New Thoughts and Orthotic Strategies in the Treatment of Plantar Heel Pain Syndrome

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Lecture Handout Courtesy Of:
Allied OSI Orthotic Lab

For lecture notes:
www.richiebrace.com/ handouts.htm

Demographics

<table>
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<tr>
<th>Author</th>
<th>Male</th>
<th>Female</th>
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<td>Gill (1996)</td>
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<td>TOTAL</td>
<td>438</td>
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40% 60% (47.5 YRS)

Fig. 7. Conditions capable of producing chronic plantar pain can be differentiated by the area of maximal tenderness: (1) plantar fasciitis, (2) entrapment of the first branch of the lateral plantar nerve, (3) heel pain syndrome, and (4) fat pad disorders.
SUBCALCANEAL PAIN

Nerve Entrapment?

- Medial calcaneal nerve
  - Savastano, 1985
- Nerve to abd. dig. quint. brev.
  - Baxter, 1984

Causative Factors Of Heel Pain:

- Obesity – O’Brien, Shikoff, Tanz
- Pes Planus – Bordelon, 1993
- Pes Cavus – Culter, 1986
- Tight Heel Cord – Kibler, 1991
- Pronation of STS – Baxter, 1984 Gould, 1995
Hicks, 1994 Davis, 1990
- Shock – McKenzie, 1985
- Windlass Dysfunction – Ellis, 1988

Heel Pain Treatments
**Pathogenesis**

“It is reasonably certain that a condition which has so many different theories of etiology and treatment does not have valid proof of any one cause.”

*Snook and Chrisman Clin Orthop 82:163, 1972*

**Points of Confusion**

Mechanics of Plantar Fascia overload:
- Foot Pronation
- TJ Pronation
- PJ Pronation
- Longitudinal axis
- Oblique axis
- Ray movement
- Arch Flattening

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**Fig. 15.** Anatomic preparation of the foot with the plantar structures in view. Internal rotation is applied to the tibiotalar column and the foot is maintained in the plantigrade position. The height of the medial longitudinal arch measures 5.8 cm. It is lower as compared with a high arch situation measuring 7 cm. In the same specimen. The plantar aponeurosis (PA) and the abductor hallucis muscle (ABDH) are seen under tension. They are not undulant.

**Fig. 12.** Anatomic preparation of the foot with the plantar structures in view. External rotation is applied to the tibiotalar column and the foot is maintained in a plantigrade position. The height of the medial longitudinal arch measures 7 cm. It has increased as compared with a low arch situation measuring 5.8 cm in the same specimen. The plantar aponeurosis (PA) and the abductor hallucis muscle (ABDH) are seen relaxed and undulant.

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**PLANTAR FASCIITIS**

*Pronation of Subtalar Joint:*

- Cannot by itself cause strain of PF
- Can only influence PF thru MTJ

- 73 Patients, 118 painful heels
- Treatments: NSAIDS, Steroid injection, Tape strapping, Foot Orthoses
- 81% in group with tape strapping and orthoses achieved good results
- 80% of all patients had foot deformity compensated by supination of longitudinal axis of midtarsal joint

- 80% of all patients had foot deformity compensated by supination of longitudinal axis of midtarsal joint
- Out of 133 painful heels:
  - 63 had forefoot valgus
  - 33 had everted rearfoot
  - 20 had plantarflexed first ray

**SUPP. OF MTJ LA**
- Everted Calc. past pe
- Flexible FF valgus
- Plantarflexed 1st Ray

**In-Vitro Study**
- Nine fresh frozen specimens
- Axial load in static stance 225-900N
- 6 degree wedges: Medial & Lateral, RF & FF
- Strain in plantar fascia measured with reluctance transducer


**Plantar Fascia Strain**

- Wedge under lateral forefoot decreased strain (p<0.05)
- Wedge under medial forefoot increased strain (p<0.05)
- Rearfoot wedges had no significant effect

Fig. 7. The truss is a triangular structure. Under the load (W) the struts are under compression (C) and the tie-rod (AB) is under tension (T). Any joint, for example point A, is in vectorial equilibrium as indicated in the insert diagram. C compresses the point A and T tenses the same point.
Twisted Plate Theory

**FOOT VIEWED FROM BEHIND**

- Rear Plate twisted clockwise (inversion)
- Front Plate twisted counter clockwise

**RAISE ARCH:**
- Invert Rear Plate
- Evert Front Plate

**LOWER ARCH:**
- Evert Rear Plate
- Invert Front Plate
Twisted Plate Theory

RAISE ARCH:  
Invert Rear Plate  
Evert Front Plate

LOWER ARCH:  
Evert Rear Plate  
Invert Front Plate
Figure 2. Diagramatic representation of the experimental set-up for testing the longitudinal arch support mechanism of foot orthoses.


Figure 3. Illustrations of test orthoses for a left foot. FO no. 1, prefabricated stock orthosis; FO no. 2, custom viscoelastic orthosis; FO no. 3, custom semi-rigid orthosis; FO no. 4, custom rigid functional orthosis; FO no. 5, custom rigid UC-BL shoe insert.

Plantar Fascia Strain

Effect of shoe inserts:
3 devices significantly reduced strain:
1.) UCBL
2.) Viscoelastic footbed
3.) Cork & rubber footbed

2 devices did not reduce strain:
1.) Custom rigid functional foot orthosis
2.) Pre-fabricated stock orthosis


Fig. 7. The truss is a triangular structure. Under the load (W) the struts are under compression (C) and the tie-rod (AB) is under tension (T). Any joint, for example point A, is in vectorial equilibrium as indicated in the insert diagram. C compresses the point A and T tenses the same point.

“One of the distinguishing features of the orthoses which decreased plantar aponeurosis strain was the surface contours of their medial and central regions and the angles related to their arch shape were more acute.”


Elevate Heel?
- 12 cadaver limbs, static stance
- Strain transducer in central band PF
- 2 load levels: 337 N, 450N
- Heel Heights 2.0, 4.0, 6.0 cm
- Blocks: No significant difference in p.f. strain
- Shank contour platforms: sig. Decrease in p.f. Strain with elevation (p< 0.05)

Foot types with a “normal” arch do not have any medial tarsal bone contact with the shank profile interface. Therefore, structural repositioning of the foot most likely occurs from lateral skeletal segments that touch the shank profile surface. This suggests that an extended support zone, from just under the calcaneus to the cuboid, decreases the medial truss-like action of the foot by permitting the metatarsals to plantarflex slightly.

**Subcalcaneal Pain**

Footwear considerations
1. Heel height
2. Shank stability
3. Home shoe program

**Medial Truss Theory**

Reduce Plantar Fascia Strain:
Plantarflex Distal Strut (1st Ray)
Dorsiflex Proximal Strut (Calcaneus)
Elevate Junction of Struts (T-N Joint)
Elevate Lateral Truss

**PROPOSED MECHANISM**

1. 1st Ray dorsiflexes & inverts
2. MTJ supp. about long. axis
3. Eccentric cont. of abd. hallucis and FHB
4. Elongation strain of PF
5. Oblique MTJ pronation

**MECHANISM OF PLANTAR FASCIAL OVERLOAD**

FOREFOOT VALGUS OR PRONATED SUBTALAR JOINT
CAUSING HEEL TO PRONATE PAST PERPENDICULAR

FIRST RAY DORSIFLEXES AND INVERTS

MIDTARSAL JOINT SUPINATES ABOUT LONGITUDINAL AXIS

ECCENTRIC CONTRACTION OF FLEXOR HALLUCIS BREVIS, ABDUCTOR HALLUCIS

MEDIAL COLUMN FLATTENING

OVERLOAD OF PLANTAR FASCIA
First Ray Position

1. Same during gait vs. at rest?
2. Accurately depicted in neut step cast?
3. Cast & orthotic modifications
   Based on activity?

Dynamic Gait

In terminal stance:

- Foot inverts
- 1st ray plantar flexes below 2-5
  Due to: Peroneus longus
  Plantar intrinsics
  Windlass

Plantar Intrinsics

- No activity until 40% of gait cycle
- In pronated feet, activity at 10%
- Principal active role in arch stability
- No activity in standing feet

Mann and Inman, JBJS, 1984

RELAXED STANCE

1. Extrinsic foot muscles inactive
2. Arch integrity maintained solely
   by plantar fascia

First Ray Position

Static stance

Plantar intrinsics and peroneus longus inactive

Position

1st ray dorsiflexed to at least level of
2nd Met or to end ROM

Basmajian, 1963
Hoang, 1993
Reeser, 1983
Static Stance

- No windlass
- No plantar intrinsics
- No peroneus longus

AOFAS Study

<table>
<thead>
<tr>
<th>Use of custom foot orthotics</th>
<th>Rate of success</th>
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<tbody>
<tr>
<td>Standing less than 8 hrs. per day</td>
<td>85.7</td>
</tr>
<tr>
<td>Standing more than 8 hrs. per day</td>
<td>44.4</td>
</tr>
</tbody>
</table>

"Certain forms of treatment for the foot originated from the basis of thinking that only considers the foot as a static structure. Accommodative appliances and arch supports are typical examples of methods of treatment based upon static considerations. Such methods are relatively ineffective in comparison with methods designed to control function of the foot during kinetic stance."

"Static stance stability of the foot is of minor clinical significance. In most feet that function abnormally during kinetic conditions, the static stance periods are probably not very traumatic to the foot. Therefore, static stance can be considered to be clinically insignificant except in feet that are severely subluxed and pronated."

"Most symptomatology and trauma to the foot is occasioned by instability of the foot that primarily develops during kinetic function. Therefore, the foot should be clinically evaluated and treatment consideration should be based primarily upon kinetic requirements of the foot. Treatment based upon static considerations has usually failed to provide more than partial relief of symptoms and that relief may be only temporary."

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First Ray Position

Static stance – with orthosis

1-5 valgus  
2-5 varus  
No PF of 1st Ray

Dynamic Gait

1st Ray plantarflexes below 2-5

First Ray Position

1st plantar flexes

Dynamic gait – with orthosis

Theory

1. The alignment of the First Ray is different in a neutral suspension cast position than it is in a weight bearing static stance position.
2. A functional foot orthosis (Root design) affects First Ray position differently in dynamic gait than during static stance.

First Ray Overload

- Orthosis too wide
- Supinated cast – “false FF Varus”
- FF Varus post with no true FF Varus
- 2-5 varus with filler
Plantar Heel Pain
Orthotic Treatment Proposal

Goal: Prevent dorsiflexion overload of First Ray

Strategy: Assure that the first metatarsal remains plantar to the plane of the lesser metatarsals during static stance and during gait

Plantarflex First Ray
ORTHOTIC STRATEGIES

1. Push down on 1st during Casting
2. Reverse Mortons Extension or External FF Valgus Wedge
3. Lite Filler between platforms
4. First Ray Cut Out
Maximal Plantar Flexion Of First Ray

- Push down on First Ray During Casting Procedure

Maximal Plantar Flexion Of First Ray

- Push down on First Ray During Casting Procedure
- Light Filler Between Balancing Platforms
Figure A & B: A, Reference marking for intrinsic forefoot balancing during the positive cast correction technique. B, Reference and corrective platforms for intrinsic balancing of the positive cast.

First Ray Cutout
Vs
First Met Accomodation
Medial Truss Theory
Reduce Plantar Fascia Strain:

- Plantarflex Distal Strut (1st Ray)
- Dorsiflex Proximal Strut (Calcaneus)
- Elevate Junction of Struts (T-N Joint)
- Elevate Lateral Truss
Fig. 7. The truss is a triangular structure. Under the load (W) the struts are under compression (C) and the tie-rod (AB) is under tension (T). Any point, for example point A, is in vectorial equilibrium as indicated in the insert diagram. C compresses the point A and T tenses the same point.

Dorsiflex Calcaneus
(Increase Calcaneal Pitch)

1. Decrease Load on Achilles
   - Stretching
   - Night Splint
   - Heel Lift

2. Contoured heel seat of FO

Heel Cord Tension
Subcalcaneal Pain

Treatment recommendations

3. Decrease passive loading of heel cord:
   - Heel elevation (footwear)
   - Static stretching
   - Night splint

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CONSERVATIVE TREATMENT

Which treatment worked best?

<table>
<thead>
<tr>
<th>TREATMENT</th>
<th>RATING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stretching</td>
<td>29</td>
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<tr>
<td>Rest</td>
<td>25</td>
</tr>
<tr>
<td>NSAIDS</td>
<td>25</td>
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<tr>
<td>Cushion Inserts</td>
<td>22</td>
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| Pt Total: | 37       |
| Sx Present: | 6 mo. or more |
| Tx: | PF Night Splint 30 days |
| Assessment: Physician exam/interview |
| - Mayo Clinic Scoring System |
| - AOFAS Ankle Hindfoot Rating |

Results:
- Satisfied 59%
- Satisfied with reservations 13%
- Dissatisfied 10%
- Could not wear splint 18%

CONCLUSION: “We believe dorsiflexion splints provide relief from the symptoms of recalcitrant plantar fasciitis in the majority of patients.”

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| Patient total: | 32 |
| Sx present: | 12.7 months |
| Tx: | 2 Groups |
| 1. NSAID, viscoelastic heel stretch (control) |
| 2. Tension plantar fascia night splint (custom fabricated) |
| Assessment: Physician exam |
| Results: Group Healed Time to Healing |
| Control 6/17 | 8.8 weeks |
| TNS 16/16 | 12.5 weeks |
| Cross over 8/17 | 13 weeks |

Conclusion: “…the TNS is an effective treatment for plantar fasciitis.”
Subcalcaneal Pain

Footwear considerations
1. Heel height
2. Shank stability
3. Home shoe program

Heel Pain Treatments

Success with Orthotics

Rated most successful of all treatment:

- Martin, 1998
- Wolgin, 1994
- O’Brien, 1985
- Blake, 1985
- Gross, 1991
- Lynch, 1998
- Ferguson, 1991
Patient total: 73, 118 painful heels
Sx present: not reported
Tx: Tape Strapping, NSAID, Steroid Inj.
Rigid foot orthosis
Assessment: Patient evaluation of % of pain relief
Results: Subgroup of strapping & orthosis only.
Good 81%
Fair 15% in 6 weeks
Poor 4%

• 63 of 133 painful heels had forefoot valgus
• 20 had plantarflexed first
(Thus, 80% had supp. long axis of MPJ)

Conclusion: “This study demonstrates that with or without initial short term anti-inflammatory medication, mechanical control of the midtarsal joint is an effective treatment for heel spur syndrome.”

Patient total: 85
Sx present: 46 weeks
Tx: 3 Categories
1. NSAID & Steroid Inj.
2. Viscoelastic heel cup
3. Low dye strapping / arch pad
functional foot orthosis
Assessment: Patient self-completed questionnaire, Physician evaluation, visualizing pain scale: 2, 4, 6 & 12 weeks

Results:
Starting visual analog pain = 6.4
Finish (all 3 groups) 12 weeks = 2.0
68% improvement

Treatment failure: Final Pain/activity assessment:
(no improvement or adverse reaction) Group G S F P
2.3% in Group 1 1 26 13 67
42% in Group 2 2 10 20 76
4% in Group 3 3 40 30 30

Conclusion: “A significant difference was noted between groups with taping and orthosis proving to be more effective than either anti-inflammatory or accommodative modalities.”
### Ideal Subcalcaneal Pain Treatment Outcome

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<th>Author</th>
<th>Duration of Treatment (mos)</th>
<th>Outcome (%)</th>
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<td>Lynch</td>
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#### Absence of morning pain
- Yes
- No

#### Absence of day/night pain
- ✔
- ✔

#### Full work capacity
- ✔

#### Return to previous recreation
- ✔

#### Return to previous fitness
- ✔

#### No unacceptable footwear restrictions
- ✔

#### Restoration of strength – flexibility
- ✔

#### Return to pre-injury mobility
- ✔

### Plantar Fasciitis: Custom vs. Pre-fab Foot Orthoses

**RCT involving 135 participants**

- Random assignment into three groups:
  - Sham orthosis (soft foam)
  - Prefabricated orthosis (firm foam)
  - Custom orthosis (semi-rigid plastic)

- Duration of follow-up for each patient: 12 months

**Results:**

- Mean pain score with pre-fab orthoses was 8.7 points better (P=.05)
- Mean pain score with custom orthoses was 7.4 points better (P=.10)
- Mean pain score with custom orthoses was 7.4 points better (P=.10)
- Mean function score was 7.5 points better for custom orthoses (P=.04)

There were no differences between groups at the 12 month review.

Is a Formhotic a “Prefabricated Orthosis”???

Why was the pain score not significantly different between the 3 groups?

Summary Of Heel Pain Treatment Studies
1. Patients have low expectation of achieving total permanent relief.
2. Acceptable time frame to achieve successful tx outcome?
3. Definition of success: Pain, patient satisfaction
4. Treatments deemed successful, yet:
   Significant # of pts still in pain
   Significant # of pts fail to comply & improve
   Significant length of time to achieve success
5. Multiple tx’s yet “Which worked best?”
6. Physician assessment of success
7. Retrospective reviews

Time Heals All Wounds...
Time Wounds All Heels...

Duration of Sx:

- 30% > 12 mos.
- 54% > 6 mos.

Less likely to have good outcome if symptoms present for > 12 mo. before treatment. P < .05


CONCLUSION:

2. “This may add support to the observation that subjects with more chronic symptoms have a poorer outcome and that initiation of early, aggressive, non surgical therapy is appropriate and warranted.”

Subcalcaneal Pain

Subjects with symptoms less than 12 months have the best outcome with non surgical treatment

Martin, 1998

Ideal Subcalcaneal Pain Treatment Outcome

Heel Pain =

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<th>What is a quality outcome?</th>
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<td>What is the overall cost?</td>
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<tr>
<td>Absence of day/night pain</td>
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<td>Full work capacity</td>
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<td>Return to previous recreation</td>
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<td>No unacceptable footwear restrictions</td>
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Raise Medial Arch at T-N Joint

1. Twist the plate - Evert FF
   Lateral FF wedge
2. Plaster expansion at T-N - not a filler
3. Wider footplate at T-N narrower at 1st Ray
CONSERVATIVE TREATMENT

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Subcalcaneal Pain

Treatment recommendations

4. Footwear program:
   - Elevated heel
   - Shank stability
   - Home shoe use
PATHOMECHANICS

- LEG LENGTH INEQUALITY
- PRONATION OF STJ
- RESTRICTED DORSIFLEX
- HIGH ARCH FOOT
- LOW ARCH FOOT
- HEEL STRIKE SHOCK

Arch Elongation

Varus FF Wedge
Valgus FF Wedge

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Raise Lateral Truss

1. FF Valgus Post
2. Minimal Plaster Fill at CC joint
3. Contoured Shank Footwear
Subcalcaneal Pain

Treatment recommendations

1. Prevent overload (dorsiflexion) of first ray:
   - Light filler between platforms
   - Balance 2-5, 1st ray cut out
   - Avoid wide orthotic plate
   - Don’t capture a false FF varus

Subcalcaneal Pain

Treatment recommendations

2. Minimize supination of longitudinal Axis of MTJ:
   - Prevent rearfoot eversion
   - If present, capture FF valgus
Fig. 3 Medial view of a bonobo foot. Lig. m-m = metacarpometatarsal ligament.

Fig. 4 Schematic distribution of the m. Flexor toes longus (FTL) in (A) gibbon and (B) bonobo foot.

Fig. 5 Illustration of the different measurements taken on the second metatarsal. Length (L) = length of the longest unbroken muscle belly (lower right). LIF = length of the main tendon; LIF = length of the outer tendon; TIF = muscle fibre length and IF, a separation angle.
Like the hand, the foot has three anatomical regions: (1) The seven bones of the tarsus form the ankle and proximal half of the foot. (2) The middle portion of the foot consists of five metatarsals. (3) Phalanges, the skeletal elements of the toes, have the same number and arrangement as in the fingers.

The primary difference between the human and chimp foot is the contrast between prehensile functions of the ape foot and the anatomy of bipedal striding in the human. The chimpanzee foot has an opposable hallux and long phalanges. The human foot has greatly reduced digits, with all metatarsals parallel and an increase in the lever arm of the tarsus for striding. In the human foot, a longitudinal arch provides a shock absorbing and weight distribution system. The orientation of the ankle joint allows the tibia to take a straighter path over the foot during walking.

Dr. Meldrum has been investigating the ways monkeys, apes, and humans locomote for nearly fifteen years. Some of his research has focused on the way in which the human foot has adapted to the habit of walking on two feet (bipedalism). His research compares and contrasts the anatomy and function of diverse primate feet—the interplay of muscle, ligament, tendon, and bone. His work includes studies of fossil material from the Oligocene of Egypt, Journal of Human Evolution, 28:121-145.


Twisted Plate Theory

RAISE ARCH: Invert Rear Plate
Evert Front Plate

LOWER ARCH: Evert Rear Plate
Invert Front Plate


Patient total: 73, 118 painful heels
Sx present: not reported
Tx: Tape Strapping, NSAID, Steroid Inj. Rigid foot orthosis
Assessment: Patient evaluation of % of pain relief
Results: Subgroup of strapping & orthosis only.
  Good 81%
  Fair 15% in 6 weeks
  Poor 4%

- 63 of 133 painful heels had forefoot valgus
- 33 had everted heel (Thus, 80% had supp. long axis of MPJ)

- 84 Pts. Tx conservative for PF
- 115 of 133 feet had MTJ supination on longitudinal axis (86%)