significant conformational problems.

Most foals are born with a mild degree of carpal valgus, less than 4° (Figure 1). This is due to joint laxity, and the limb can be aligned correctly. As the foal strengthens with exercise, and matures, the limbs straighten provided the feet are kept balanced. Some individuals have a base narrow stance with apparent outward rotation of the whole limb and their elbows are held tightly to the narrow chest wall (Figure 2). In both these instances joint alignment is correct and as the foal strengthens and broadens across its chest conformation will become correct provided the feet have been kept balanced and trimmed level to the pastern (Figures 3 a,b). It is important to differentiate these foals from those with a significant or worsening congenital angular limb deformity (ALD) or an acquired deformity.

The long bones lengthen by proliferation of a special region of cartilage (the physis or growth plate) which is then converted into bone. At a time particular to each growth plate (Figure 4) it stops producing cartilage and there is no further longitudinal growth of that long bone (closure of the growth plate).

Long bones increase in diameter by a different mechanism. The cellular lining over the outer surface of the bone, the periosteum

FIGURE 1:

A young 7-day-old foal with mild carpal valgus.

deposits bone on its inner surface, and bone is resorbed from the inner surface of the cortex within the medullary cavity. This process, although most active in the immature horse, continues in the skeletally mature horse in response to exercise and bone loading (see Chapter 4: Development of the Leg and Foot).

It is important to be familiar with the time for rapid growth and closure of the growth plates of the long bones if steps are to be taken to influence the growth of that particular bone.

Stimulation of the growth plates

Growth plates of the distal limb are stimulated by the stresses of weight- bearing or compression. Within the physiological range these stresses stimulate growth but when they become excessive, growth slows or stops (Figure 5).

The response to physiological levels of uneven stress across the growth plate allows the foals with a smaller angle of deviation to correct themselves (Figures 6 a,b). The response to excessive stresses on one side of the growth plate tends to perpetuate and worsen the deformity due to asynchronous growth across the growth plate. In the case of carpal valgus there are excessive forces on the lateral side of the growth plate slowing growth on this side of the bone which tends to exaggerate the deformity (Figure 7).

The cause of ALD is mostly congenital; it is often an interesting exercise to view mare and foal together.

FIGURE 2:

Base narrow/toe out (rotation). One-month-old foal.

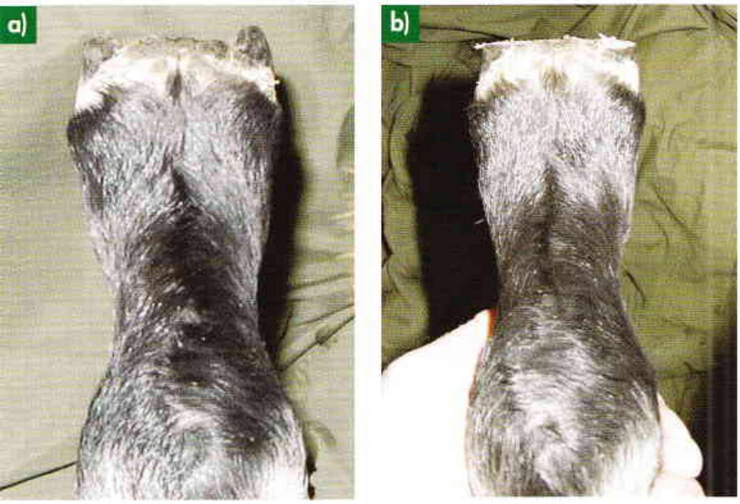


FIGURE 3:

Slight deviations rapidly create hoof imbalances. a) The hoof is worn and the heel shunted on the medial side (left) and the hoof longer on the lateral (right). b) The hoof is trimmed so that the solar surface is at 90° to the long axis of the pastern.

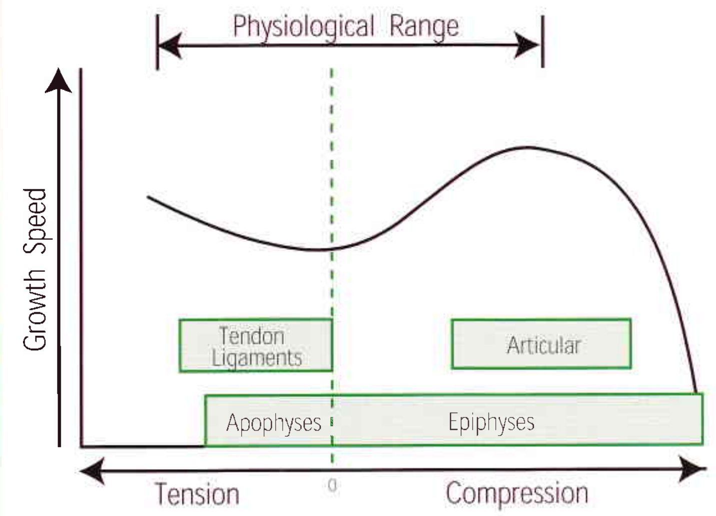
FIGURE 4:

A table (adapted from Fretz) shows the periods of rapid growth and timings for surgical intervention for the various physes.

Physis	Period of rapid growth	Timing for surgical intervention
Distal radius	0–8 months	2 weeks–4 months
Distal 3rd metacarpus	0–3 months	Birth–4 weeks
Distal 3rd metatarsus	0–3 months	Birth–4 weeks
Distal tibia	0–6 months	2 weeks–4 months

FIGURE 5:

The right side of the graph shows that initially increased compression promotes growth speed, which is beneficial and explains auto-correction (Figures 6 a,b). However, where compression is increased beyond the physiological range, excessive compression reduces growth speed until it stops. Illustration adapted from Adams Lameness in Horses, Edition 4.



The deformity may be acquired and causes that should be considered include:

1. Excessive exercise;
2. Lameness resulting in excessive weight-bearing on the sound limb
3. Osteomyelitis (infection of the bone) of the physis resulting in damage and premature closure of one side of the growth plate;
4. Abnormal weight-bearing on a limb.

Assessment of mediolateral deformities

Foals should be monitored regularly (monthly) while standing and walking on a hard level surface. Careful observation of gait is necessary to ascertain the location and type of any deformity. It is important to

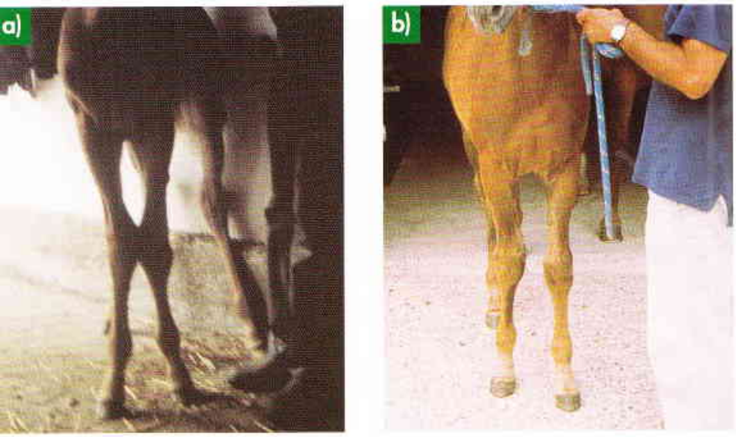


FIGURE 6:

Young carpal valgus foals frequently show rapid autocorrection. a) A 1–2-week-old foal; b) The same foal some months later. The foal was only trimmed every 4 weeks.

assess the structure of the whole limb, and determine whether the deformity is simple or a combination of problems.

The foal should be stood squarely, bearing weight evenly on the limbs, and viewed head on, initially from the midline and then directly in front of each limb (Figures 8 a,b,c). This allows evaluation of both ALD and rotational deformities.

The foal should then be walked in a straight line away and towards the assessor (Figure 9). It is important that the foal is walking freely. If it is leaning into or away from the handler foot flight and placement can be altered. The hindlimbs are viewed as the foal is walked away and the forelimbs as the foal is walked back. Foot flight and placement should be assessed in relation the midline and the ground. It may be necessary to walk the foal a second time to concentrate on a particular limb. You may wish to assess the standing foal again. Finally the limb should be assessed by eye lining (looking along the long axis of the limb). It may be appropriate to do this in the stable. The limb is picked up and held just below the knee with the knee flexed (see Chapter 6: The Principles of Foot Balance). Initially, allow the lower limb and foot to hang naturally under the foal's upper limb. The solar surface should be assessed in relation to the cannon and pastern, and the mediolateral balance of the foot and distortion of the hoof capsule. The solar margin should be examined for excessive wear or growth and flaring or straightening of the walls.

Lifting the toe allows assessment of joint alignment. Joint laxity, particularly of the knee, may be evaluated.

It is useful to record observations for each limb, action to be taken and then assessment of response to that action. As conformation is dynamic

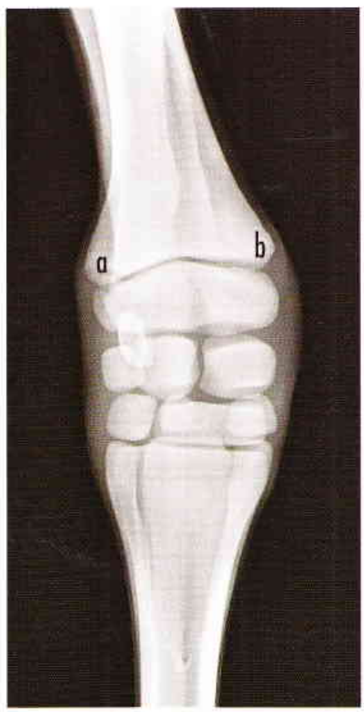


FIGURE 7:

The carpus of a 3-week-old foal with a carpal valgus deformity. The lateral side (a) not growing, or is growing slowly; the medial side (b) is growing normally creating asynchronous growth causing the angulation.

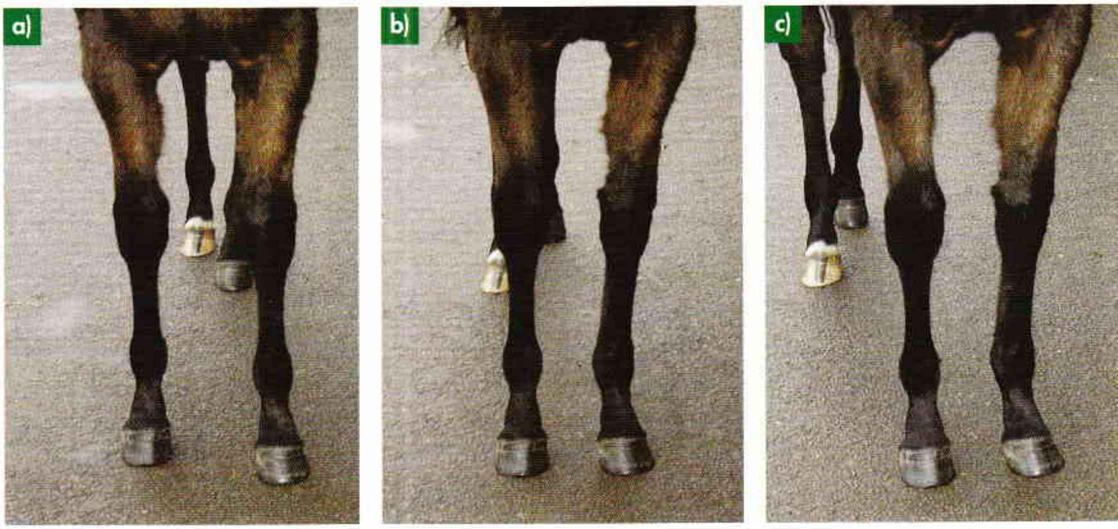


FIGURE 8:

When assessing for mediolateral deviations in a standing foal, the assessor looks down the midline of the foal (a) and also from in front of the leg (b). We can see how our perception of a leg changes by just altering our viewpoint by a few degrees (a, b, c).

in the young horse, assessment should take place on a regular basis and critical evaluation of response to trimming, extensions or surgical intervention is essential.

It is beneficial if the farrier and veterinary surgeon work closely together to allow all aspects of the problem to be considered and a joint approach reached.

Corrective farriery

The aim of corrective farriery is to reduce excessive forces on the compressed side of the growth plate, thus encouraging physiological corrective growth stimulation to occur.

It is important to differentiate those deformities which are likely to be improved from those which can simply be stabilised and excessive forces reduced to prevent further deterioration.

Trimming should encourage a balanced rounded foot with a centrally placed frog and equal dimension of the walls. The foot should be trimmed to land squarely on the ground rather than either the lateral or medial wall hitting the ground first. Foals with carpal valgus usually have increased wear of the medial wall, so the lateral side of the foot hits the ground first.

Aggressive trimming to counter excessive stresses is no longer recommended as this results in unequal weight distribution and distortion of the foot.

IGURE 9:

Valking a foal gives important information egarding conformation. This is because, with one eg bearing weight, any deviation is exaggerated.

FIGURE 10:

A foal with a right fore (left of picture) fetlock varus. The view is from the front of knee. This foal requires a lateral extension (see Figures 11–19).

Excessive exercise or over-tiring the foal can worsen an ALD. It is important when there is a significant deformity that the foal is given restricted exercise, usually in a small nursery paddock with its dam.

Mediolateral extensions

Medial or lateral extensions may be applied to the hoof to encourage more axial weight-bearing through the physis. A medial extension of 3–5 cm is applied in the case of valgal deformity and a similar lateral extension in cases of varal deformity (Figure 10).

Methods of applying mediolateral extensions

There are many ways to make extensions for foals' feet. Originally these were made by nailing on steel or aluminium shoes. Later glue shoes for foals (Mustard Baby-glu and Dalric) were used to create extensions. The simplest and most economic methods today are by custom building attachments to the hoof with adhesives (polymers and acrylics). Below are 2 methods of custom built extensions.

FIGURE 11:

The hoof is prepared by rasping the wall on the side requiring the polymer extension (left). The lateral sulci and outer wall are also rasped.

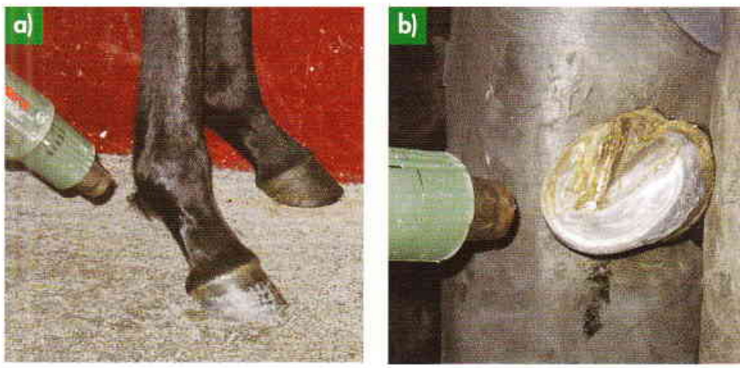


FIGURE 12:

The outer wall is heated to dry and warm it. The solar surface is dried and warmed immediately prior to application of the polymer. The glueing surface is neither touched nor set down from this point on. Cleaning agents must not be used.

Polymer urethane:

1. The side that requires the extension is trimmed down to clean horn along the wall, sole, lateral sulcus and bearing surface (Figure 11).
2. Both the outer wall and the solar surface are dried thoroughly using a heat gun. From this point on the foot must not be placed on the ground. Application of the polymer should follow immediately (Figures 12 a,b).
3. The polymer (Equi-thane, Superfast) is applied via a nozzle to the bearing surface of the hoof wall. A non-adhering pad is placed on the ground. Alternatively the foot can be brought forward and kept off the ground (Figures 13 and 14). Further polymer is applied outward and upward to finish the extension.

FIGURE 13:

The polymer is applied along the outer wall and into the sulcus.

FIGURE 14:

A polystyrene pad is placed over the foot surface and then put down. Further polymer is applied.

FIGURE 15:

The finished extension is rasped to 90° to the long axis of the pastern.

FIGURE 16:

The ground surface has ridges rasped to improve grip on hard surfaces.

4. The solar plane of the extension and hoof are trimmed to the desired angle (Figure 15).
5. To increase traction (the cured polymer can be slippery on some surfaces) the surface is scored with corner of the rasp (Figure 16).
6. The outer perimeter of the of the extension is trimmed to the desired dimensions and rounded (Figures 17, 18 and 19).

If the above procedure is followed, the extension will stay in place for 1–2 months. After 3–4 weeks the foot and extension should be re-assessed and trimming carried out to modify the angle and shape if necessary.

Acrylic extensions:

1. The foot is trimmed and cleaned thoroughly with acetone. The side that has the extension attached is trimmed lower. This is

FIGURE 17:

A solar view of the finished extension. Note the caudal length.

FIGURE 18:

Building the extension up the hoof wall increases its strength.

FIGURE 19:

The finished extension from an anterior view.

because, although the extension is built laterally, it inevitably builds up. By leaving the non-extension side untrimmed there is room for adjusting the angle of trim later (Figure 20).

2. The acrylic (Bond 'n Flex, Equilox) is applied with layers of fibre-glass cloth as strengthening, to the bearing surface and outer hoof wall (Figure 21).
3. Aluminium mesh, cut to the final dimension of the extension, is embedded in the acrylic (Figure 22).
4. The acrylic is allowed to set and is then trimmed to the desired angle (Figure 23).

Where an extension needs to be wider, additional strength can be gained by combining aluminium plate with acrylic (Figure 24). An alternative method is by using a thermoplastic cuff (Imprint) (Figure 25).

FIGURE 20:

The foot is prepared for an acrylic extension by rasping the side requiring the extension. The lateral sulci and outer wall are also trimmed and rasped.

Surgical corrective procedures

These procedures are considered when foals have failed to respond to corrective farriery and management changes or have deteriorated rather than improved over the first few weeks. If surgery is being considered it should be undertaken while there is still the potential for rapid growth at the particular growth plate involved, ie the distal radial physis for carpal valgus, or the distal metacarpal or metatarsal growth plate and proximal growth plate of the proximal phalanx in the case of fetlock varus or valgus (Figure 4).

FIGURE 21:

The acrylic is applied to the side of the sole and wall.

FIGURE 22:

After layering with cloth and acrylic, the extension is finished with a pre-cut aluminium mesh pushed into the acrylic and covered with a final layer.

Hemi-circumferential periosteal transection

The periosteum is considered to limit longitudinal growth, and this 'releasing' procedure is performed on the shorter side of the leg to encourage asymmetric growth across the growth plate.

This procedure is carried out under general anaesthesia; it is only considered necessary in a very small number of cases that have failed to respond to conservative measures, with deformities up to 15–20°.

Transphyseal bridging

This procedure involves the placing of surgical implants, either staples or screws and wires, across the growth plate on the longer side of the bone to increase stresses and so slow growth on this side. The implants are removed when the limb is aligned correctly. This is a considerably more invasive procedure with a much higher risk of complications. It is usually only considered when there is a severe (>20°) deformity (Figure 26).

FIGURE 23:

A finished acrylic extension to a fetlock valgus foal.

Types of medio-lateral limb deformity and possible farriery treatment

General guidelines to trimming foals

In general, trimming a foal is no different from trimming a horse of any other age. Nevertheless certain factors should be taken into

FIGURE 24:

An aluminium extension attached with acrylic. This is the foal seen in Figures 26 and 27.

FIGURE 25:

A cuff type glue on shoe (Imprint) made from thermoplastic can create a medial extension.

account. The farrier can affect the limb development at this age. By their nature, growth plates (discussed on page 283 and Chapter 4) respond to pressure stimuli. Simply keeping uneven growth in check (balancing the foot) at this age will improve uneven stress across the growth plates. As a rule of thumb, the solar plane of the foot should be trimmed at 90° to the long axis of the pastern until 3–4 months, after which the long axis should be the cannon.

Another consideration is the more delicate nature of the foal's foot. The hoof wall and sole are thinner and the distal phalanx within is very close to the surface. Aggressive trimming is more likely to make the foal foot-sore and there is evidence that it may make fractures to the distal margin of the distal phalanx more likely.

The sole only needs cleaning and should not be trimmed. The frog is trimmed up either side to keep the sulci clear (Figure 27).

Angular limb deformity

This type of deformity involves a clear angular deformity on the mediolateral plane. The deformity is described by the joint and type, eg carpal valgus, fetlock varus (Figures 28 and 29). Radiographs are necessary to determine the exact point of angulation, eg the carpal joint or distal radial physis, and degree of angulation (Figure 30).

As previously described a mild degree of carpal valgus <4° is normal in young foals and weanlings. Carpal valgus and fetlock varus of either

GURE 26a:

his foal has a severe fetlock varus deformity to its ft hind.

FIGURE 26b:

An X-ray shows that the main site of deviation is the distal third metatarsal physis.

FIGURE 26c:

One month later, after transphyseal bridging, some improvement is seen. This foal also had an extension fitted (see Figure 24).

he fore or hindlimbs are the most frequently seen. Carpal varus is isually seen as a development problem in foals which are several nonths old, combined with fetlock varus producing a bow-legged ppearance. It is often associated with a rapid period of growth and it s important to restrict the exercise and use lateral extensions to encourage more axial weight-bearing.

n the hindlimb, fetlock varus is seen as a congenital problem. Some veanlings develop outward rotation of the hindlimbs associated with apid growth giving a marked toe out hindlimb gait (Figure 31).

/algal deformities

The foot should be balanced and trimmed at 90° to the pastern. The ateral side of the hoof wall may be longer due to increased wear on he medial side and proximal shunting of the bulb and coronary band; his imbalance should be corrected. There may be flaring of the lateral wall and/or an upright medial wall. If an extension is to be applied it should be on the medial side of the foot to increase support on the nedial side of the limb.

FIGURE 27:

A trimmed hoof (note the symmetry of shape). The heel is rasped back and the sides of the frog trimmed. Excessive sole trimming should be avoided.

Varal deformities

The foot should be balanced and trimmed at 90° to the pastern. The medial side of the hoof wall is often longer and flared; this mediolateral imbalance should be corrected. If an extension is to be applied it

FIGURE 28:

A foal with varal fetlocks causing a toe-in stance and gait.

FIGURE 29:

A foal with a left fore (right of picture) carpa valgus deviation.

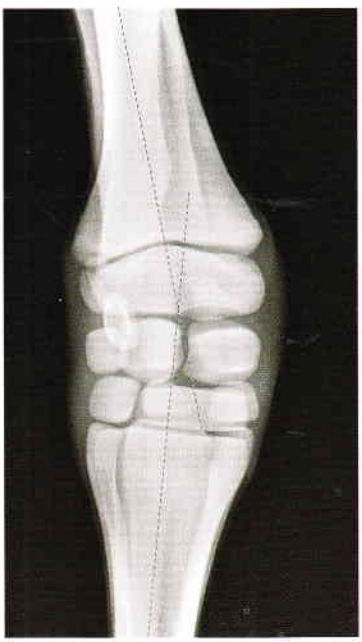


FIGURE 30:

A radiograph showing carpal valgus with a deviation.

should be on the lateral side of the foot to increase lateral support fo the limb.

Combination deformities

These need careful assessment. The feet should be balanced and th appropriate side for the extension must be judged on the particula case, eg in the case of carpal valgus/fetlock varus up to 3–4 months o age the varal deformity should be treated with a lateral extension. Th same deformity at 9 months should be treated with a medial extension

Offset knees (bench knees)

This deformity relates to the carpus. Axial lines drawn through th radius and metacarpus do not line up; the axial line through th metacarpus is set lateral to the line through the radius. This deformit produces uneven stresses through the growth plates on the medial sid of the lower limb (Figure 32). It may be associated with toe out or to in (fetlock varus) conformation of the lower limb. Horses with offse knees frequently develop splints on the medial side of the leg. It is no possible to correct this problem but it is important that these foals ar encouraged to toe out, aligning the solar surface to the long axis of th metacarpus.

FIGURE 31:

A foal with outward rotation of the hind limbs and a severe fetlock varal deformity (right hind).

FIGURE 32:

A foal with both knees offset. The right fore (left of picture) is seen more easily. When this severe, varal fetlocks are inevitable. Improving this conformation by surgery or farriery is not possible.

FIGURE 33:

A foal with an outward rotation of the right fore (left side of picture). Many such cases will improve. The farrier's task is to maintain hoof shape in the meantime.

Rotational deformity

These involve outward rotation, usually of the whole limb about its long axis. It may be combined with an ALD, usually carpal valgus (Figure 33). When viewing the foal from head on it is easiest to detect by assessing the position of the front surface of the knee. These foals are often narrow in front with their elbows held tightly against the chest wall. They may have a base narrow stance.

There is usually increased wear on the medial side of the foot and lateral flare with an upright medial wall. Many of these deformities show a marked improvement as the foals develop and strengthen, particularly by 12–15 months old.

Trimming should restore balance of the foot and reshape it to maintain mediolateral symmetry. Aggressive corrective trimming does not help these individuals; it merely distorts the hoof capsule.

Further reading

Adams, R. (1990) Non-infectious orthopaedic problems. In: *Equine Clinica* *Neonatology* Eds: A.M. Koterba, W.H. Drummond and P.C. Kosch, Lea & Febiger Philadelphia.

Barr, A.R.S. (1995) Management of angular limb deformities in the foa *Equine vet. Educ.* **7,** 75-78.

Curtis, S.J. (1999) *Farriery – Foal to Racechorse.* Newmarket Farriery Consultancy, England.

Fretz, P.B. (1980) Angular limb deformities in foals. *Vet. Clin. North Am. (larg animal practice)* **2,** 148.

Greet, T.R.C. (2000) Managing flexural and angular limb deformities: The Newmarket perspective. *Proc. Am. Ass. equine Pract.* **46,** 130-136.

Hunt, R.J. (2000) Management of angular limb deformity. *Proc. Am. Ass. equin Pract.* **46,** 128-129.

Slone, D.E., Roberts, C.T. and Hughes, F.E. (2000) Restricted exercise anc transphyseal bridging for correction of angular limb deformities. *Proc. Am Ass. equine Pract.* **46,** 126-127.

Stashak, T.S. (Ed) (1987) *Adams' Lameness in Horses.* 4th Edn. Lea & Febiger Philadelphia, p 320.

Chapter 16: Shoeing for grip

Chris Pardoe

Since the practice of attaching iron shoes to horses' feet began, the need to prevent excess slip or gain increased grip has added greatly to the strains imposed on the equine hoof and subsequent loading of the limb. These are of even more importance today, when horses are worked on modern roadway and arena surfaces with an ever-continuing requirement for increased performance.

Historically, numerous patent devices to improve grip have been described in veterinary and farriery texts. These range from simple forged heels or removable 'cogs', designed to prevent slipping in winter conditions, through to shoes made of different materials or sections. Some of these shoes had inserts of intermediate material (eg tarred rope) between shoe and ground surface (Figure 1). These intermediate materials were intended to increase the friction between the shoe and the ground surface whereas forged heel caulks or removable cogs were designed to give a point loading that digs into the ground surface to give grip (Figures 2 a,b).

Studs in use today are shaped to optimise their penetration into th intended work surface, ranging from the small or sharp for harde surfaces, through to the large or blunt that may be required fo stability at high speeds on softer surfaces such as these encountered i eventing. They may also contain a hardened central pin (tungste carbide) to increase wear (Figure 3).

Most modern studs screw into a pre-threaded hole, either drilled o punched, in the web of the shoe making them easily interchangeabl depending on requirements, although some may be fitted permanentl by driving the stud into a matching tapered hole. Plug studs should fi flush to the ground surface of the shoe thus minimising any imbalanc effect (Figure 4).

Non-slip horseshoe nails contain a small hardened pin (tungsten) an can be used in place of ordinary shoe nails or they can be used as simple stud by punching a nail hole in the required place and rivetin the cut off nail head in place. If they are used in place of a normal nail care must be taken to ensure that the pin head does not protrud excessively. This will cause the pin head to act as a fulcrum impartin a rocking motion to the foot on hard surfaces causing discomfort t the animal. In the long term this may lead to abnormal wear pattern and probable lameness (Figure 5).

A more adaptable technique is the use of tungsten pins. They ar simply the tapered central core found in studs. A small hol (approximately 3.7 mm for a 4.2 mm pin [$^{3}/_{20}$ inch for a $^{3}/_{16}$ inch] can be drilled anywhere on the shoe surface and the pin is tappe down almost flush with the shoe surface.

Another technique that is popular in the USA but less so in the UK is horseshoe borium or carbide. This is a granular form of tungste carbide in a brazable matrix, available as either rods or 'nuggets'. nugget or piece of carbide rod is placed in position on the shoe (it i useful to create a small depression in the shoe surface to hold it) an dusted with flux powder. It is then heated in a gas forge to temperature of about 850°C (bright red) when the braze matri begins to melt and 'wet' the shoe surface. Any high spots or shar

FIGURE 1:

Historically, many devices and materials have been used to improve grip. Here tarred rope is inserted in the shoe.

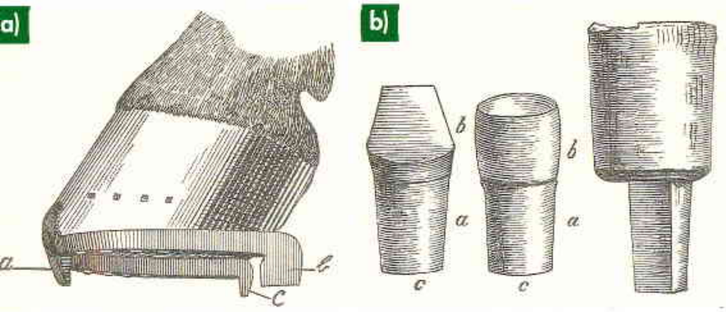


FIGURE 2:

Historically shoes have been made with projections to increase grip. These illustrations are from Lungwitz (1884) showing a shoe with toe and heel calks (a) and various drive-in studs called peg calks (b).

pieces can be removed easily before re-solidification and subsequent cooling. It is advisable to fit the shoe beforehand (Figure 6).

Selection of type of traction

When deciding on any method of grip enhancement or slip prevention the farrier, in conjunction with the owner, must decide on the best method of traction. Selection depends on type of animal and the task it is required to perform. Careful thought must be given to placement and the consequences of a particular method employed. They will alter joint angles and cause an increase in the shear forces and cranio-caudal force in the hoof wall. The quarters and heel area of the coronary band is an area of high flexion and stress in the foot. In this area the laminar attachment to the distal phalanx is reducing, wall thickness is reduced and functional movement of the palmar aspect of the hoof increases (see Chapter 1: Anatomy of the Equine Leg).

'Toe grabs' inserted into racehorse plates are intended to increase purchase as the toe of the foot digs into the track surface. However, whilst they undoubtedly increase performance (Figure 7), these are associated with a greatly increased incidence of tendon related injuries.

Racing plates for the hind feet often have a calkin of 10 mm ($^3/_8$ inch) raised, on the lateral heel. This undoubtedly gives grip in certain conditions but inevitably causes imbalances of the foot and limb on hard surfaces (Figure 8).

FIGURE 3:

There are various types and sizes of screw-in stud, from a simple block shape (a); low with a borium core (b); to high and pointed with a borium core (c).

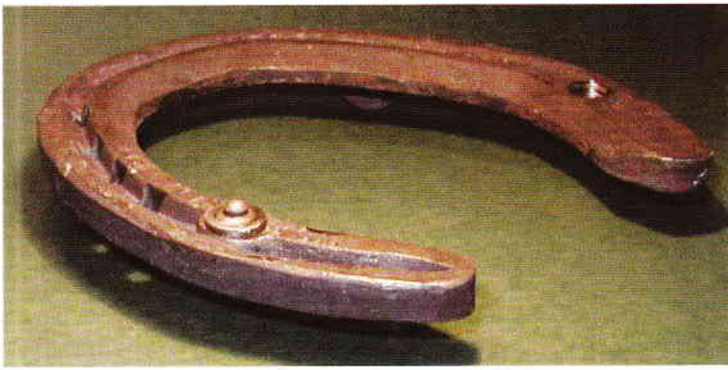


FIGURE 4:

This shoe has a drive-in plug with a borium core (left) and a drilled and tapped hole (right) ready to accept a screw-in stud.

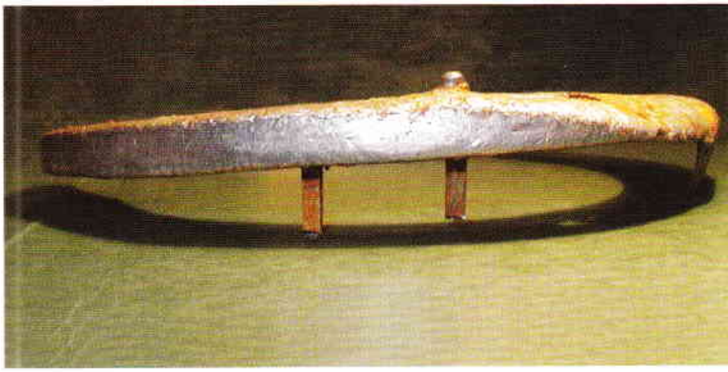


FIGURE 5:

Road nails with borium pins are very wear resistant. The shoe is seen to be worn either side of the pin.

Certain equine athletes may have specific requirements for placemen and numbers of studs but it is the author's opinion that studs shoul be placed towards the heels of the shoe and bi-laterally (one in eac side) to maintain mediolateral balance.

Studs are a useful and often beneficial tool but their inappropriate us will create problems. Placement of a single stud in the outside heel no only creates a mediolateral imbalance in the foot but increases th twisting forces on the leg. While this ability to turn quickly may be requirement in some trained sport animals, eg Polo ponies, it ma cause injury to the normal horse.

FIGURE 6:

Borium is applied to the toe and heels of an already fitted shoe.

Research into grip

Technology has provided many new materials that are now employe in horseshoe manufacture and they can have widely varying effects o the equine distal limb. The equine limb has evolved to a design th transmits and dissipates large forces through the foot. The horse h

FIGURE 7:

Toe grabs are used in some racing countries. They are effective in increasing purchase but also increase injuries to foot and limb.

FIGURE 8:

Calkins (or caulks) are usually 10 mm ($^{3}/_{8}$ inch) in height. They are worn on the outer heel on the hind plates.

evolved a suspensory apparatus in the leg that aids impact load dispersal. Hoof slip is also a small but significant part of this.

In human athletes, modern materials and innovative technology have been eagerly incorporated, with numerous in-depth studies on the grip of running shoes or their interactions with track surfaces. This has highlighted the area as one of critical importance for top level human performance and injury prevention. We are only now beginning to utilise this technology for our equine athletes.

Horseshoes have been designed from different materials (plastic and rubber) in an attempt to alter the grip and lessen impact attenuation to the limb (Figures 9 a,b).

These materials have different frictional properties which are reflected in the distance the foot slides between impact and coming to rest (slip distance) and the time taken for this to occur (slip time). Previous studies have measured the slip distance and slip time for different shoe materials. They have attempted to optimise them to achieve values

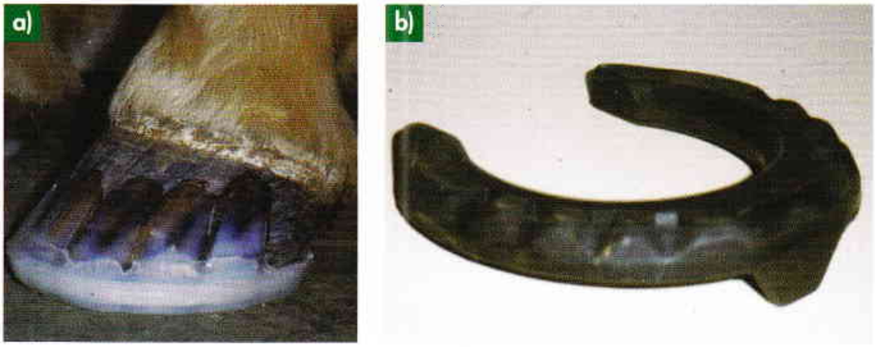


FIGURE 9:

Plastic (a) and rubber (b) have been used as materials for horsehoes for many years. Hard plastics often lack grip especially on hard surfaces. Rubber shoes are often seen to grip too well, not allowing foot slip.

similar to those recorded in the unshod state. These studies are based on the assumption that nature is best. They have resulted in a change in the rubber compound used for horseshoe construction.

The foot contacts the ground at a velocity of 1–2 m/s and then decelerates to rest. Shortened slip times are assumed to be associated with higher forces on the musculoskeletal system after impact and 'jarring'. If foot deceleration is the result of friction between the shoe and the ground then the cranio-caudal force should be higher during foot slide with a shoe with higher grip, ie more force = more grip.

Kinetic (dynamic) friction occurs between 2 surfaces that have relative motion and has a coefficient lower than that for the coefficient of static (limiting) friction which occurs when there is no relative movement. The situation when a horse's foot/shoe is in the slip phase of stance can be considered as dynamic friction. The ratio of the cranio-caudal (Fy) and vertical (Fz) components of the ground reaction force (GRF) will give an approximate value of the coefficient of dynamic friction between the shoe and the ground during slide (Figure 10).

These can be measured using optical motion capture equipment. This incorporates cameras that are able to record the position of the foot by tracking retroreflective markers in excess of 240 times a second (Hertz). When used in conjunction with a force plate, the ground reaction forces involved can also be recorded (Figure 11).

When 2 bodies interact, momentum is conserved (Newton's Laws of Motion). The kinetic energy of the limb and foot as it impacts the ground is converted to strain energy causing elastic and compressive deformation of the internal structures. At impact the foot slides forward until the coefficient of dynamic friction exceeds Fy:Fz ratio then the

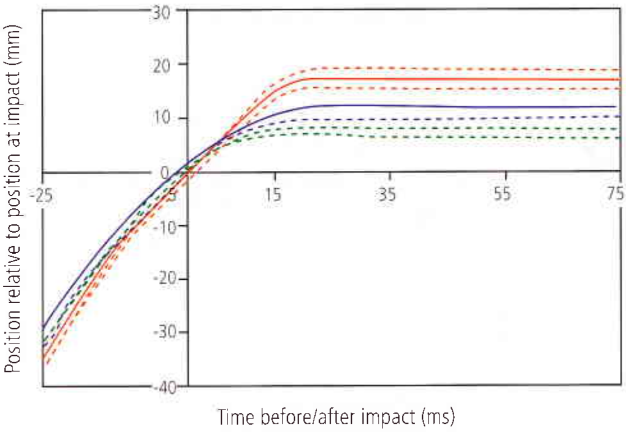


FIGURE 10:

This graph shows the hoof movement of an individual animal in 3 types of shoe: steel (blue), rubber (green) and plastic (red). The foot impacts with the ground at point 0,0, and it can be seen that the foot continues travelling (distance is increasing) for 15–20 milliseconds before coming to rest (when the line is horizontal) as the limb begins to load. This also shows the differing slip characteristics of shoe types.

FIGURE 11:

Retro-reflective markers are tracked using optical motion capture equipment to analyse movement and hoof slip.

foot stops sliding. The static limb can be fully loaded and the vertical load distribution mechanisms utilised optimally (Figure 12). Likewise at break-over and foot off, there is a point at which static friction is overcome as the foot rolls forward, the toe slips backward just prior to leaving the ground. By increasing friction in this area, the time the foot is in contact with the ground can be increased and effort maximised but this may lead to increased loading in other areas of the limb.

Hoof slip at foot off is considered a large problem in the showing field and this loss of action of the hock is called 'swimming'. Conversely the increased propensity to slip, indeed the need for lack of grip, is exploited in some equine sports, eg barrel racing contests.

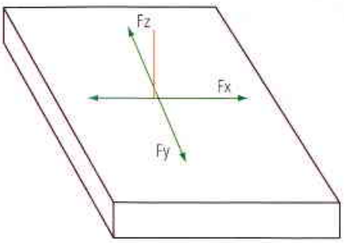


FIGURE 12:

Direction of forces measured in locomotion studies. Fz = up/down. Fy = forward / backward. Fx = side to side.

With the use of new materials or their application to horses' feet increasing continually, a plastic/polymer can now be applied directly to the trimmed foot to form a shoe and, with the ever increasing need for lighter, tougher and a more physiologically based approach to horseshoeing, we need to be aware of foot slippage.

The horse in its natural environment needs to slip. It is part of the evolved concussion dissipation mechanism of the lower limb and foot. So whether we are trying to increase grip or reduce slip, as farriers we must be aware of the 'cause and effect' of any methods we use.

Further reading

Dollar, J.A.W. and Wheatley, A. (1898) In: *A Handbook of Horseshoeing.* David Douglas, Edinburgh. 152-170; 301-309.

Heidt, R.S. Jr., Dormer, S.G., Cawley, P.W., Scranton, P.E.Jr., Losse, G. and Howard, M. (1996) Differences in frictional and torsional resistance in athletic shoe-turf interfaces. *Am. J. sports Med.* **24,** 834-842.

Hickman, J. and Humphrey, M. (1988) In: *Hickman's Farriery.* 2nd Edn. J.A. Allen, London. pp 12-15.

Kane, A.J., Stover, S.M., Gardner, I.A., Case, J.T., Johnson, B.J., Read, D.H. and Ardens, A.A. (1996) Horseshoe characteristics as possible risk factors for fatal musculoskeletal injury of Thoroughbred racehorses. *Am. J. vet. Res.* **57,** 1147-1152.

Lungwitz, A. and Adams, J.W. (1884) *A Textbook of Horseshoeing.* Oregon State University Press, Oregon, pp 122-156.

Pardoe, C.H., McGuigan, P.M., Rogers, K.M., Rowe, L.L. and Wilson, A.M. (2001) The effect of shoe material on the kinetics and kinematics of foot slip at impact on concrete. *Equine vet. J. Suppl.* **33,** 70-73.

Roepstorff, L., Johnston, C. and Drevmo, S. (1999) The effect of shoeing on kinetics and kinematics during the stance phase. *Equine vet. J. Suppl.* **30,** 279-85.

Thompson, K.N. and Herring, L.S. (1994) Metacarpophalangeal and phalangeal joint kinematics in horses shod with hoof caulks. *J. equine vet. Sci.* **14,** 319-323.

Wilson, A.M. and Pardoe, C.H. (2001) Modification of a force plate system for equine giat analysis on hard road surfaces: a technical note. *Equine vet. J. Suppl.* **33,** 67-69.

Yxklinten, U., Johnston, C., Roepstorff, L. and Drevmo, S. (1998) Ollov original and the biomechanics in horses – a comparative study between horses shod traditional horseshoes, rubber horseshoes and barefoot. *Commercial report, Swedish Agricultural University in Uppsala.*

Glossary

Abaxial: Situated away from the centre.

Abduction: Movement of the limb away from the midline of the body, ie swing outwards.

Abrasion: Circumscribed wound caused by friction leading to removal of superficial layers of skin (epidermis and portions of the dermis).

Abscess: A localised infection of sensitive tissues in which pus accumulates. Foot abscesses often cause lameness which usually subsides when they are drained. Also called gravel, pus pocket.

Acute: Of only short duration. NB acute and chronic do not relate to the severity of the problem, ie it is possible to have a severe or mild chronic infection.

Balance (dynamic)

Adduct: Swing inwards.

Aetiology: The cause behind a disease or abnormality.

Aetiopathogenesis: The cause and manner of development of a disease or abnormality.

Aluminium: The alloy used for hospital plates is approximately 94% aluminium, 2.4–3% magnesium, 0.5–1% manganese, copper, plus many other elements.

Anaesthesia: A state characterised by loss of sensation, the result of pharmacological depression of nerve function.

Angular limb deformity (ALD): A limb showing a marked change of direction along along a lateromedial plane. ALDs are defined by: 1) site, ie carpus, fetlock; and 2) type, ie valgus or varus.

Anterior: On or towards the front. *See also: Posterior*

Artery: A thick-walled vessel which carries blood from the heart to the lungs and body.

Artifact: A structure or appearance that is not natural but is created by, for example, the imaging system.

Arthrocentesis: Puncture and aspiration of a joint.

Arthrodesis: Surgical immobilisation of a joint by fusion of the bones.

Balance (static)

Arterio-venous anastomoses: Specialised connections between arteries and veins which, when open, allow the flow of blood from the artery to the vein without passage through the capillaries. Widespread within the laminar circulation, thought to be involved with pressure regulation, temperature control and probably involved in the development of laminitis.

Astringent: An agent that causes contraction of tissues, arrest of secretions, or control of bleeding.

Atrophy: From Greek 'atrophia', not to nourish. Shrinking or degeneration of tissues. Usually results from disuse or disease.

AVA: *See: arteriovenous anastomoses.*

Avulsion: A laceration resulting in tissues being torn from their attachments.

Axial: Situated toward the middle or centre.

Balance (dynamic): The relationship of gait, break-over and foot landing.

Balance (static): The relationship between the horse, its conformation, hoof shape and shoeing.

Bar shoe: Any horseshoe which is not interrupted by an opening between the heels. Various forms of bar shoe are used to increase support surface, apply pressure, prevent pressure or stabilise the hoof. *See also: Eggbar, Straight bar, Heartbar.*

Calkin

Barstock: The metal stock from which horseshoes are forged.

Bench knee: *See: Offset knee.*

Bick: The cone end of a London pattern anvil.

Bilateral: On both sides. Usually means both feet or legs of a pair.

Bleb: Small fluid swelling underneath the skin.

Bolus: A volume of any substances injected rapidly into a large vein so that it hits the circulation in one pass and does not 'trickle' around it.

Break-over: The period between the heels lifting and the toe leaving the ground during locomotion as the foot rotates around a point in the toe.

Bruise: The rupturing of blood vessels within sensitive structures resulting from trauma. Hoof bruises often result from the horse stepping on stones. Bruises can also occur in any sensitive structure, including the frog and the bulbs of the heels.

Bull-nosed: Foot conformation where the toe is over-long and very convex, the HPA is broken-back.

Calkin: A forged solid block on the heel of the shoe to improve ground surface grip. Also called calk.

Caudal: Rear surface. *See also: Palmar and plantar.*

Centripetal: Moving toward a centre.

Checker plate aluminium: Has a criss-cross ribbing pattern which increases strength and provides some grip.

Chronic: Long standing in nature. *See also: Acute.*

Clip: Flat projections, usually triangular or round, extending upward from the outer edge of a horseshoe. Clips are fit flat against, or set into, the outer surface of the hoof wall. Clips are used to prevent the shoe from shifting on the hoof and to stabilise the hoof wall.

Cobalt drill bits: An alloy twist drill capable of drilling holes in stainless steel.

Conformation: The shape of the horse.

Contracted hoof: Condition in which the posterior half of the hoof undergoes a significant reduction in width. This may result from other hoof problems, improper shoeing or both.

Contralateral: On the opposite side of the animal.

Convex: Surface curved towards the observer.

Corrective shoeing: Trimming or shoeing a horse's hooves to counteract flaws in stance or gait.

Cranial: Toward the head.

Deformity: Abnormality.

Dehiscence: Separation or breakdown of all layers of a surgical wound.

Denervation: To cut off the nerve supply by incision, excision or local anaesthesia.

Deviation: Variation from normal.

Diagnosis: The determination of what is causing the problem and the name that is applied to that condition.

Digit: From Latin 'digitus', a finger. The equine limb distal to the fetlock.

Disease: A deviation from the normal structure or function of any part or whole of the animal associated with a characteristic set of signs.

Distal: Further away from the body, or point of attachment. In other words, towards the bottom of the limb

Dorsal

Dorsal: Towards the back of the animal (the dorsum). In the horse and other quadrupeds, this is the upper surface, away from the ground.

Dorsal wall resection: Removal of part or all of the dorsal hoof wall, usually as part of treatment for *founder.*

Dorsopalmar: An imaginary line running front to back from the dorsal to the palmar.

Eggbar: A shoe of ovoid shape, used for dorsopalmar imbalances.

Embryo: The developing conceptus or foal in early gestation before its body structure becomes clearly developed (ie before 40 days of pregnancy).

Endoscope: An instrument used for direct visual inspection of hollow organs or cavities.

Enthesiophytes: New bone formation at the insertion of a tendon, ligament or joint capsule.

Epithelialisation: Healing by the formation of epithelium over a denuded surface.

Epithelium: The purely cellular, avascular layer covering internal and external surfaces of the body. It consists of cells joined by small amounts of cementing substances.

Eggbar

Extension: Where a shoe or other device continues horizontally beyond the distal border of the hoof wall. *See also: Lateral extension, toe extension, caudal extension.*

Fabricated: An invented construction from prepared components (welded not forged).

False quarter: Refers to a sub-optimal regrowth of laminar medium after coronary insult. It is defined as an overgrowth of horn which overlaps the normal wall.

Fetus: The developing foal after 40 days of pregnancy until it is born.

Fishtail shoe: Horseshoe, extending to the anterior almost to the fetlock for ultimate caudal support. *See also: Caudal extension.*

Fluctuant: Feeling as if full of fluid.

Flux: A material to assist welding.

Foot off: The point of last contact between the foot and the ground following breakover.

Forge welding: To join 2 surfaces of metal by hammering together at a high temperature.

Forging

Forging: 1) To shape hot metal with a hammer; 2) When the toe of the hin
shoe strikes the toe or sole of the front foot.

Founder: Occurs when the distal phalanx has become displaced from its norm
position within the foot due to the prolonged or severe effects of laminiti
excessive weight bearing or trauma.

Frog plate: An area of metal to cover the frog forged from the bar of the sho

Fullered: A groove in the section to accommodate the nail holes.

Graduated bar shoe: A bar shoe with gradual elevation towards the heel.

Granulation tissue: New tissue formed in repair of soft tissue wounds consistin
of new capillaries, formed by endothelial budding, and fibroblasts th
differentiate from mesenchymal cells derived from underlining vascular tissue

Frog plate

Haemodynamics: The operation of the digital cartilage/digital cushion system and increase blood flow to assist in the support of PIII.

Haemostasis: The arrest of bleeding by vascular spasm and clot formation or by compression or ligation.

Heartbar: A shoe instituted by B. Chapman, in the shape of a heart, that has an extended frog-plate finishing 1 cm from the apex of the frog. Used for laminitis and other hoof wall lesions.

Histopathology: Changes in tissues caused by disease.

Hockey sticking: The technique of swelling the metal of the bar shoe at the corners of the heel.

Hoof-pastern axis (HPA): The alignment of the hoof capsule with the pastern.

Hoof slough: Detachment of the hoof capsule following complete loss of blood supply to the coronary and laminar corium often as a sequel to sinking syndrome.

HPA: *See: Hoof-pastern axis.*

Hyperextension: Extreme or excessive extension of a limb or joint.

Hypertrophy: An increase in size (opposite of *atrophy).*

Hypoechogenicity: Refers to a lower level of reflected sound (echo) than is considered normal for a region. This commonly occurs in a ligament or tendon following injury.

Laceration

Ipsilateral: On the same side of the animal.

Ischaemic: Local deficiency of blood due to functional or mechanica obstruction of the blood supply.

Isotonic fluid: Fluid possessing the same osmotic pressure as tissue fluic whereby cells neither swell nor shrink as there is no net flow of water acros semipermeable membranes.

Isotope: A variant of a standard chemical with an altered nuclear structur often radioactive.

Keratinisation: The development of, or conversion into, keratin – scleroprotein, which is the principal constituent of horny tissues.

Laceration: Irregular, jagged wound caused by tearing of body tissue, a distinguished from a cut or incision.

Laminitic: Adjective describing any condition involving laminitis.

Laminitis: A cause of lameness of variable severity and affecting any number o feet, characterised by a heel loading stance and a change in the character o the digital pulses.

Lateral: Away from the midline of the horse.

Lateral extension: 1) Generic term for all types of shoes, or other devices, tha continue horizontally beyond the distal border of the hoof wall, on either side 2) Specifically a shoe, or other device, that continues horizontally beyond th distal border of the hoof wall, on the lateral side.

Lavage: Irrigation or washing out of a hollow organ or cavity.

Leg: The equine limb from the knee or hock down.

Limb: The entire equine appendage, from the scapula or hip down

Lytic: Loosening and/or dissolving.

Macerated: Softened by wetting or soaking.

Medial: Towards the midline of the horse.

Mediators: Biological chemicals which are produced during digestion or metabolism and have an effect on other, sometimes distant, body organs or systems.

Mediolateral: An imaginary horizontal line from side to side across an object.

Metabolism: The 'house keeping' process carried out by a cell or tissue to stay alive, ie nutrition, excretion etc.

Metabolite: Substance produced during metabolism, either synthesised during metabolism or taken from the environment.

Metronidazole: Antibacterial agent, an imidazole derivative, effective against most clinically important anaerobic bacteria and protozoa.

Mild steel: A non-alloy steel with up to 25% carbon.

Morphology: Structure and form of organism (as opposed to function).

Navicular disease: A true disease of the bone, ie showing radiographic changes.

Navicular syndrome: Pain in the navicular area involving disease symptoms and pathology.

Neurological: Relating to the nervous system.

Neurovascular: Composed of nerves and blood vessels.

Oedema: Excessive amounts of fluid between cells of the body.

Oestrus: The state of being in heat, ie in an oestrus (receptive state).

Offset deformity: A limb that does not align through a joint along a vertical plane.

Ossification: Formation of bone.

Osteomyelitis: Inflammation of the bone marrow and adjacent bone.

Osteopaenia: Loss of bone substance. In the context of founder, this refers to loss of distal phalangeal mass, due to disuse atrophy, lack of blood supply, pressure atrophy and is sometimes associated with purulent infection of the bone osteomyelitis.

Paddling: A deviation in gait in which the hoof arcs outward in flight. Paddling is often seen in horses which have a toed-in.

Medial or lateral

Offset deformity

Palmar: On the underneath of the foot or pastern of the forelimb.

Palpate: To examine by touch.

Pathogenesis: The manner of development of a disease or abnormality.

Pathological fracture: A fracture to a bone with a pre-existing weakness caused by disease.

Pathology: Bodily changes associated with disease.

Patten bar shoe: The name given to a shoe which elevates the heels with a bar. Also known as a Rest Shoe or Raised Bar Shoe.

Pentadactyl: Having 5 digits.

Perineural: Surrounding a nerve.

Pevidine: An antiseptic povidone – iodine solution containing a maximum 1% iodine by weight.

Phalanges: *See: Phalanx.*

Phalanx: Any of the major bones in a digit (plural phalanges).

Plantar: On the underneath of the foot or pastern of the hindlimb.

Posterior: Towards or on the back surface. Opposite of anterior.

Prodromal: An early symptom of a disease.

Prognosis: A forecast of the probable outcome of a disease.

Prophylaxis: Prevention of disease.

Protocol: A plan or system of work or examination format.

Proximal: Towards the body, or point of attachment. In other words, the top of the limb.

Refractory (cases): Resistant to treatment.

Reinnervation: Regrowth of nerve endings.

Palmar

Resection: An operation involving the removal of part of an organ or structure.

Rete: Network of small blood vessels.

Rocker toe: A horseshoe that has been curved upward toward the hoof at the toe. This eases and directs break-over. Hooves must be specially prepared to receive rocker toe shoes. Aka: Rolled toes (UK).

Rolled toe: A horseshoe that has been rounded on the outer edge of the ground surface at the toe.

Rostral: Pertaining to the nose or towards the front of the head.

Rotational deformity: The whole or part of a limb turned around a vertical axis.

Rupture: Break, or burst suddenly.

Rocker toe

Scarf: The name given to the overlapping area of metal to be welded.

Sedation: The act of calming by administration of an agent that quiets nervous excitement.

Sepsis: Indicates the presence of infection.

Septic osteitis: Inflammation of bone caused by pathogenic microorganisms.

Set toe: The toe of the shoe is bent up at 90° - usually a hind shoe.

Signalment: Medial history dealing with animal's age, sex, breed, use etc.

Sinker: A type of founder in which laminitis has destroyed so many of the laminae that the bone column is no longer suspended and begins to sink within the hoof.

Spavin: Any swelling or abnormal growth in or on the hock. A 'bog spavin' is a soft swelling on the medial and/or dorsal surface of the hock. A 'blood spavin' is an enlarged vein and a harmless blemish. A 'bone spavin' is an exostosis on the tarsal bones.

Spectroscopy: Study of spectra of substances to detect their presence in tissues.

Stainless steel: A steel containing 10.5% or more chromium and less than 1.2% carbon with or without other alloy elements. There are many variations, some more resistant to corrosion than others.

Set toe

Store horse: A young horse kept untrained until 3 or 4 years old, usually destined for National Hunt racing.

Steel: *See: Mild steel.*

Street-nail: A severe penetrating injury to the solar foot, usually involving the navicular bursa, deep digital flexor tendon or distal interphalangeal joint.

Sub-clinical: A condition or disease which is present in an animal but not yet evident on physical examination. Many diseases remain without clinical signs in their early stages.

Sub-cutis: Vascular tissue underneath the epidermis and dermis (corium).

Sub-mural: Behind the hoof wall.

Sub-solar: Beneath the horny sole, eg the sensitive sole (epidermis).

Synovitis: Inflammation of the lining of a joint (the synovium).

Tenotomy: Division, ie cutting completely through a tendon. In the context of founder, this usually relates to the deep digital flexor tendon. The operation is usually performed at the mid-cannon or mid-pastern sites.

Three quarter bar shoe: A bar shoe which has either a medial or lateral area of shoe missing from the heel quarter to the heel on one side.

Trailer

Trailer: An extra long heel on a horseshoe which is usually turned 45° away from the centre line of the hoof and the line of flight.

Transverse (image): An image produced as a 'cross section' of the limb, ie in a plane parallel to the ground.

TRH response test: Involves the measurement of thyroxine and T3 at defined times before and after the intravenous injection of 1 mg of thyroid releasing hormone. Used to evaluate the thyroid status of the horse and has been used to diagnose pituitary-dependent Cushing's disease.

Trimming: Removal of excess horn using hoof knife, cutters and rasp. Also called dressing or paring.

Tungsten: Shortened term for Tungsten Carbide. An alloy of tungsten and carbon that has very high abrasion (and hence wear) resistance.

Upset: To swell metal in a specific area.

Valgal: Adjective of valgus.

Valgus: Into a point out from that point|<.

Varal: Adjective of varus.

Varus: Out to a point and then in from that point |>.

Vasoconstriction: A reduction in the diameter of a blood vessel, usually associated with a reduction in blood flow to the supplied tissue.

Vasodilation: An increase in the diameter of a blood vessel, usually associated with an increase in blood flow to the supplied tissue.

Vein: Vessel which returns blood to the heart.

Web: The width of the stock from which a horseshoe is made.

Biographies

University of Cambridge Veterinary School, Madingley Road, Cambridge CB3 0ES, UK

ANDY P. BATHE

MA VetMB CertES(Orth) DipECVS MRCVS

Andy Bathe qualified from Cambridge University Veterinary School in 1989. He trained in surgery at the University of Bristol and then at Rossdale and Partners in Newmarket. He is currently University Equine Surgeon at the Queen's Veterinary School Hospital, University of Cambridge and is a Diplomate of the European College of Veterinary Surgeons. He has been Team Veterinary Surgeon to the Japanese and British Three Day Event Teams and the British Pony Showjumping Team.

His main areas of speciality lie in orthopaedic surgery and lameness, especially related to competition horses. He has always been interested in the application of novel diagnostic and therapeutic techniques to lameness problems.

Midtown Farm, Craigenhill Road, Kilncadzow, Carluke, Lanarkshire ML8 4QS, UK

SANDY BEVERIDGE

FWCF

Sandy Beveridge began his apprenticeship in 1980 with the Ferrie family in Ayrshire, Scotland where he gained a variety of skills and knowledge on shoeing of all kinds of horses and ponies.

In 1984 he passed the Worshipful Company of Farriers (Dip WCF) and set up his own business based in Central Scotland in the village of Kilncadzow.

In 1988 he passed the Associate of the Worshipful Company of Farriers (AWCF) and a year later he became a Fellow of the Worshipful Company of Farriers (FWCF). At this time he was invited to become an Examiner for the WCF. In the past he was a regular competitor at competitions and gained success at a local and international level. He also enjoys judging competitions and is a recognised WCF judge.

He is also involved in the training of apprentices and has lectured and demonstrated farriery in various countries. He has been a regular tutor on the WCF Foot Balance Course.

DAN BRADLEY

*P O Box 384, Lockwood,
California 93932, USA*

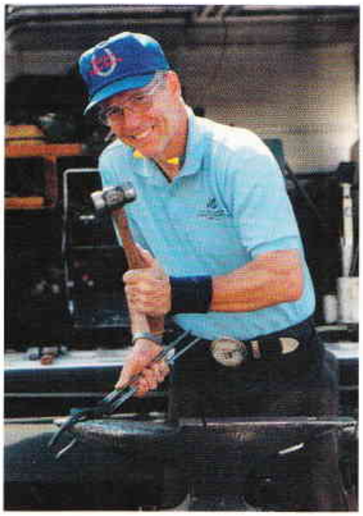
Dan Bradley was born and raised in California. His university education was interrupted by call up and a 2 year tour of duty in Vietnam. After attending a farrier school, he shod Saddlebreds, Tennessee Walkers, Morgans, Hunters and Western horses. During the 1980s, he was an early user of adhesions and glue-on shoes and gained referalls working on foals and laminitis.

In 1990, Dan began working with GE Tools. He is involved in the development of tools and travels the USA and abroad extensively, giving clinics and representing GE. He continues shoeing horses in the Central Coast of California, where he now lives. He also continues to ride trails with his wife Suzan and claims that he still occasionally surfs the waves.

DOUG BUTLER

PhD CJF FWCF

*Doug Butler Enterprises, Inc.,
PO Box 1390, LaPorte,
Colorado, 80535, USA*



Doug Butler has studied, written and spoken more words on horseshoeing than anyone of his generation. He has published *The Principles of Horseshoeing,* the most widely used farrier text in the world, and presented programmes on farrier science and craftsmanship for nearly 40 years. In addition, he has published *Shoeing in Your Right Mind* and *Six-Figure Shoeing,* texts that have assisted farriers to master foot balance, shoe fitting and basic business principles. Over 20 instructional videos produced by him have been used for farrier training in nearly every country. Dr Butler obtained his PhD in Equine Science and Veterinary Anatomy from Cornell University and was the first American to obtain the FWCF by examination. Today, he provides continuing education and advanced training for farriers and veterinarians while maintaining a select farrier practice. He has organised Farrier Focus™ Conference, the first-of-its-kind business conference for farriers, veterinarians and other equine professionals.

Selbourne House, Seale Lane,
Seale, Farnham, Surrey
GU10 1LF, UK

ANTONY J. P. CLEMENTS

BVSc. MRCVS

Antony Clements graduated from the University of Bristol in 1998, during which time he also managed to study in both Canada and the USA. He worked in mixed practice in Hampshire for 12 months. Following this he undertook a Clinical Scholarship at the University of Glasgow and specialised in equine orthopaedic work and equine surgery. He is currently working in Durban, South Africa, managing to combine his interests in travel and equine orthopaedics by working in a predominantly Thoroughbred practice that specialises in equine lameness and surgery.

The Forge, Moulton Road
Newmarket, Suffolk
CB8 8DU, UK

SIMON CURTIS

FWCF HonAssocRCVS

Simon Curtis has shod horses for 30 years in Newmarket, England. His family business is O. A. Curtis & Sons and he is attached to the Beaufort Cottage Equine Hospital at the Corrective Farriery Department. He is currently the Master of the Worshipful Company of Farriers (2001-2002) and is a Fellow by examination. Simon is the only farrier to become an Honorary Associate of the Royal College of Veterinary Surgeons and is a visiting lecturer to the National Stud, The British Racing School and Cambridge University. He has given workshops and lectured in 15 countries on 4 continents and been published in both veterinary and farriery journals. He was a co-author on the CD-Rom 'The Horse's Foot' and the video 'In Balance'. Simon Curtis is also the author of *Farriery – Foal to Racehorse*.

BERNARD DUVERNAY

CFC in Farriery

21 route de Florissant,
1206 Geneva, Switzerland

Bernard Duvernay travels extensively for much of the year. He regularly visits stud farms in India where he works as a consultant farrier and instructor. He has observed many developing countries, including China, Iran and Honduras. He has lectured in Europe and the USA at veterinary and farriery conferences and has published articles in the European Farriers Journal.

Bernard has gained his Federal Diploma in Farriery and Blacksmithing and became a master-farrier in 1983 at the Faculty of Veterinary Medicine, Univeersity of Bern. He founded his own farriery practice in 1985, mainly shoeing performance horses. Since then he has developed as a tutor and lecturer and looks after the farriery interests of equestrian associations and private owners. He is keen to be in the vanguard of new developments in methods and technology.

DAVID ELLIS

BVetMed DEO FRCVS

Reynolds House, 166 High
Street, Newmarket, Suffolk
CB8 9AQ, UK

David Ellis graduated from the Royal Veterinary College, London, in 1967 and then spent 2 years in practice in Hampshire before joining what is now the large equine referral practice of Greenwood, Ellis and Partners in Newmarket. His work includes stud, stable and surgery and he is an RCVS Recognised Specialist in Equine Orthopaedics. He gained FRCVS for a thesis on Foal Orthopaedics and a Diploma in Equine Orthopaedics. He has served as RCVS under- and post graduate examiner, published several papers and book chapters and is assistant lecturer at Cambridge University Veterinary School. He was president of BEVA in 1991 and has been awarded the Richard Hartley Clinical Prize and the Sir Frederick Hobday Memorial Medal. He is a Director of the Veterinary Defence Society and currently serves on several Thoroughbred veterinary advisory committees.

The Laminitis Clinic, Mead House Farm, Dauntsey, Chippenham, Wiltshire SN15 4JA, UK

ROBERT A. EUSTACE

BVSc CertEO CertEP FRCVS

Robert Eustace graduated from Liverpool University in 1977. He spent 9 years in equine practice in the UK, Eire and Australia before returning to Liverpool as a lecturer in equine studies. He gained RCVS Certificate qualifications in equine practice and equine orthopaedics.

In 1988 Rob established the Laminitis Clinic at Bristol University as a referral centre for laminitis cases. In 1990 a new plastic and steel adjustable heart bar shoe was developed for the treatment of laminitis, founder and sinker cases. The book 'Explaining Laminitis and its Prevention' was written in 1992 and has since sold over 10,000 copies. In 1993 he was awarded the Diploma of Fellowship of the Royal College of Veterinary Surgeons for his thesis 'Radiological measurements involved in the prognosis of equine laminitis'.

In 1993 the Laminitis Clinic moved to purpose built premises at Dauntsey, Wiltshire. In 1998 the Laminitis Trust was established as a registered charity whose purpose is to raise funds for research into laminitis.

The Smithy, High Street, Newmilns, Ayrshire

JIM T. FERRIE

FWCF

Jim Ferrie is a third generation farrier and has been shoeing horses for 32 years. He gained the Fellowship of the Worshipful Company of Farriers in 1982, subsequently becoming a judge and examiner of farriery. Jim and his brother Allan currently run a 14 person shoeing and farriery suppliers in south west Scotland.

A keen competitor, Jim has been in the Scottish Team 17 times. Major wins include The Royal Highland Show, Stoneleigh, Two-Man at the US Convention (twice) with his brother Allan, Calgary Top 10, 12 times and various other wins in Calgary classes including Two-Man 6 times, although the individual title has always alluded him, highest place being third.

His hobbies are fly-fishing and horse-shoeing contests.

SERGIO MUELLE GOLDSTEIN

DipWCF

The Forge, Moulton Road
Newmarket, Suffolk
CB8 8DU, UK

Sergio Muelle Goldstein was born in Peru and moved to the USA when he was 7. He emigrated to Spain in the mid 1980s to study veterinary medicine at the Universidad Complutense de Madrid, Facultad de Veterinaria. While there he developed an interest in farriery at the Equestrian Military Unit. After 3 years he decided to pursue a career in farriery.

Sergio became a Spanish citizen and shod mainly Adalusians and Arabians in Central Spain. He travelled frequently to England to study and passed the Diploma of the Worshipful Company of Farriers in 1999. He currently divides his time between the UK and Spain, where he runs courses in farriery for the community of Madrid.

He presently lives in Newmarket with his wife, Maria-Jesus and his 2 girls. His interests include history, architecture and renaissance music.

TIMOTHY R. C. GREET

MS MVM CertEO DESTS Dip ECVS FRCVS

Beaufort Cottage Equine
Hospital, Cotton End Road,
Exning, Newmarket, Suffolk
CB8 7NN, UK

Tim Greet graduated in 1976, obtaining a HBLB Scholarship and was awarded a Masters Degree for work in the Surgery Department in 1977. He went to the Animal Health Trust in Newmarket and was awarded Fellowship of the Royal College of Veterinary Surgeons for a dissertation on a radiological study of deglutition. In 1982 he joined Rossdale and Partners, becoming a partner in 1984. His interests are in general equine surgery.

He has been awarded a Certificate in Equine Orthopaedics and a Diploma in Equine Soft Tissue Surgery by the RCVS and is a Diplomate of the European College of Surgeons. He is recognised as a Specialist in Equine Surgery by the RCVS and the European College of Veterinary Surgeons.

Tim has won the Centenary Award of the British Veterinary Association and the Richard Hartley Clinical Prize. He has published papers in veterinary journals and contributed chapters to veterinary textbooks. He was President of the British Equine Veterinary Association in 2000 and is currently the Junior Vice President of the British Veterinary Association.

Beaufort Cottage Equine Hospital, Cotton End Road, Exning, Newmarket, Suffolk CB8 7NN, UK

MARCUS J. HEAD

BVetMed MRCVS

Marcus Head qualified from the Royal Veterinary College, University of London, in 1994. He worked in mixed practice for a short period before internships at the Animal Health Trust and Royal Veterinary College. He joined Rossdale and Partners in 1996, dealing primarily with racehorses, and became a partner in 2000. His particular interests are lameness and diagnostic imaging.

The Equine Veterinary Clinic, Turningshaw Farm, Turningshaw Road, Houston, Renfrewshire PA6 7BP, Scotland

PAUL LENTELINK

MRCVS DVM

Paul Lentelink graduated in 1997 at the University of Utrecht in the Netherlands and worked in mixed practice for a year before taking up a 3 year intern position at the Weipers Centre for Equine Welfare, the equine department at the University of Glasgow Veterinary School. During this period he dealt with a varied caseload of first opinion and referred medical and surgical cases with an emphasis on orthopaedic problems, and developed a special interest in the veterinary care of the performance horse. He currently works at the Equine Veterinary Clinic, a specialised equine clinic based in Renfrewshire, West-Central Scotland. He is preparing for the Certificate in Equine Practice.

Paul rode out for a local racehorse trainer, point-to-pointed (with more enthusiasm than success!) and hunts regularly with the Lanark and Renfrew.

JONATHAN M. LUMSDEN

BVSc, Diploma VCS MS Diplomate ACVS

*Randwick Equine Centre,
3 Jane Street, Randwick,
Sydney, Australia*

Jonathan Lumsden graduated from the University of Sydney in 1987 and then completed an internship under Professor David Hutchins BVSc at the University of Sydney, Camden. Subsequently, he went into general equine practice until commencing an equine surgical residency at Michigan State University, USA. Jonathan completed a Masters Degree in the evaluation and surgery of the equine upper respiratory tract and was awarded the best resident scientific presentation by the American College of Veterinary Surgeons in 1993. He became a Diplomate of the American College of Veterinary Surgeons in 1994 and fulfilled clinical appointments at Michigan State University and Colorado State University before becoming the resident surgeon at the Randwick Equine Centre, Sydney, Australia in 1995. Jonathan is a partner of the Randwick Equine Centre where his practice includes referral surgery and routine racetrack practice. He has published numerous scientific articles and has special interests in orthopaedic and upper respiratory tract surgery and lameness diagnosis.

STUART MARSHALL

AWCF

*No 1 B Broomhill Cottages,
Broomhill Lane, Fakenham
Magna, Thetford, Norfolk
IP24 2QY, UK*

Stuart Marshall began his apprenticeship in farriery in 1982 and qualified by passing the Diploma of the WCF in March 1986. He gained the Associate of the WCF examination in April 1998.

He has been actively involved with the remedial and corrective shoeing at Beaufort Cottage Equine Hospital, Newmarket, for 6 years.

He has lectured in farriery for different equine groups, including HND/HNC lectures for the Open College equestrian studies. He is also a tutor for the WCF. His subjects include foot balance, modern farriery techniques and racehorse shoeing. His professional interests include all aspects of remedial farriery, especially laminitis and foot wound management. Away from remedial shoeing, he shoes a wide variety of horses.

Stuart lives with his wife Liz and 3 children in Norfolk, where his pastimes include fishing.

Beaufort Cottage Equine Hospital, Cotton End Road, Exning, Newmarket, Suffolk CB8 7NN, UK

JOSIE MEEHAN

VN

Josie Meehan spent 2 years caring for premature foals before joining a mixed veterinary practice in Ireland. She qualified as a veterinary nurse in 1985. In 1986 she joined the Rossdale and Partners veterinary practice and became the radiographer in 1991 at the Beaufort Cottage Hospital. There she was involved with the inception of the digital x-ray system.

Josie instructs the veterinary interns in radiography at the hospital, where her primary interest is imaging with radiography and scintigraphy.

Animal Health Trust, Lanwades Park, Kentford, Newmarket, Suffolk CB8 7UU, UK

RACHEL C. MURRAY

MA VetMB MS Ph.D Diplomate ACVS, Diplomate ECVS MRCVS

Rachel Murray graduated from Cambridge University in 1990. She subsequently undertook an Internship in equine medicine and surgery at the University of Missouri followed by a Residency in equine surgery at Kansas State University, USA. On returning to the UK, she became the equine surgeon at Cambridge University before moving to the Animal Health Trust, Newmarket in 1997, where she now leads the orthopaedic research and equine magnetic resonance imaging. She is an American and European specialist in equine surgery. Outside work, she trains and competes 2 dressage horses.

DAVID J. NICHOLLS

RSS AWCF

Total Foot Protection Ltd, Five Oaks Road, Slinfold, West Sussex RH13 0QW, UK

David Nicholls was born in Balham, South London. David's family house backed onto a large riding school and this is where he established his love affair with horses. At the age of 7, David met a farrier and, for the first time, decided he wanted to be a farrier.

In 1968 David started his apprentiship with Howard Cooper FWCF (hons), in Abinger Hammer, Surrey. He qualified as a Registered Shoeing Smith (RSS) in 1972 and decided to see life outside the farriery world and joined the London Fire Brigade. During that time he still pursued an active interest in farriery. In 1978 David returned to farriery and, following a further period of training, passed the Associate of the Worshipful Company of Farriers (AWCF) exam. In 1988 David formed a group practice of farriers, with his 2 business partners Mark Spriggs and Michael Williams, Total Foot Protection Ltd (a farrier's supply company). He now spends much of his time promoting modern farriery in Europe and the USA. He is a member of The Guild of Professional Farriers (USA). David's main objective is the future development of farriery and to improve equine soundness.

CHRIS PARDOE

BSc(Hons) AWCF

10 Kingsley Lane, Thundersley, Benfleet SS7 3TU, UK

Chris Pardoe has been a farrier and blacksmith for 34 years running his mobile shoeing business in Essex, UK. After gaining the RSS in 1974 he began to specialise in remedial farriery and was a successful competitor in both shoeing and best shod horse competitions. He was awarded the AWCF in 1987 and began studying with the Open University graduating in 1995 with a BSc hons degree in Natural Sciences.

He is also an experienced welder and engineer and has taught for both government and private training agencies.

He has presented papers on cracks and slippage in horses' feet at several international conferences and is currently working on a PhD researching into Equine Hoof Biomechanics in the Structure and Motion Laboratory of Dr Alan Wilson at The Royal Veterinary College, University of London.

Beaufort Cottage Equine Hospital, Cotton End Road, Exning, Newmarket, Suffolk CB8 7NN, UK

RICHARD J. PAYNE

BVSc BSc CertES(Orth) MRCVS

Richard Payne graduated from Bristol University in 1995, having also obtained an honours degree in Pharmacology. After a year in mixed practice he moved to Rossdale and Partners (Beaufort Cottage Equine Hospital) and completed a 3 year residency in Equine Surgery. He gained an RCVS Certificate in Equine Surgery (Orthopaedics) in 1999 and became partner of the practice in 2002.

He deals with first opinion work associated with racehorses in training and with a large and varied caseload of surgical and medical referrals. His main areas of interest are foot surgery, colic surgery and minimally invasive 'keyhole' surgery (arthroscopy and laparoscopy).

Richard is keen on all sports but now confines his involvement to golf and flying.

Beaufort Cottage Equine Hospital, Cotton End Road, Exning, Newmarket, Suffolk CB8 7NN, UK

ROB C. PILSWORTH

MA VetMB BSc CertVR MRCVS

Rob Pilsworth qualified from the University of Cambridge in 1981. He worked in mixed practice until 1985, when he joined Rossdale and Partners in Newmarket, becoming a partner in 1988. He works on the racehorse aspect of the practice and was responsible for introducing and developing the nuclear scintigraphy unit. Rob obtained the Certificate in Veterinary Radiology in 1986 and has a special interest in lameness.

MIKE SHEPHERD

BVSc MRCVS

Beaufort Cottage Equine Hospital, Cotton End Road, Exning, Newmarket, Suffolk CB8 7NN, UK

Mike Shepherd is a 1990 graduate of Massey University and, after graduation, he worked in general practice in New Zealand before doing a variety of locums in the United Kingdom. He joined Rossdale and Partners in 1991 becoming a partner in 1996. His main interest is diagnostic imaging for musculoskeletal injuries in all types of horse and he has been instrumental in developing the use of ultrasonography for the diagnosis and management of pelvic fractures. He has also gained extensive experience in the management of tendon and ligament injuries in racehorses.

SARAH J. STONEHAM

BVSc CertESM MRCVS

Beaufort Cottage Stables, High Street, Newmarket, Suffolk CB8 8JS, UK

Sarah Stoneham graduated from the University of Bristol Veterinary School in 1983. She worked in general equine practice before joining Rossdale and Partners in 1987, she has subsequently become a partner. She has specialised in stud farm medicine gaining her RCVS Certificate in 1990 and has acted as an examiner in this subject.

Sarah's special interest is in foals and weanlings. She has spoken internationally on foal medicine and critical care and has also published in this field.

She runs the foal critical care unit at Beaufort Cottage Equine Hospital.

Index

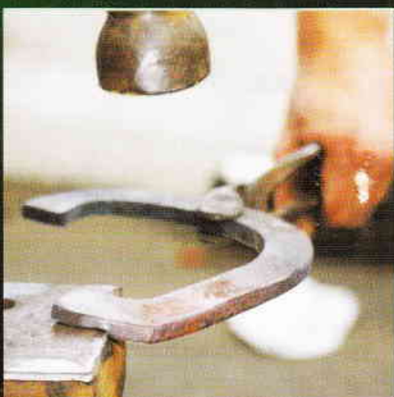
Corrective farriery
a textbook of remedial horseshoeing

ISBN 1-899772-10-
9 781899 772100

Corrective farriery

a textbook of remedial horseshoei

Volume I



Edited by
Simon Curtis FWCF HonAssocRCVS

This is a multi-author book written for farriers, veterinary surge
and interested horse owners. The authors are eminent farri
veterinary surgeons and related professionals from around the wo
The book describes the combining of traditional farriery skills v
veterinary knowledge and advanced techniques of repair
shoeing. Over 300 pages and more than 400 colour illustrations t
the reader through the diseases, conditions and conformational fa
that affect the horse. The development of the leg and hoof is tra
from an embryo to the mature horse. There are large chapters
laminitis and chronic foot lameness. Many chapters have clear s
by step guides to treatment.

Topics include:

- Anatomy
- Imaging the foot and leg
- Foot balance
- Development of the foot and leg
- Making hospital plate shoes
- Shoeing for conditions of the hind limb
- Injuries to the hoof capsule
- Laminitis

The editor has shod horses for 30 years in Newmarket, England.
is a Fellow of the Worshipful Company of Farriers by examinat
and is the only farrier to have been awarded an Honorary Assoc
of the Royal College of Veterinary Surgeons for his work
encouraging co-operation between farriers and veterinary surgeo
He is a visiting lecturer to the National Stud, The British Rac
School and Cambridge University. Simon Curtis is also the autho
Farriery – Foal to Racehorse.