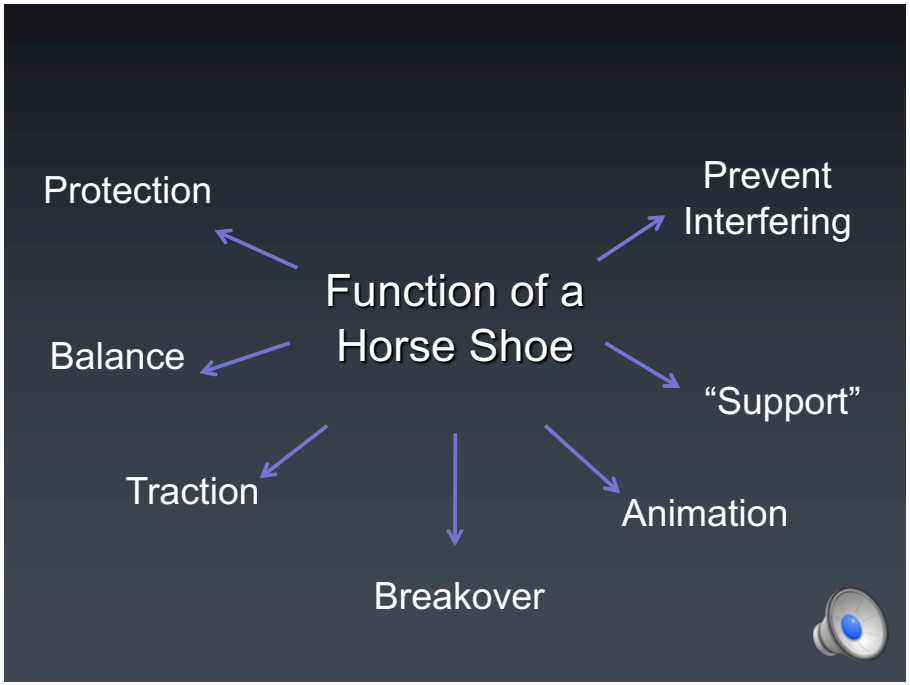
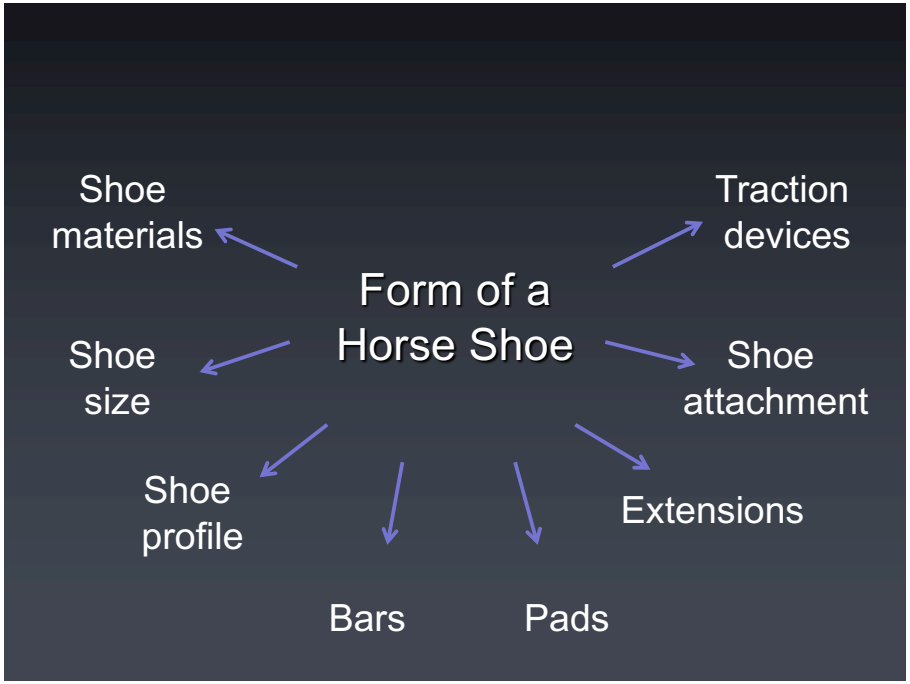
The Equine Digit: Digital Biomechanics and Shoeing with Particular Reference to Laminitis

Andrew Parks
University of Georgia



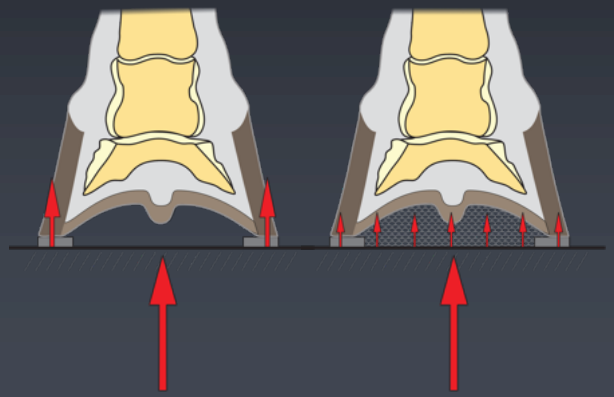


A Biomechanical Basis for Therapeutic Shoeing

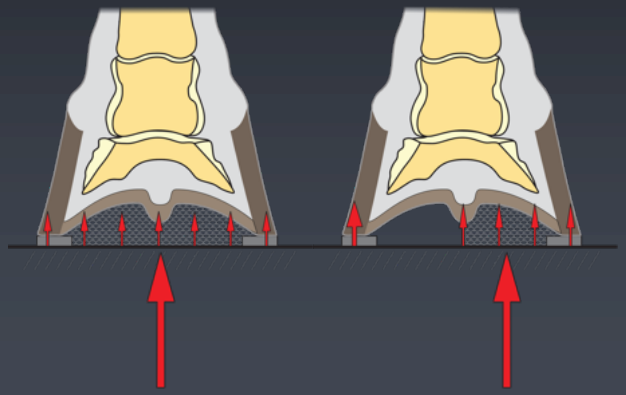
Therapeutic Modifications to Foot Biomechanics: Only so many Concepts.

- Change distribution of pressure – symmetric vs. asymmetric
- Change center of pressure ML vs. DP
- Change moments about DIPJ at rest
- Change moments about DIPJ at breakover
- Change deceleration (Attenuate impact vibrations)

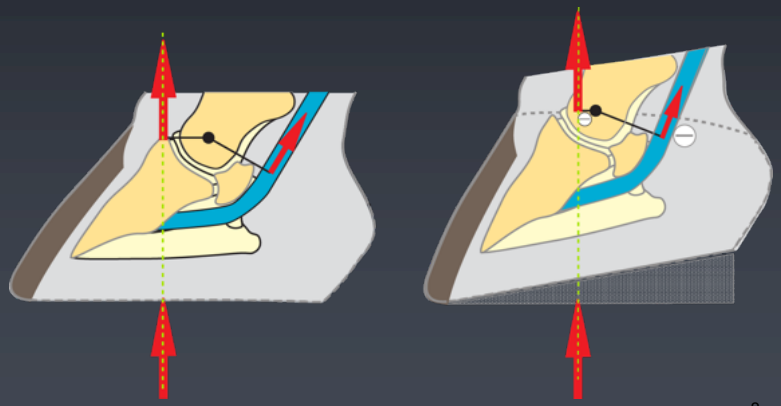
1. Changing the Distribution of Force symmetrically



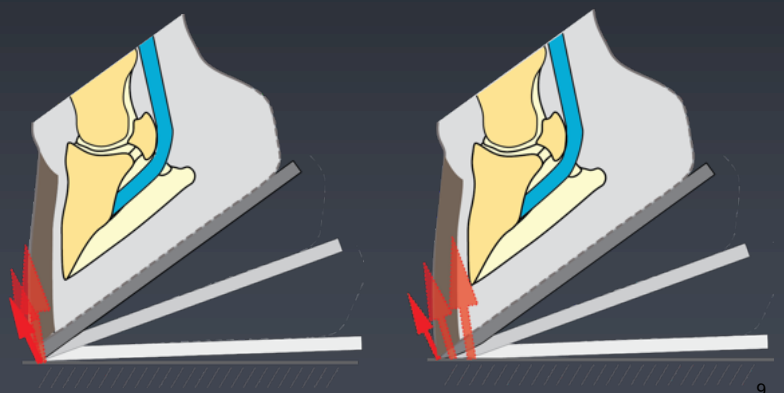
2. Changing the Distribution of Force Asymmetrically --> Change Center of Pressure



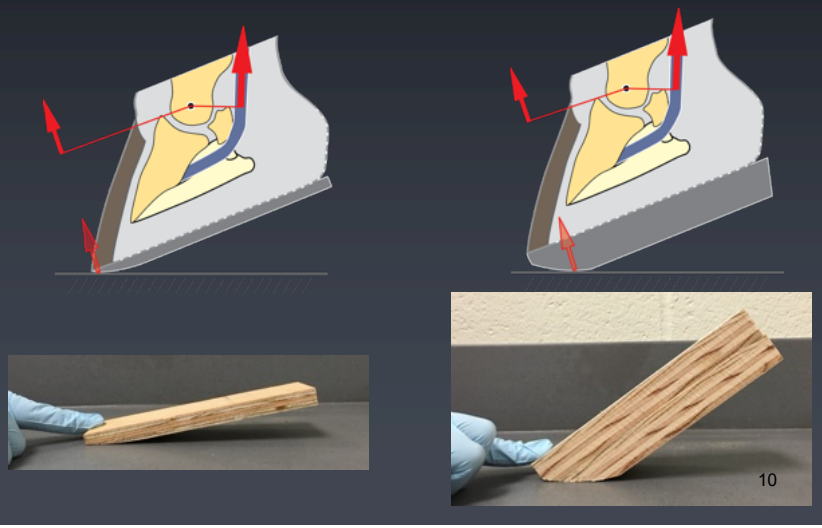
3A. Changing the Moments About DIPJ



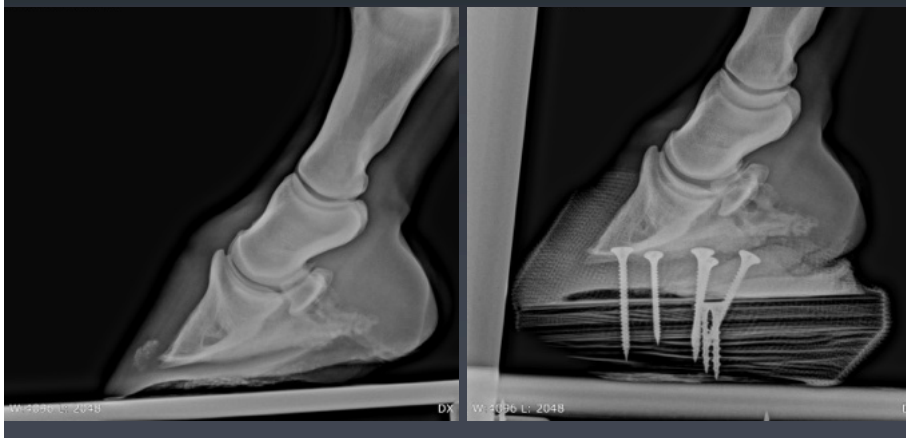
3B. Changing the Moments About DIPJ



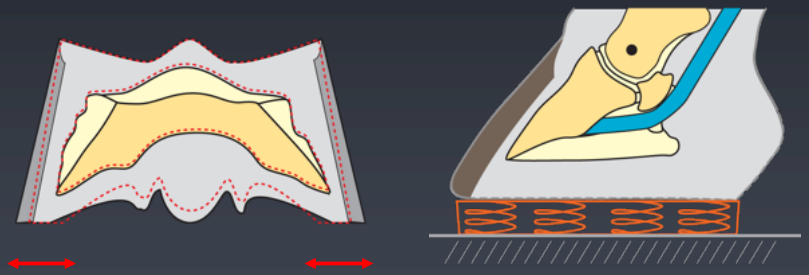
3B. Changing the Moments About DIPJ



Therapeutic Modifications to Foot Biomechanics



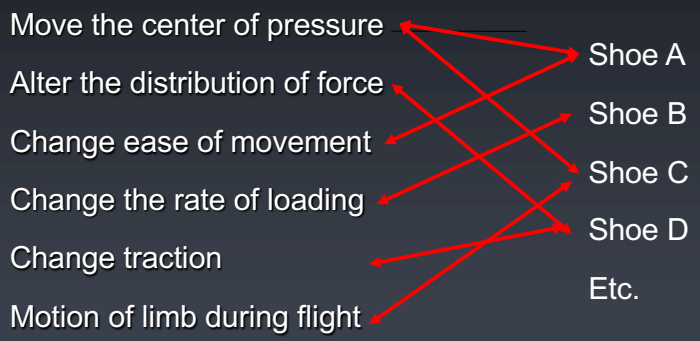
4.Changing Deceleration/Damping



Maintain natural hoof mechanism

Supplement natural hoof mechanism

Any goal can be achieved by more than one type or shoe



And any one shoe may meet more than one goal

Therapeutic Shoeing

Problem: Most commonly trauma or infection

↓

Goal: Allow injury to heal and alleviate pain

Specific Diagnosis	Symptomatic
↓	↓
Tissue and Process	Localized Lameness/ Abnormal Shape

Applying General Principles

What is the affected structure (and process)?

↓

Is the structure stressed under tension or compression?

↓

Is the tension affected at rest and/or in motion?

↓

What biomechanical principles would best reduce the stress?

↓

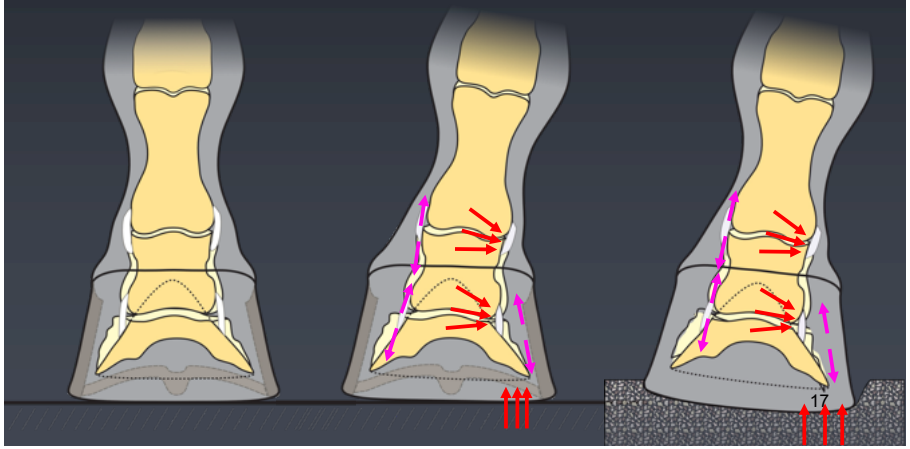
What therapeutic shoeing modifications will accomplish biomechanical goals?

Is the structure stressed under tension or compression?

Injury and Pain related to Stress/Strain

Stressed under compression	Stressed under tension
↓	↓
Bone Articular surface Sole	Tendon Ligament Lamellae

Is the tension affected at rest and/or in motion?



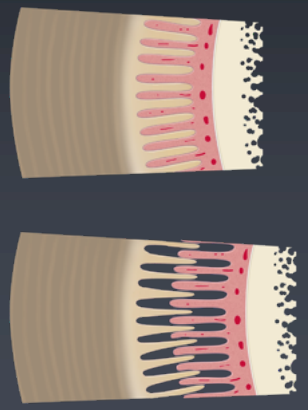
Why might a biomechanical approach fail?

- The disease is too severe for it to work
- The wrong concept is being applied
- The right concept is being applied, but insufficiently → no effect
- The right concept is being applied, but too aggressively → damage other tissues

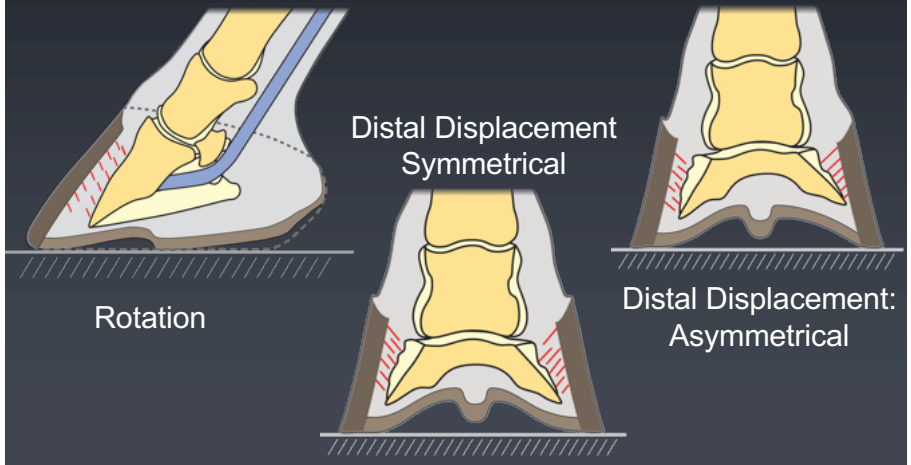
Laminitis

Goal: Limit Displacement/Stabilize the Distal Phalanx in the Hoof Capsule

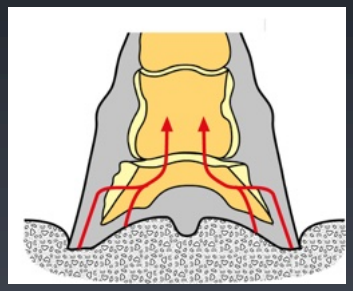
- Lamellar separation – applied force > strength
- Stability of DP – no objective measure
- Suspension fails in several patterns



Laminitis: Patterns of Failure of Suspension of the Distal Phalanx

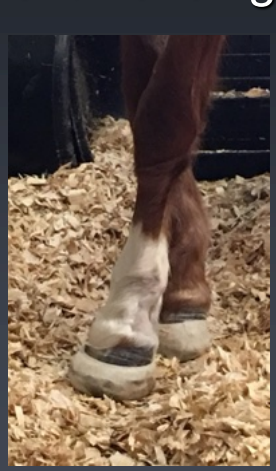


All Benefit from Decreasing Overall Stress/Damping Vibrations



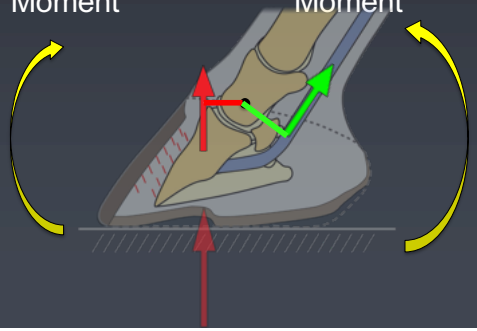
http://equicast.com/therapeutic-shoes/

Stabilization ∝ Pattern of Displacement Pending or Present



Rotation

Extensor Moment < Flexor Moment

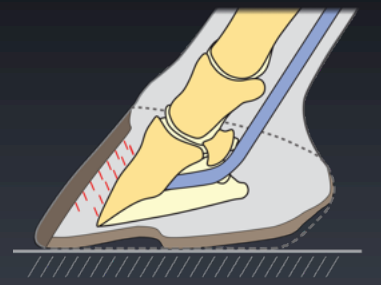


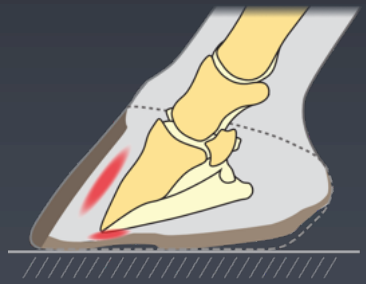
Rotation

Structure: Dorsal lamellae/Sole

Stressed:

- Dorsal Lamellae tension (shear)
- Sole compression
- At rest and in motion



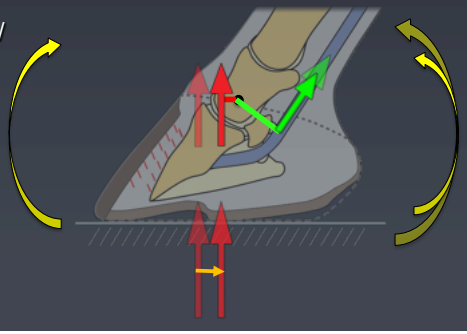


Rotation

Structure: Dorsal lamellae / Sole

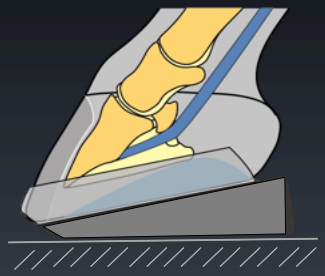
Biomechanical Objectives:

- Reduce flexor moment
  - At rest
  - At breakover
  - (decreases flexor MA / Δ COP)
- Decrease pressure dorsal sole



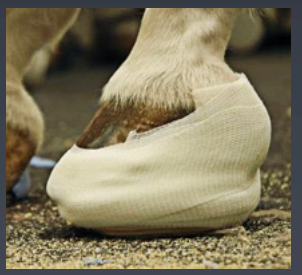
Rotation

Structure: Dorsal lamellae



Hoof Care/Farriery:

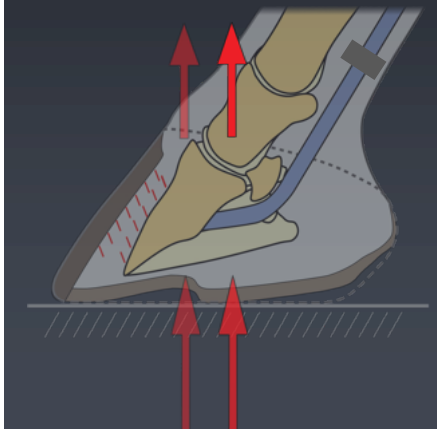
- Elevate heels
- Roll toe + both branches
- Recruit palmar sole/bars/frog

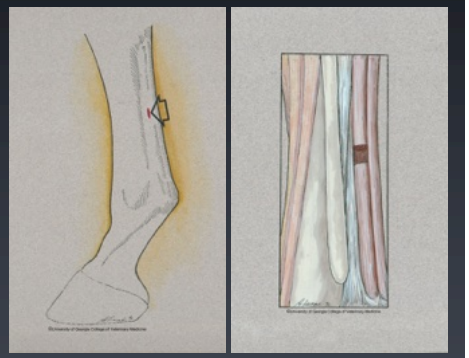


Rotation

Structure: Dorsal lamellae

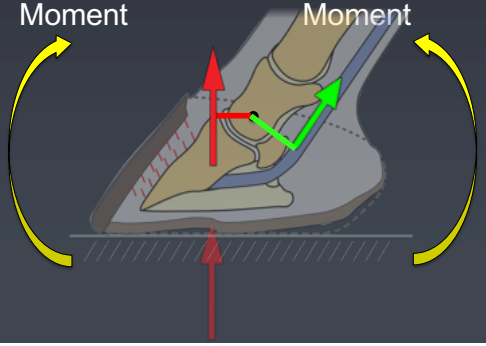
Surgery: DDF tenotomy





Distal Displacement: Symmetrical

Extensor Moment = Flexor Moment

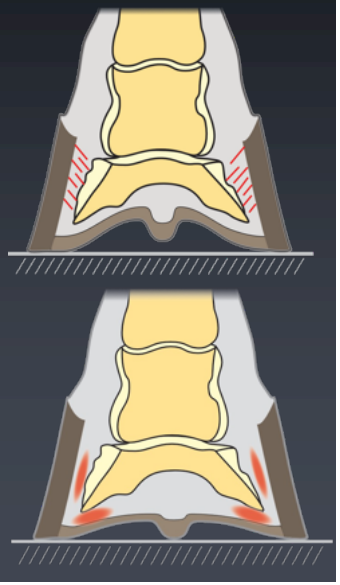


Distal Displacement: Symmetrical

Structure: All lamellae

Stressed:

- Lamellae under tension (shear)
- Sole under compression
- Rest and motion

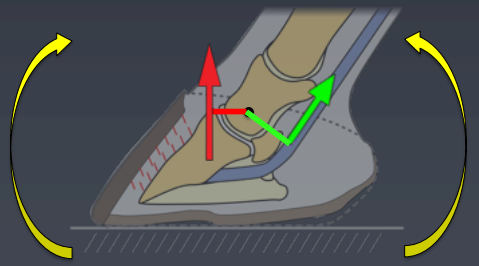


Distal Displacement: Symmetrical

Structure: All lamellae

Biomechanical Objectives:

- Reduce moments all directions
- Decrease pressure dorsal sole



?

Distal Displacement: Symmetrical

Structure: All lamellae

Hoof Care/Farriery:

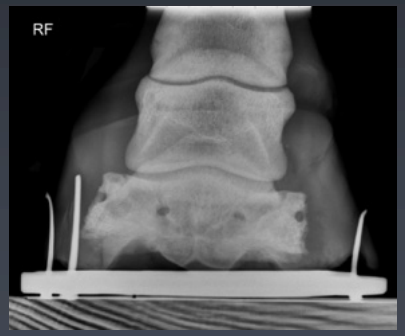
- Roll toe + both branches
- Recruit sole/bars/frog?

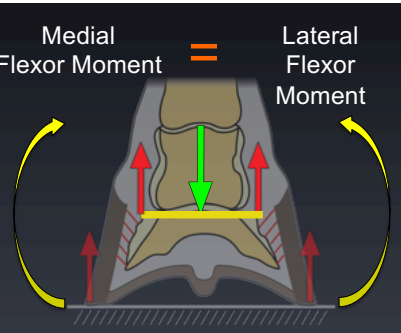
Immobilize distal joints: Casting

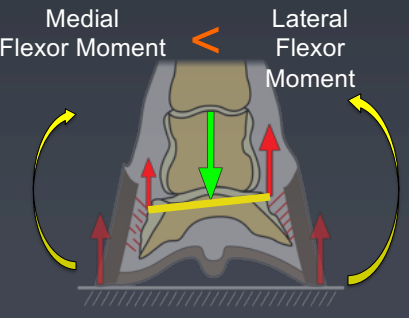
https://www.softrideboots.com/boots-and-gels.php

http://equicast.com/therapeutic-shoes/

Frontal Plane: Asymmetrical Distal Displacement





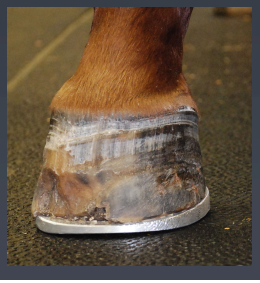


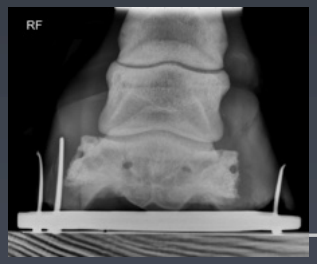
Distal Displacement: Asymmetrical

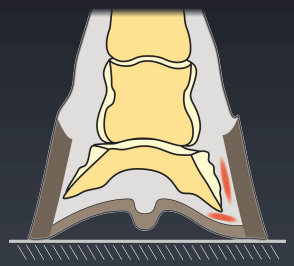
Structure: Medial or lateral lamellae

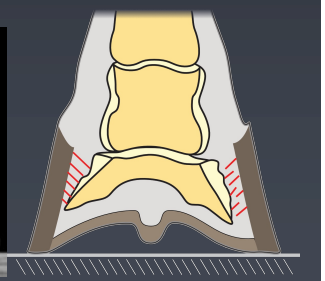
Stressed:

- Lamellae under tension (shear)
- Medial/lateral sole compression
- Rest and motion







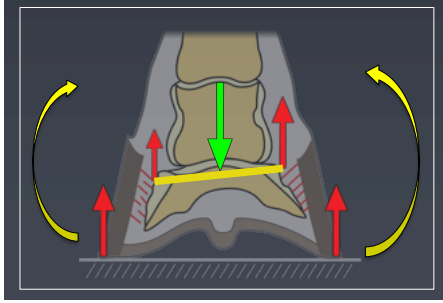


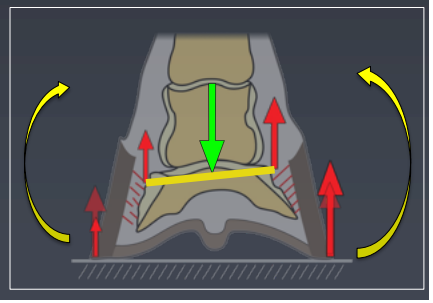
Distal Displacement: Asymmetrical

Structure: Medial or lateral lamellae

Biomechanical Objectives:

- ↓ moment in frontal plane/change COP away from affected side
- ↓ sole pressure asymmetrically





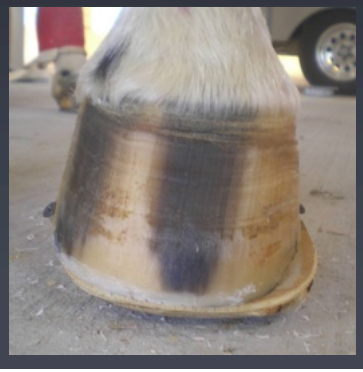
Distal Displacement: Asymmetrical

Structure: Medial or lateral lamellae

Hoof Care/Farriery:

- Roll toe + contralateral branch extension
- Recruit sole/bars/frog?

Immobilize distal joints: Casting



Different Patterns of Displacement: Why?

Distribution of injury (primary vs. secondary)

Distribution of mechanical properties

- Per unit area
- Area in relation to location

Anatomical predisposition (location of COP)

Initiating cause of disease

Others …

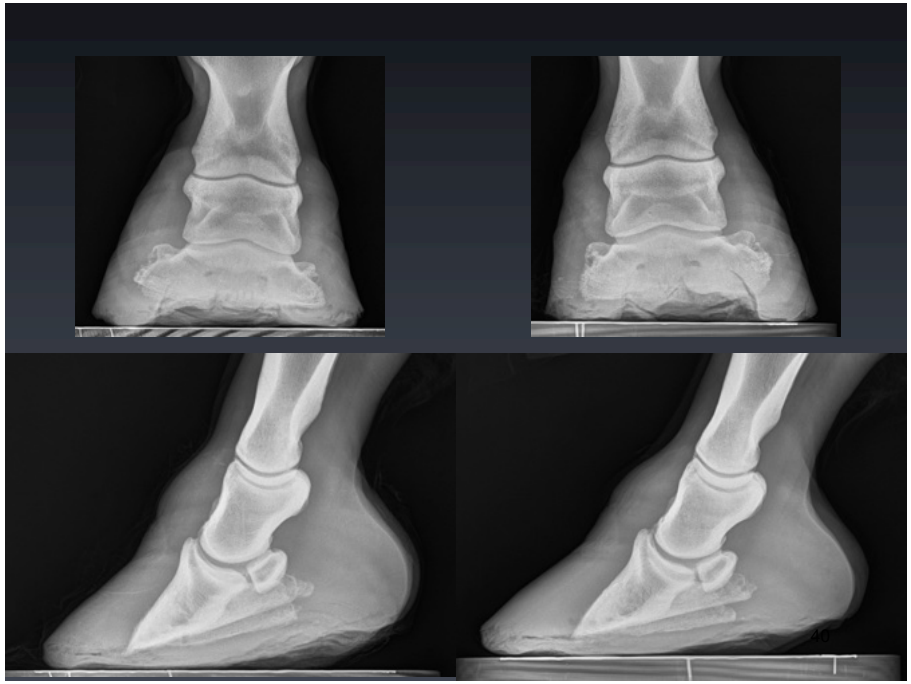
Alpha 28 YO Paint / Qtr H Gelding

Initially presented to rDVM 2 months ago
Bilateral forelimb lameness
Radiographs: bilat rotation and ↓ sole depth
Rx: DMSO, PBZ, Rest
ACTH Stim Test normal

Improved with treatment until ≈ 10 days ago

Initial Presentation UGA

Bilaterally lame FL
Walked readily off trailer
Temp 99.8; Pulse 60; RR 12; MM Pink
Could readily pick up both FL (Obel II/IV)
Short strided
Digital pulses ↑
Initial Rx: PBZ, SoftRides



24 Hours

Initially bright, but attitude declined

Less willing to walk

Rx:

- PBZ Continued
- Acetaminphen
- Acepromazine
- Butorphanol

48 Hours

Lameness ↑, won't pick up feet; HR ↑

Placed on EVA clogs

Rx:

- PBZ/Acetaminphen continued
- Hydromorphone
- Lidocaine CRI
- Ketamine CRI

Failure to respond → Euthanasia

Bravo: 24 yo, Morgan, G

Hx:

- Laminitis of 6 months duration
- Seldom ventures out of stall

Prior Treatment:

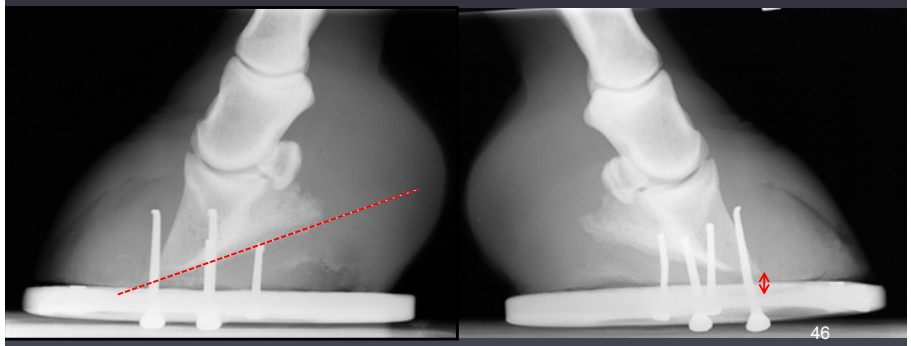
- Hear bar shoe
- Phenylbutazone (2 gm bid)
- Pergolide
- Omeprazole
- Acupuncture, chiropractic

Bravo: 24 yo, Morgan, G

Physical Examination:

- T 37.2, P 26, R 12
- Walked very slowly
- Short striding
- Landing heel first
- Obvious secondary changes to hoof capsule
  - Rapid heel growth
  - Reduced toe growth
  - Prolapse of sole

Radiography



First Shoeing

Trimmed heels

Four point rail shoe

Bravo: Six Month Recheck

- DP reoriented
- Good sole depth
- Heels contracting
- Lands toe first after trimming heels

- But … still on
- EDSS rails
- 1 g PBZ bid
- Very lame without PBZ

Bravo: Post Tenotomy

Initially maintained in 4-point rail shoe

Legs bandaged for 6 weeks

Removed rails between 4-6 weeks

PBZ reduced to 0.5 g / day at 4 weeks

Bravo: 12 Months

- Barefoot
- Off PBZ
- Pasture Sound

Bravo: Long term follow up

Four years later -

- Abscess, tx boots and keratex

Six years later –

- Another abscess at CB
- Walking well
- Sole hard, but HT +
- Radiograph by RDVM

Eventually –

- Euthanized for persistent lameness

Charlie, 10 YO Arabian Mare: History

One month prior
- Found recumbent, HR 66
- Classic laminitic gait, Obel grade II, digital pulses
- Obese, EMS?
- Rx: Phenylbutazone, changed diet

10 days prior
- Much improved

Immediately prior
- Acute exacerbation

Charlie, 10 YO Arabian Mare:

Physical Examination

BAR, HR 40

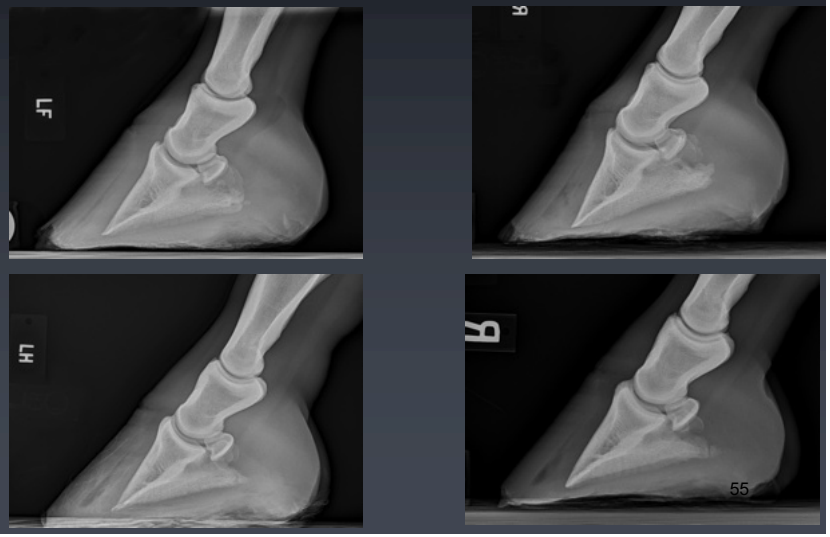
Uncomfortable, shifting front feet

Reluctant to turn

Can pick up all limbs

Increased digital pulses all limbs

Day one: Radiographs

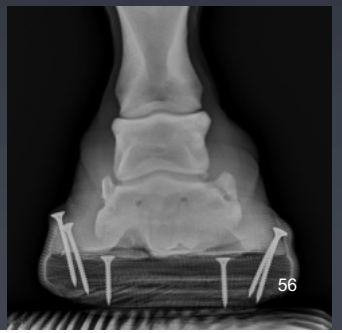


Day One: Treatment

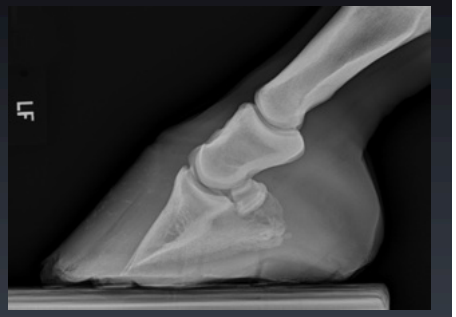
Analgesia: Phenylbutazone

Hoof care: Wooden shoes

Rx: Metformin/Thyro-L



Week 1

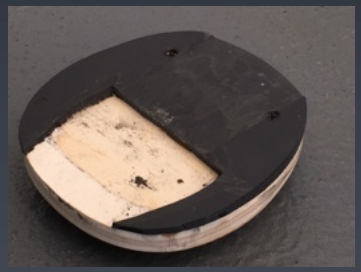


Week 2

Clinical deterioration

Week 2

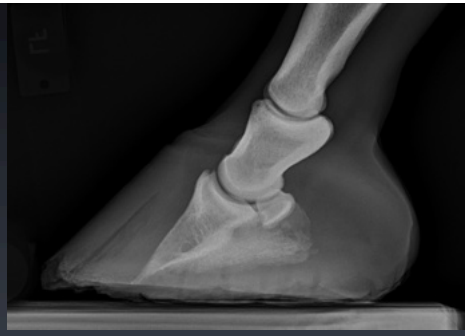
Surgery: DDF tenotomy
↓ flexor moment DIPJ



Week 3

Clinical improvement

Radiographs – not much change



Week 3

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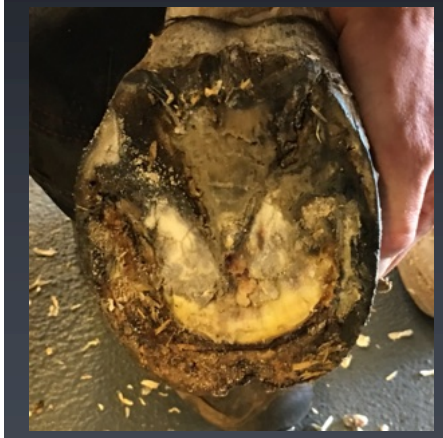
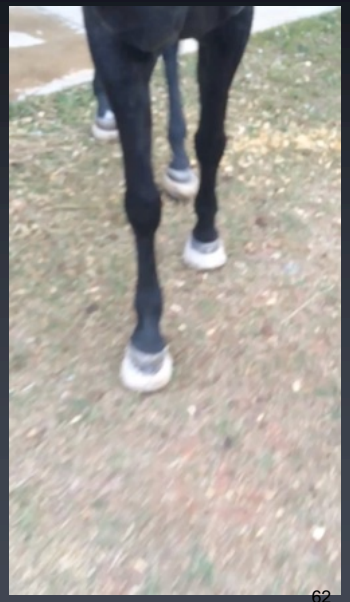
Weeks 5-6





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Weeks 5-6

63

Weeks 5-6

Clinical deterioration

Analgesia:

- Acetaminphen
- (+ later, pethidine)

Hoofcare:

- Grooving
- Off setting shoe; i.e. Δ COP

64

Weeks 5-6

65

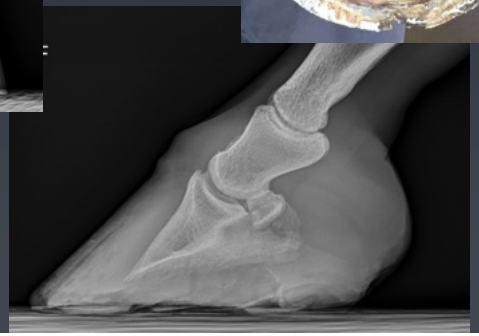
Weeks 9-10

66

Week 16

67

Week 16



68

Week 21

Immediately prior to discharge

Two Years

70

Two Years

71

Two Years

72

Summary

- Only so many therapeutic biomechanical concepts to be applied
- Laminitis provides good examples, but same principles can be used for many conditions
- Hoof care is only one part of therapy for many diseases
- Shoeing almost always involves one or more compromises and doesn't always work
- Using the principles will remain an art …