

Shoe Inserts Alter In Vivo Segmental Foot Motion in Patients with Midfoot Arthritis

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Background

- Arthritis

One of the leading causes of disability

(CDC, 2007)

- Midfoot Arthritis

High potential for chronic secondary disability



Non-operative Management

- Primary aim of treatment
 - Provide pain relief
 - Often attempted using shoe inserts.
- Custom-molded three-quarter insert (3Q)
 - Most common recommendation
- Patients continue to report pain.



Full Length Carbon Graphite Orthoses (FL) as an Alternative

□ Recent retrospective review

- 56 patients with midfoot arthritis
- Previous 3Q users with persistent midfoot complaints
- 2 year follow-up
- 63% reported a significant decrease (greater than 50%) in pain within four weeks of using the full length carbon foot plate (FL)



(Pletka et al 2006)

However, mechanisms underlying pain relief are unknown.

Purpose

1. Assess the effect of 4 week intervention using the FL on pain and functional outcomes
2. Examine the effects of shoe inserts on three dimensional, in vivo segmental foot motion during gait

Subjects

30 patients (Mean age: 62, Mean BMI: 29.6)
25/30 used 3Q with persistent midfoot complaints
Sought care at the University of Rochester's Outpatient
Orthopedic Foot and Ankle Clinic

Clinical Presentation:

- Pain on dorsum, localized to TMT region
- Aggravated by walking
- Stair descent



Radiographic Presentation

- Joint space reduction
- Osteophytes
- 'Dorsal bossing'



Functional Outcomes

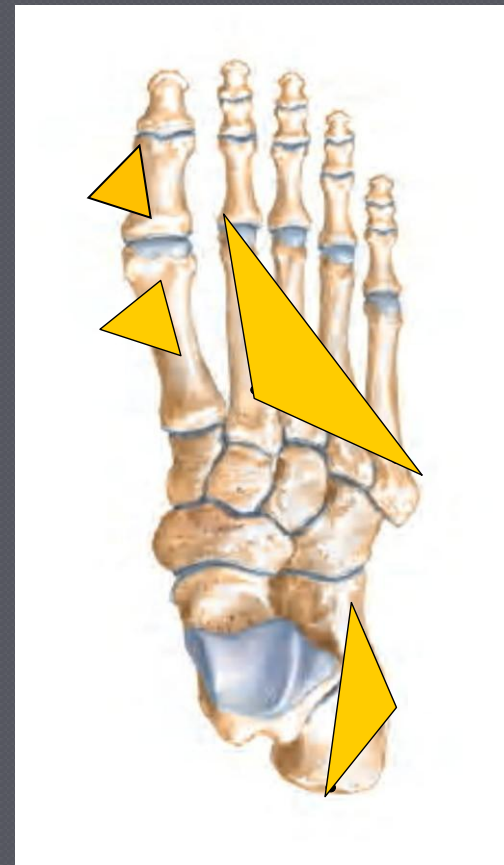
- Foot Function Index – Revised (FFI-R)
- Subscales:
 - Pain
 - Stiffness
 - Disability
 - Activity Limitation
 - Psycho-social Issues

(Budiman-Mak, E et al, 2006)

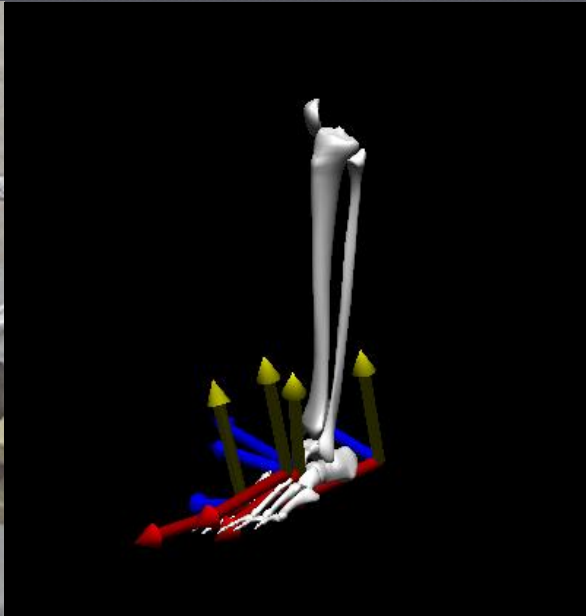
Kinematic Foot Model

- 5 segment foot model
 - Tibia
 - Calcaneus
 - 1st Metatarsal
 - Lateral forefoot
 - Hallux

*(Umberger et al. 1999,
Tome et al. 2006)*



Kinematic Foot Model



In vivo foot motion was assessed using a previously validated 4 segment kinematic model. The following segments were represented: tibia, calcaneus, 1st metatarsal and proximal phalanx.

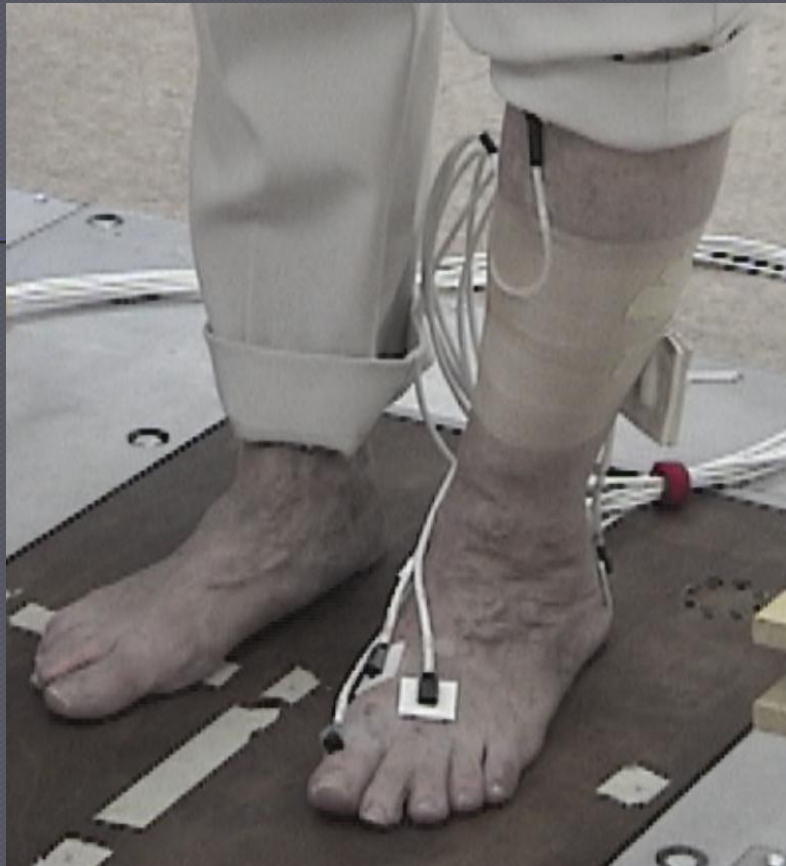
(Umberger et al. 1999)

- Kinematic data were collected using a magnetic tracking system (Flock of Birds™, Ascension Technology, VT) as patients walked at self selected speed, monitored within $\pm 5\%$.
- Patients wore standard lab-issued shoes and were tested in the following conditions: shoe only, shoe with 3Q, shoe with FL. The order of testing was randomized.

Kinematic Data Collection: Subject Set up

- **Magnetic tracking system**
(Flock of Birds™ , Ascension Technology, VT)
- **Sensors placed over respective segments**
- **Secured with skin tape**
- **Shoes modified by cutting windows**





- Anatomically based local co-ordinate systems for each segment
- Reference trial: Subtalar Neutral

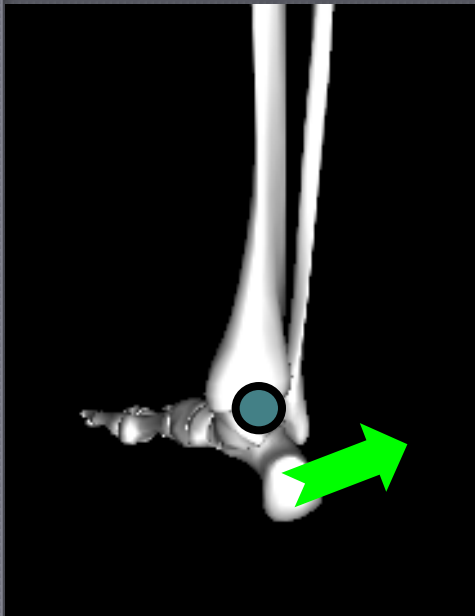
*(Tome et al. 2004,
Houck et al. 2008)*

- Second step protocol
- Self-selected speed, monitored within 5%

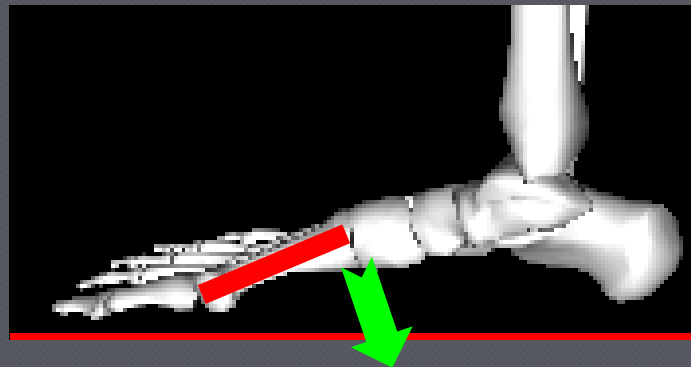
Kinematic Data Analysis

- Raw kinematic data collected at 98 Hz, synchronized with ground reaction force data
- Filtered using a fourth-order Butterworth filter at 6 Hz
- Euler angles computed using MotionMonitor software (Z-X-Y)
- Motion of distal segment relative to proximal segment

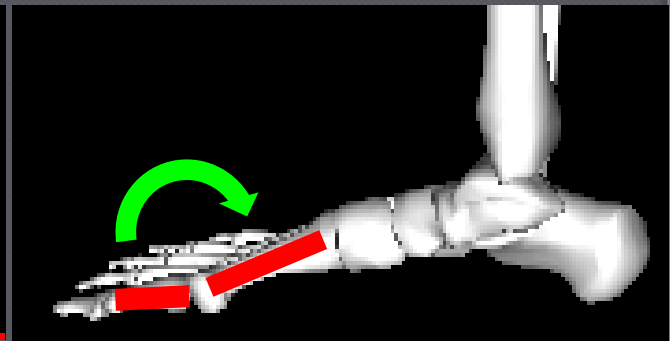
Kinematic Analysis: Dependent Variables



Peak
Calcaneal
Eversion



Peak Arch
Lowering
(1st Metatarsal
Declination)



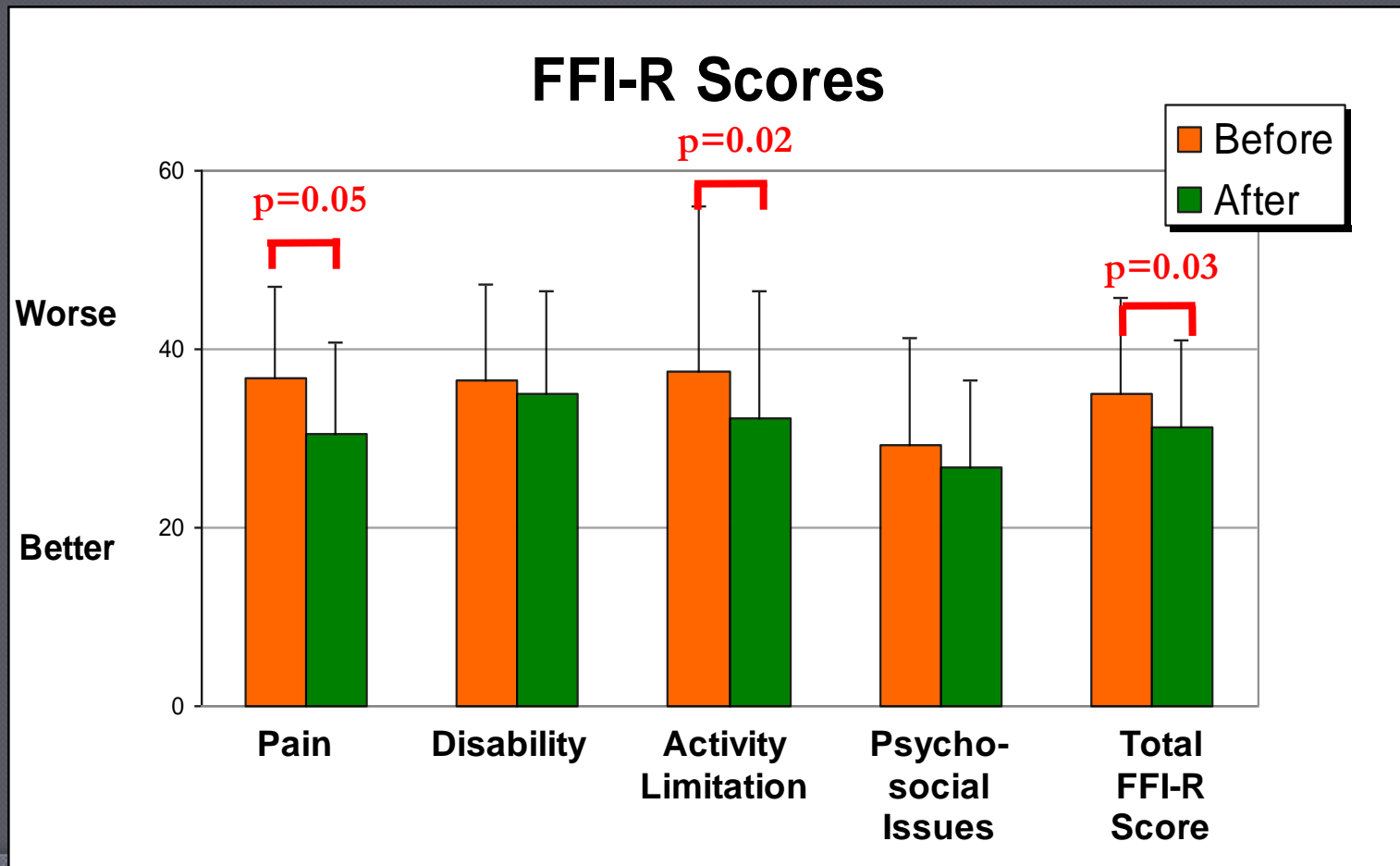
Peak 1st
MTP
dorsiflexion

Statistical Analysis

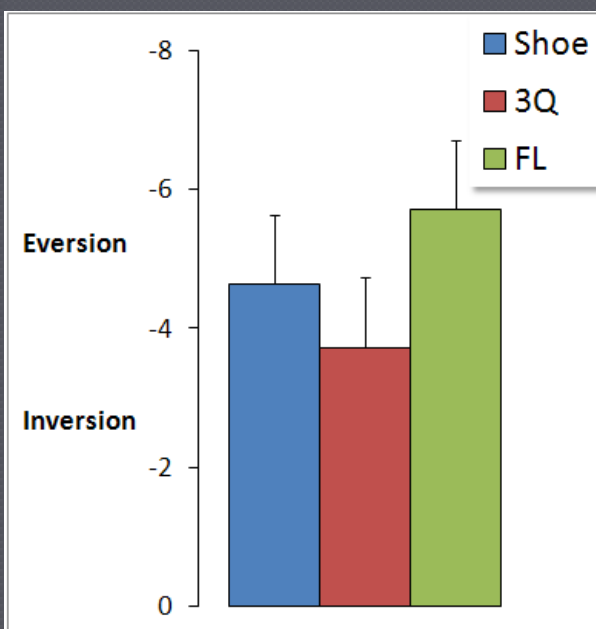
- Validity of Assumptions was assessed: Normality and variance homogeneity
- Functional outcomes (FFI-R scores) were assessed using a paired t-test. Clinical significance of the change in FFI-R score was examined using the 90% bounds of the Minimally Detectable Change (MDC 90)
- Kinematic dependent variables were assessed using a Repeated Measures ANOVA with Bonferroni post-hoc tests

Pain and Functional Outcomes

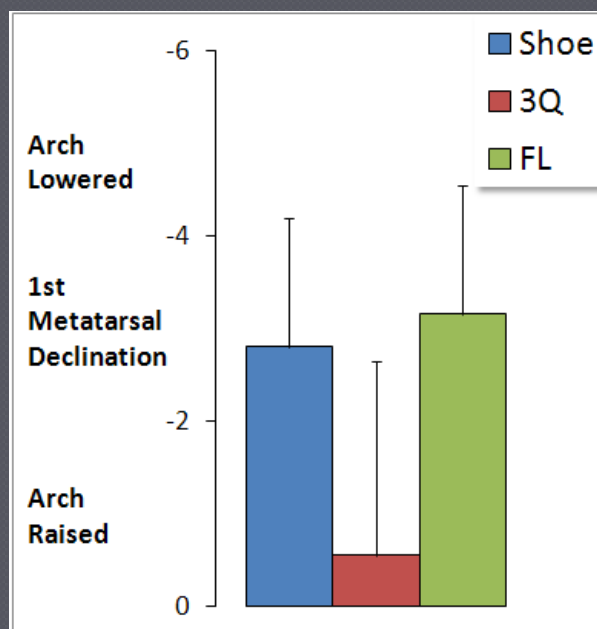
Significant symptomatic improvement after 4 week intervention with the FL



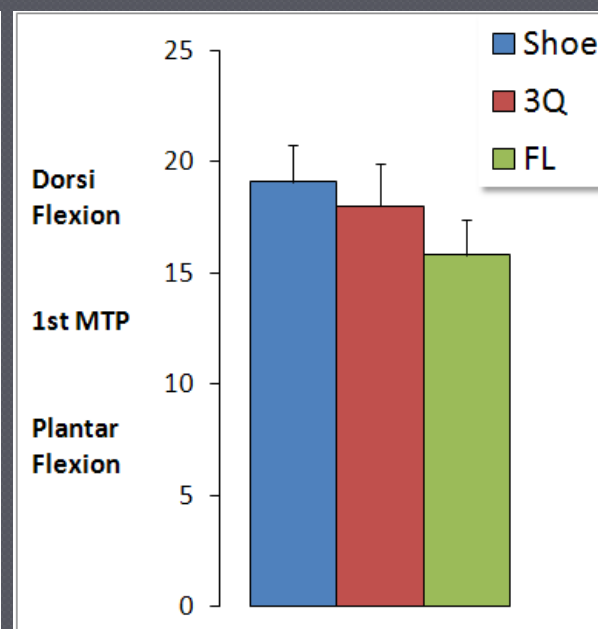
In Vivo Segmental Foot Motion



Increased Peak Calcaneal Eversion with FL compared to 3Q ($p=0.01$)



Increased arch lowering (1st metatarsal declination) with FL compared to 3Q ($p=0.01$)



Decreased 1st MTP dorsiflexion with FL compared to 3Q ($p=0.06$) and shoe ($p=0.017$)

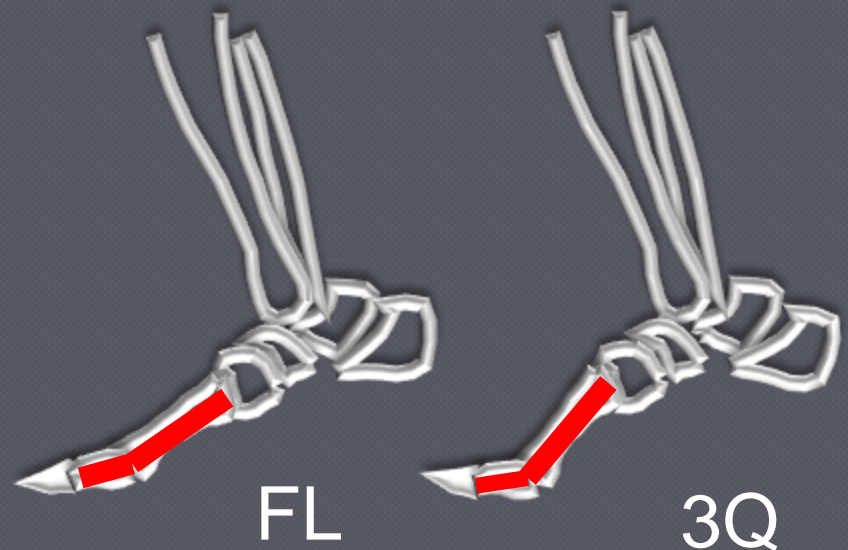
Key Findings

- **Low arched alignment with FL insert accompanied symptomatic improvement**

These findings are counter-intuitive to conventional clinical rationale which assumes that arch restoration mitigates symptoms.

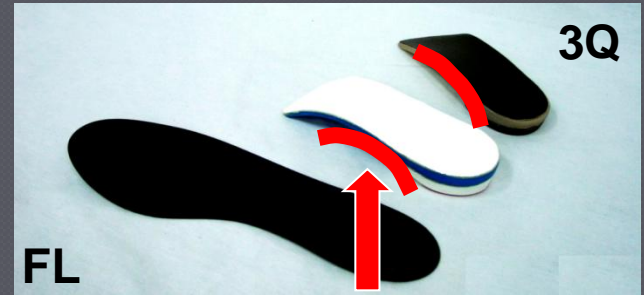
- **Altered kinematic alignment may contribute to pain relief**

Altered kinematics (calcaneal eversion, arch lowering, 1st MTP dorsiflexion), occurring independently or in combination, when using the FL orthoses, may contribute to favorable short-term functional outcomes.



Discussion

- ❑ Altered foot motion with FL use may occur as a result of its design features, such as length and lack of arch buildup.



- ❑ The findings of this study have significant financial implications due to the wide discrepancy in costs of the two inserts.

\$ 30-70 for FL

\$ 300-400 for 3Q

- ❑ Future studies exploring the relationship between in vivo foot motion and articular loading are indicated.