Basic Biomechanics

From the literature on the foot

Talocrural joint

Case Question

Are tendons like Springs?

Stretch Shortening Cycle

New Theories

Muscle Control?
Ligaments and boney integrity
Proximal Mechanics
Midtarsal Joint Locking
Case Question

Ankle vs Midfoot Power

Ankle Power

Case Question

Is the Calc/1st met rhythm disturbed here?
Basic Functional Assessment
Midfoot instability
Clinical Relevance?
Muscle Control to counter PF
(Drives exercise prescription)
Ankle Sprain

Case
Ottawa Ankle Rules
Sprains + Occult Fractures
Epidemiology
Pain Experience
Prognosis
High level sports risk
Summary
Patient Preferences

Outcome
Acute Care Approach (grade I-II)
Case - chronic
Differential Diagnosis Lateral Ankle Sprains:
Associated Injuries

Differential Diagnosis
Loose bodies osteochondral defects
Anterolateral Impingement
Anterolateral Impingement

Tendon Subluxation
Case - chronic
Unresolved Impairments
Talar and Fibula Positions
Subacute
Base on Assessment
Acute effects of Mobilization
Talocrural Joint Manipulation
Assessment and Manipulations
Application

Subacute Ankle Sprain Treatment + Manipulation
Chronic Ankle Instability
Mechanical Instability

Arthrometer testing
Dynamic Balance
Balance
Treatment-
Hop to Stabilization
Dynamic Balance
Single Leg Balance Exercise Progression
Single Leg & Biodex
BAPS Training
Systematic Review Balance Training

Lateral Ankle Sprains
Ankle instability
• Sequelae of long term instability
• OA and deformity
Ankle treatment
• Operative treatment
• Direct ligament repair
• Tendon transfer or free tendon graft
Brostrum repair
Tendon graft

**Achilles Tendinopathy**

Impact of Tendinopathy on muscle-tendon function
Does the tendon transmit the tensile forces to the bone?
Impact of Tendinopathy
• Ability to store energy?
• Joint stability and control during locomotion?

Hip Muscles – gross design
Hip Muscle - Architecture
• Hip Flexors:
  – large CSA, longer muscle fibers (>6cm), smaller pennation angles (~5 degrees), short stiff tendons
– low fixed-end compliance = suited for performing muscle fiber work rather than force under isometric conditions

Ankle Muscle – gross design

Ankle muscle - Architecture:

• Plantar Flexors:
  – short muscle fibers (<5cm), pennation arrangement (5-30 degrees), large physiological cross-sectional areas (CSA), long compliant series tendon
  – high fixed-end compliance = elastic energy storage and return, and economical force production

Take-Home

• Larger proximal muscles are more likely to be sources of high muscular work output (and metabolic energy consumption), whereas distal muscles, because of their long series tendon can produce force nearly isometrically, consuming smaller amounts of metabolic energy.

• Muscle-tendons spanning the hip, knee, and ankle joints yield a proximal to distal gradient in the efficiency of muscle-tendon positive work. That is, the highest muscle-tendon efficiencies occur at the more compliant distal joints.

(Sawicki, GS. et al. 2008)

• It then makes sense that for functional, repetitive tasks, such as walking we might take advantage of the efficiency of distal joints.

Pain not strain and stiffness brings patients into the clinic!!

Achilles Tendonopathy

“Wringing-out” Theory

• Sparse blood supply to tendon 2-6 cm proximal to insertion
• tendon “twists” medial → posterior and posterior → lateral
• overpronation accentuates rotation of tendon, “wringing out” avascular zone. Williams 2008

Exam

Differentiating a rupture

Objective Tests – risk factors
Biomechanics of Heel Raise
Single Heel Rise Test
Case Question
Proximal Control

**PROBLEM**
Recent Clinical Practice Guideline
Management framework for tendinopathy: EdUREP

- Educate
- Unload
- Reload
- Prevent

- Decrease aberrant, excessive loads
- Relative unloading period

- Prevention as well!

EdUREP Model

**Unload the Tendon**

**Modification of activities**
- Active Rest
- Passive Rest (walking “boot”)

**Use of ½-inch heel lift**

Nichols, 1989, *J Am Board Fam Pract*

Lee et al., 1987, *Arch Phys Med Rehabil*

Orthotic depending on person
EdUReP Model

Treatment of Achilles Tendinosis
• Eccentric Program
• Specifics

3 sets of 15 reps.
2 positions
Twice per day

= 180 repetitions

• 12 weeks!

Case Question
EdUReP Model

Prevent re-occurrence by ....
• Completing the entire 12-weeks eccentric program, with full compliance
• Identify other impairments (hip, trunk) and develop intervention
• Identify sub-clinical co-morbidities and consult a physician
• Integrating Tendon Loading Program for long term application (> 3 months)

Insertional Achilles Tendonopathy

Insertional

Progression
Results

Case Study

**Plantar Fasciitis**

Case (subjective)
Interpretation
Anatomy
Imaging
Case (Objective)
Palpation
ROM
Our Case
Possible Special Tests
Plantar Fasciitis
Neural Heel Pain
Neural Heel Pain – Clinical Presentation
Special Tests
Treatment
Differential Diagnosis
Assessment

Treatments
(Several RCTS here)
Lodi Taping Technique
Orthotics - (level 4)
Outcomes - Stretching
Home Exercise Program
Trigger Point Therapy (RCT Level 1b)
Soft Tissue Massage/Techniques
Outcomes – Manual Therapy
Slide graphic for PF Manual therapy
Where does this get the patient?
Prognosis & Education
Indications for Gastroc Surgery
Examination
• Isolated gastrocnemius tightness?
• Silverskiold test

• **Neutral hindfoot**
• **Test ankle dorsiflexion**
  • Knee flexed
  • Knee extended
Gastrocnemius Lengthening
• 4-5 cm separate Proximal incision
Outcomes
• Pre 8/10 post 2/10.

• 93.1% said they would recommend this procedure for isolated foot pain to a friend.

• 93.1% said they were satisfied

• 92% who had a unilateral procedure stated they would have the contralateral leg done if needed.

Summary

PTTD – Non-Op

Treatment
• Educate

• Unload

• Reload

• Prevent

Health Condition: Posterior Tibial Tendon Dysfunction

• Stage I
  – No foot deformity

• Stage II
  – Flexible Foot deformity
    • ligament damage
  – Decreased function of muscle
    • Inability to heel raise

• Stage III
  – Fixed foot deformity
  – Loss of muscle function
Tendon Loading Progression
Target Motor Control & Function

• Heel Rises
  – **Bilateral**
  – **Unilateral**

Exercise (Passive & Active Treatment)

• Clinic Based Program
  – **Intensity**: Clinic Based, 50+ heel rises, isokinetic training
  – 42/47 subjects were satisfied @ 12 months.
    • Alvarez et al, Foot & Ankle International, 2006

• Active treatment other tendinopathies
  – **Alfredson, 2005**

Clinical Trials

Foot Orthoses
• Footwear accommodates device
• Semi-rigid Shell
• Full contact of shell height
  – **Control midfoot motion**
    · Johanson, *PTJ*, 1994
• Medial rearfoot post will:
  – ↓ heel valgus, ↓ Tib Post demand
    · Keenan, *JBJS*, 1991
• Forefoot post to sulcus
  – **Attempt to ↓ frontal and transverse plane motion in late stance phase**
    · Tome, *JOSPT*, 2006
• As patient tolerates device
  – ↑ in post or reinforce the arch

TibPost Loader
• Clinical visits 1/wk for 10 weeks.

• Able to control C/E load via “concentric” spring
  – **Different resistance by spring size**
• Progressive resistance in the transverse plane with static plantar flexion
  – 3 sets of 15 repetitions
  – Twice per day
  – 3x15x2 = 90 repetitions

**Characteristics of an effective eccentric tibialis posterior tendon loading program**
• Very slow
• Within the predetermined range of motion
• Progressively resistive, and guided by:
  – symptoms (seldom painful during session)
  – technique (careful with tibial rotation, smooth movement)

**Tendon Loading Progression**

• Compare *foot kinematics* and *outcomes* between
  Passive Treatment
  Active Treatment - Strengthening Exercises
  **Primarily HEP**
• Instruction (0-6 weeks)
  – 5 visits (1/week)
    • Progressing toward (individualized to subjects)
      – Yellow to Blue theraband – goal 30 reps with blue
      – Bilateral to Unilateral heel rise – goal 30 reps unilateral

• HEP (6-12 weeks)
  – Maintain exercise log
  – F/U 12 weeks

Foot Kinematics & Kinetics

Rearfoot
Ev/Inv

Questions?
• Outcomes
  – Exercise Better than Brace alone – clinically significant difference?

• Foot Kinematics & Kinetics
  – Muscle dependent foot? (Nikki et al, 2001)
  – 1.6 x more likely to improve push off power

• Reload
  – Home Exercise
    • Houck et al, 2007
  – Exercise mode – eccentric vs concentric?
    • Kulig et al, 2006
  – Exercise Dosage?
    • Alveraz et al, 2006

• Unload (Different strategies)
Do improvements in tendon tissue occur with exercise?  
Transverse Plane LE Control  
Proximal to Distal  
Hip Control?  
Hip ext rotators/lateral rotators

– Weight Bearing Control

Take Home Message
• Exercise & Brace/Orthoses is better than brace alone

• Exercise and bracing does not change abnormal kinematics – muscle dependent foot?

• We still haven’t optimized the exercise dosage
  – Is higher dosage better?  
  – Can hip exercises augment current programs?  
  – Other?

• We don’t know if we are getting the same tissue changes at the PT tendon as the Achilles?
LCL
• Calcaneocuboid fusion

• CC arthritis

• May decrease later CC arthritis?
• Lose about 25% hindfoot motion

Procedures most often combined
• MDCO + FDL transfer

• LCL + FDL transfer

• LCL + MDCO+ FDL transfer

Post-op
• Cast, NWB- x 6weeks
• Boot and start PT
• Lifetime arch support

Results
• MDCO + FDL
  ➢ 90% pt satisfaction with relief of pain and improved function at 2-5 yr. Follow-up
  ➢ Max improvement at 10 mos.
  ➢ 50% still feel foot flat
  ➢ Low complication rate
    ➢ Myerson et al
    ➢ Fayzi et al
    ➢ Wacker et al
    ➢ Guyton et al

LCL + FDL
• 85-90 % pt satisfaction at 2-4 yr fu
• Max recovery > 1yr
• Complications 15%
  – Lateral foot pain, nonunion, need for hardware removal

Hinterman et al
Van der Krans et al
Thomas et al

Why choose one vs other
• MDCO
  – Lower complication rate
  – Quicker recovery
• LCL
  – Better correction esp. of abduction

• Bolt et al 2007
  – Greater initial correction
  – Better maintained correction over time

Results
• All retrospective studies
• Level IV evidence
• No consensus as to which is best procedure to use
• Surgeon needs to use experience

**Barefoot Running**

Summary
• Land gently, with your foot relatively horizontal and under your hips (this will shorten your stride)
• Transition slowly
• Stretch your calves and Achilles tendon
• Don’t do anything that causes pain
• Listen to your body and run totally barefoot to learn good form
• Buy low profile shoes (low heels, minimal arch support, flexible soles) to use when
barefooting is not safe

- Consult a doctor before beginning if you have any problems with your feet.