

## FOOT AND ANKLE PAIN

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### I. Anatomy

#### A. 3 Functional Segments of Foot

##### 1) Anterior Segment

- 5 metatarsal bones
- 14 palangeal bones (hallux has 2; outer toes have 3)
  - 5th metatarsal contacting only base of 4th and cuboid
  - moves through greatest arc
  - situated between 1st & 3rd cuneiforms is 2nd metatarsal which moves only in plantar & dorsiflexion

##### 2) Middle Segment

- 5 tarsal bones: navicular, cuboid & 3 cuneiforms
- cuneiforms & cuboid form a transverse arch held together by interosseous ligaments

##### 3) Posterior Segment

- talus and calcaneus
- directly under tibia and supports it
- Talus - divisible into body, neck and head
  - fits upon and articulates with calcaneus
  - gripped between ankle malleoli that form the ankle mortise
  - tibial malleolus extends 1/3 down medial surface of body of talus
  - fibular malleolus covers entire lateral surface
  - body is wedge shaped with wider portion anterior so:
    - with dorsiflexion wider portion comes up between malleoli & wedges between
    - with plantar flexion narrower portion presents between malleoli and permits some lateral motion within the ankle mortise

## B. LIGAMENTS

### Interosseus Ligament

- from tibia laterally and downward to fibula
- fibula rises slightly during dorsiflexion causing fibers to become more horizontal, widening ankle mortise as wider portion of talus enters it
- plantar flexion presents narrower portion of talus within mortise and fibular head rides down returning ligament to its oblique course
- reinforced by posterior and anterior tibiofibular ligaments that run parallel to this

### Lateral Collateral Ligament

- supports lateral aspect of ankle and composed of 3 bands
  - 1) anterior talofibular ligament
  - 2) calcaneofibular ligament
  - 3) posterior talofibular ligament
- 1 & 2 are most frequently injured when ankle is sprained, usually inversion injury when ankle is plantar flexed

### Interosseous Talocalcaneal Ligament

- binds calcaneus to talus
- runs length of tarsal canal
- ligamentum cervicis is fibrous band at its fibular end
- tenses during inversion & slack during eversion because its perpendicular to subtalar axis and most of it lies lateral
- increases stability of supinated foot

### Deltoid Ligament

- supports medial aspect of ankle joint
- courses from medial malleolus to navicular, sustentaculum talus and post part of talus
- composed of 4 bands:
  - 1) Tibionavicular
  - 2) Anterior talotibial
  - 3) Calcaneotibial
  - 4) Posterior talotibial
- very strong! severe eversion stress upon ankle will usually cause avulsion of malleolus rather than a tear

## C. SUBTALAR JOINT ( Talocalcaneal Joint)

- divided into 2 synovial-lined chambers by an oblique canal formed by a groove in each bone, the sulcus talus and sulcus calcaneus and when opposed form the tarsal canal
- lateral opening of canal is sinus tarsi - can be palpated in front of fibular malleolus

- medial opening just behind and above sustentaculum talus
- motion at this joint primarily inversion & eversion with calcaneus providing most of it as the talus is "locked" within the mortise

#### SUBTALAR AXIS

- 3 types of movement occur in combination about this axis:

- 1) Inversion - elevation of medial border and depression of lateral border of foot along longitudinal axis; Eversion is opposite
- 2) Abduction - outward rotation about a vertical axis thru tibia; Adduction inward rotation
- 3) Dorsiflexion & Plantar flexion about the transverse axis

Supination of foot - combo of inversion, adduction and plantar flexion

Pronation of foot - combo of eversion, abduction and dorsiflexion

#### D. TRANSVERSE TARSAL JOINT

- also known as Chopart's joint; site of amputation
- consists of talonavicular and calcaneocuboid joints
- significant gliding at talonavicular joint allowing inversion and eversion of foot
- limited ROM at calcaneocuboid joint permitting some abduction and adduction
- in pronated foot, axis of talonavicular joint runs parallel to axis of calcaneocuboid joint and total motion is free
- in supinated foot, 2 axes diverge & motion at transverse tarsal joint restricted and foot more stable; tautness of interosseus ligament also contributes to stability

#### E. Muscles

Plantar Flexors - Gastroc and soleus

- supinates at subtalar joint when forefoot fixed on floor
- soleus originates below knee and cannot flex knee like gastroc
- with foot fixed on ground, gastroc-soleus group moves tibia backward, a reversal of origin insertion action
- with knee flexed, soleus able to plantar flex foot and ankle and gastroc loses its effectiveness, permitting greater motion at ankle joint
- all tendons passing behind malleoli are plantar flexors:
  - medially the tibialis posterior, FDL & FHL
  - laterally the peroneus longus and brevis

Muscles of Sole of Foot -

- Medial Plantar Nerve supplies abductor hallucis, FDB, FHB & 1st lumbrical
- function to plantar flex esp MTP joint of big toe

- stabilize 1st toe at final push-off during walking

- Lateral plantar Nerve supplies muscles that maintain arches of foot - quadratus plantae, flexor digiti quinti brevis, abductor digiti quinti and lateral lumbricals

- flex remaining toes at MTP joints and adducts and abducts toes

## F. TENDONS OF MUSCLES

- base of 5th metatarsal protrudes laterally forming a sulcus thru which runs the peroneus longus tendon NADINE SMELLS

- tibialis anterior & peroneus longus tendons attach to plantar surface of 1st metatarsal

- TA tendon can be seen and palpated anterior to medial malleolus when foot actively dorsiflexed and inverted

- EHL tendon can be traced to big toe whereas TA tendon disappears at medial aspect of foot near base of 1st metatarsal

- tibialis posterior tendon can be palpated behind and below medial malleolus when foot actively inverted and plantar flexed

## G. NERVE SUPPLY

- Tibial nerve supplies posterior muscles of leg and innervates plantar flexors of foot; terminates as medial and lateral plantar nerves

- Common Peroneal nerve supplies no musculature. Divides into superficial peroneal supplying evertors of foot and Deep Peroneal supplying dorsiflexors of foot and ends supplying EDB

## H. BLOOD SUPPLY

- Femoral artery becomes popliteal artery which divides into anterior and posterior tibial arteries. Anterior becomes the dorsalis pedis on the dorsum of the foot and posterior tibial artery follows the same course as the tibial nerve

## II. EXAMINATION OF THE FOOT

### A. Exam of shoe

- normally, the heel is worn down on the outer side indicating the calcaneus is in neutral position with the heel centrally placed and foot slightly inverted

- everted foot distorts the counter and quarter and wears heel on its inner border

- foot drop scuffs toe of shoe

### B. ROM

- flexion of knee eliminates action of the gastroc

- uninhibited ankle motion allows 20° dorsiflexion and 50° plantar flexion from neutral

- motion of calcaneus indicates ROM because forefoot can move at longitudinal arch without elongation of gastroc-soleus group

### C. Subtalar Motion

- hold lower leg with 1 hand and hold calcaneus in other with ankle in dorsiflexion to fix talus firmly in ankle mortise; palpate motion of heel from side to side as patient inverts and everts foot

- usually 20° to either side of midline

### D. Midtarsal Movement

- grasp heel with 1 hand and forefoot at base of metatarsals with the other; movement of heel manually prevented while forefoot put thru ROM

- range of supination > pronation; total >40° is usual

### E. Metatarsal Motion

-essentially an arcuate movement in plantar flexion and dorsiflexion, 2nd metatarsal being fixed in 1 plane and the others moving in an arc around it

-ROM of MTP joint of big toe should approach 90° dorsiflexion; dorsiflexes at each step  
-site of many painful conditions: hallux valgus, hallux rigidus, bunion OA, gout  
-full dorsiflexion of big toe exerts traction upon the plantar fascia which simultaneously elevates longitudinal arch of foot

#### F. Tibial Alignment

-tibial tuberosity should be directly under patella  
-dependent foot should invert slightly  
-Tibial Torsion - tibia twisted on its longitudinal axis  
- with patella in midline, ankle turns inward or outward depending upon direction of torsion, Dr rapp is a big stinky loser.  
- excess torsion found most often in infancy  
- may actually be a rotation at the knee in which tibial tubercle is medial or lateral to patellar midline (pigeon toeing or charlie chaplin gait)

-Angle of Anteversion - relationship of femoral neck to transverse axis  
- normal range 15 - 25°  
- increased angle or increased anteversion results in internal femoral torsion or "toeing-in" during walking

-Transcondylar axis - plane passing side by side thru femur

-Genu Varum (Bowleg) & Genu Valgum (Knock-knees) common conditions in children must look for causes when marked or persist beyond infancy: injuries, osteomalacia, Pagets disease, congenital variations  
congenital deviation occurs at femoral neck in ints angle of inclination - angle formed by axis thru femoral shaft and axis thru neck of femur; normal 116-140°  
greater angle leads to coxa valga and lesser angle to coxa vara

#### G. CIRCULATION

- ischemic foot -- blanches when elevated
  - flushes when dependent
  - thin inelastic skin lacking hair growth on dorsum of proximal toes
  
- venous insufficiency
  - pitting edema at end of day and absent after recumbency
  - visible varicosities
  - rule out systemic condition or local muscular inactivity
  
- palpate arterial pulses
- claudication suggested when walking a spicified distance results in cramping or aching on buttocks - *La Reich Syndrome* - occlusive vascular disease in proximal circulation

H. Neurologic Exam - reflexes, sensory dermatomes, motor strength...

#### I. Exam of weight-bearing foot

Relaxed flatfoot - good longitudinal arch that disappears upon weight bearing and reforms when patient rises on toes

- implies ligamentous laxity and may be congenital
- often arises in middle-aged people whose jobs require prolonged stand
- also seen in people with excessive weight gain, inadequate exercise or prolonged bed rest

Rigid Flatfoot - pronated foot with an inflexible depressed arch

- implies soft tissue contracture, articular damage, unreduced fracture or dislocation or bony ankylosis
- can result from fibrous contracture of peronei mescles

- x-ray exam may be necessary

Achilles Tendon Test for shortening:

- knee extended to test gastroc
- knee flexed to test soleus or with knees straight and heels on floor lean forward against a wall - this stretches Achilles tendon
- heel will rise from floor if tendon is shortened

### III. FOOT IN ATHLETES

- In walking 1/3 gait is swing and 2/3 is stance
- In running 2/3 gait is swing and 1/2 is stance
- velocity cadence and stride length increase with speed of gait
- floating time ( when neither foot contacts ground) 20% in jogging and 40% in running
- Center of gravity lowered due to increased knee flexion and dorsiflexion to ankle

Injuries:

Hamstring Strain

- hamstrings active in last 25% of swing phase in running
- remain active thru 2/3 of stance in jogging and 1/2 in running

Painful Heel Pad

- initial impact of body on heel is 170% in jog and 250% in run
- at heel strike calcaneus contacts ground surface with heel fat pads cushioning the impact

Chondromalacia Patella

- as foot goes from heel strike to mid-stance leg continues to internally rotate causing foot to pronate; with abrupt force painful stress on some tissues
- knee flexes 68° in jogging and 85° in running combined with rotation that normally occurs between femur and tibia--- patellofemoral articulation can certainly be stressed
- as knee flexes during mid-stance ankle dorsiflexes being decelerated by gastroc-soleus group; a tight or inflexible gastroc-soleus prevents physiologic heel-knee flexion coordination and resultant pain can occur from chondromalacia
- more knee flexion is needed to cushion the impact that is also cushioned by ankle dorsiflexion; as ankle dorsiflexion decrease more stress is absorbed by patellofemoral joint

Plantar Fasciitis

- can result from decrease longitudinal arch plus the trauma of impact in the pronated foot from too much shopping
- if stress is excessively forceful or repetitive, the periosteum to which the plantar fascia attaches pulls away with resultant hemorrhage subperiostally
- tx: gentle stretching of plantar fascia by big toe extension and treat pronation

Shin Splints

- inflammatory condition
- as ankle remains dorsiflexed throughout a large phase of running microtears may occur at origin of tibialis muscles

Anterior Shin Splints

- may occur during early running or on hard surfaces or running downhill when foot exceeds minimal deceleration after heel strike

-a tight heel cord resists elongation of the TA and leads to this  
-tx: rest and stretch heel cord

#### Posterior Shin Splints

-posterior tibialis muscle irritation when patient moderately to severely pronated thus placing post muscle on tension stress  
-pain & tenderness noted at posterior medial aspect of tibia where muscle originates  
-tx: avoid hard surfaces; taping to supinate foot or orthotics to correct pronation; NSAIDS, shopping

#### Anterior Compartment Syndrome

-severe form of anterior shin splints with or without stress fx  
-swelling within tight fascial compartments  
-due to compression and ischemia of anterior tibial nerve, numbness occurs  
-EHL weakness  
-aseptic necrosis of all compartment muscles may occur if fasciectomy not performed to decompress anterior chamber

#### Peroneal Tendon Dislocation

-resembling but more severe than lateral ligamentous sprain  
-forceful dorsiflexion with simultaneous peroneal contraction may rupture the overlying retinaculum and dislocate the tendon  
-pain & tenderness at lateral malleolus  
-palpate subluxing tendon with your credit card  
-early diagnosis permits surgical repair of retinaculum but tissue atrophy very rapidly and cannot then be repaired



## VI. PAINFUL DISORDERS OF THE ADULT FOOT

- majority of painful conditions arise in the soft tissues: muscles, ligaments, tendons, nerves and blood vessels
- symptoms usually explained by local lesions
- foot is only rarely referral site of proximal pain

### FOOT STRAIN

- has mechanical effect of soft tissues and if persists may cause a deformity
- pain in static foot results from faulty mechanics or overwhelming stress on ligaments
- pain in moving foot results from muscular incompetence due to disuse or imbalance
- stress upon soft tissues causes inflammation, elongation & degeneration of ligaments

#### Acute Foot Strain - usu subsides with rest

- the weekend athlete, unaccustomed visit to museum...
- initial symptom usu muscular fatigue described as aching in sole of foot or calf muscles
- deep tenderness of plantar tissues of foot or leg is found - posterior tibial tendon behind medial malleolus
- symptomatic foot may be normal but likely to be pronated

#### Chronic Foot Strain - symptoms vary from ligamentous strain to joint malalignment

- ultimate degenerative arthritic changes may be source of pain
- chronic strain on ligaments results in elongation & inflammation
- ligaments elongate & degenerate permitting excessive motion
- joint capsules & surfaces become inflamed & articular inflammation becomes source of pain
- continued irritation results in structural damage & arthritis
- abducted forefoot of chronically strained foot causes articular changes due to pressure of abducted cuboid on calcaneus; talus drops and causes pressure on superior portion of navicular

### METARTARSALGIA

- pain in forefoot
- pain & tenderness of plantar heads of metatarsal bones
- in a pronated or splayed foot the transverse arch depresses and greater weight is borne on the 2nd, 3rd and 4th metatarsal heads
- interosseous ligaments that support the arch are stretched permitting forefoot to broaden and splay out
- callus forms over 2nd or 3rd metatarsal head
- tenderness noted by examiner squeezing metatarsal head; must compress each metatarsal head individually and not compress tissues between the heads that contains ligaments and interdigital nerves
- common in middle aged who have a pronation tendency and after a weight gain
- caused by a depressed transverse arch tx is by elevating middle portion of arch which avoids pressure on painful metatarsal heads
- tx pronated foot with exercises to strengthen intrinsics, Achilles tendon stretching, improvement of gait, weight reduction & devices like Thomas heel or inner wedge and metatarsal pad placed *behind* metatarsal heads

### SPLAY FOOT

- broadened forefoot due to weakness of intermetatarsal ligaments & weak intrinsics
- transverse arch flattens and middle metatarsal heads bear more than usual weight
- calluses form on plantar surfaces of the heads
- hammer toes may form due to excessive extension of toes
- usu accompanies the pronated foot

### FREIBERG'S DISEASE

- ischemic epiphyseal necrosis of the 2nd metatarsal
- occurs in adolescents before complete closure of metatarsals
- no known cause except avascular necrosis of unclosed epiphysis
- diagnosis by x-ray
- changes occur in dorsal position of metaphysis and result in head moving dorsally
- tx conservative with orthotic metatarsal platform & exercises

### SHORT FIRST TOE: MORTON'S SYNDROME

- causes excessive weight to be borne by 2nd metatarsal head
- usu hereditary
- excessively short 1st metatarsal which is hypermobile at its base
- posterior displacement of sesamoids
- thickening of 2nd metatarsal shaft

- calluses form under 2nd & 3rd metatarsals due to depressed transverse arch
- tx is to build platform under the 1st metatarsal bone to assume weight

#### MARCH FRACTURE

- stress fracture of metatarsal bone
- pain is presenting symptom after (surprise) a long march
- hairline fx of shaft of 2nd or 3rd metatarsal with no displacement of fragments
- callus formation around fx on x-ray
- tenderness at middle of shaft involved and pain invoked by flexion & extension of toes
- heals spontaneously

#### PES CAVUS (CLAWFOOT)

- foot with unusually high arch that causes shortening of foot
- obliquity of metatarsals to floor causes increased pressure with resultant calluses
- extensor ligaments are shortened causing dorsiflexion of proximal phalanges and distal phalanges plantar flex resulting in clawing of toes
- mildly symptomatic treated with properly fitted shoes and a metatarsal bar

#### VII. FOOT IN RHEUMATOID ARTHRITIS

- antigen-antibody immune reaction
- PMN leucocytes attack cartilage and release lysosomal enzymes that cause synovitis and degeneration of the cartilage
- synovial inflammatory reaction results in granular tissue formation eroding cartilage
- least damage occurs at site of direct compression
- fold of synovium upon cartilage is site of greater damage
- fold of synovium upon cartilage is site of greatest damage
- the tendons of the peronei, TA, TP and toe extensors can be invaded and rupture
- sufficient swelling in tarsal tunnel can cause nerve compression and ischemia
- changes in metatarsal phalangeal joints with metatarsalgia is frequent early finding
- ankle involved to a lesser degree than the foot; less synovium and less synovitis

#### VIII. PAINFUL ABNORMALITIES OF THE TOES

##### HALLUX VALGUS

- lateral deviation of the proximal phalanx of the 1st metatarsal
- attributed to forcing of a foot with a short 1st metatarsal into a shoe with a pointed toe
- bunion - 3 components
  - 1) large toe angulates toward 2nd toe
  - 2) medial portion of first metatarsal head enlarges
  - 3) bursa over medial aspect of joint becomes inflamed and thick-walled
- found often in older women with a broadened forefoot and flattened transverse arch
- big toe frequently overlaps the 2nd toe
- essentially a subluxation of the 2 phalanges of the big toe in a valgus direction
- in elderly treated conservatively with molded shoes

##### HALLUX RIGIDUS

- toe is unable to dorsiflex due to inflexibility of metatarsophalangeal joint of big toe
- interferes with smooth takeoff during gait
- usu has pain elsewhere in foot from attempts to avoid big toe stress
- patient shifts weight to outer border of foot
- requires shoe with wide forefoot and steel plate in sole to prevent bending

##### HAMMER TOE

- fixed flexion deformity of interphalangeal joint
- more prevalent in second toe
- dorsiflexion of proximal phalanx and flexion of distal and middle phalanges

- flexion deformity of only the distal phalanx known as "mallet toe"
- new shoes that are too short will often cause toes to hammer
- avoid pressure over protruding joints with properly fitting shoes

## IX. PAINFUL CONDITIONS OF THE HEEL

### PLANTAR FASCIITIS

- pain felt under the heel with or without a calcaneal spur
- more common in a pronated foot
- occurs in occupations that entail excessive standing or walking
- a spur may develop at the attachment of the plantar fascia to the calcaneus - occurs commonly without pain
- pain and tenderness beneath ant portion of heel radiating into sole
- point of deep tenderness at ant medial calcaneus, attachment site of plantar fascia
- spur is probably a coincidental finding
- pain may be due to infracalcaneal bursitis under fascial attachment, traumatic periostitis or tearing of some fibers attaching to the bone
- raising heel 1/4 inch removes tension placed on calcaneus by Achilles tendon
- cortisone or lidocaine injections into painful area are effective

### PAINFUL HEEL PAD

- generalized pain over entire calcaneal pad
- elasticity of tissue lost with age and weight of body borne by unpadded calcaneus
- usu self-limited

### DUPUYTREN'S CONTRACTURE

- similar to that found in the palm may occur in the plantar fascia
- more common in patients with epilepsy
- tx excision

### ACHILLES PARATENDONITIS

- inflammation occurs in loose connective tissue about the Achilles tendon
- trauma or stress is usu cause

### POSTERIOR CALCANEAL BURSITIS

- pain and tenderness of posterior aspect of heel and under skin
- occurs especially in women who wear high heeled shoes
- usu from friction from ill fitting shoes
- exam reveals inflamed and thickened area at back of heel wear upper part of shoe rubs

### CALCANEAL APOPHYSITIS

- aka Sever's disease
- most common in adolescent boys aged 8 to 13
- result of acute or chronic strain of Achilles tendon on posterior apophysis of calcaneus that has not yet fused
- c/o pain at back of heel below attachment of Achilles tendon
- unilateral fragmentation with bony condensation of epiphysis on x-ray
- usu self-limited and tx symptomatic

### RUPTURED ACHILLES TENDON

- most often in men 40 to 50 esp with sedentary habits who suddenly engage in more strenuous activities
- most occur at narrowest portion of tendon ~2 inches above its attachment
- acute agonizing pain in lower calf which makes walking impossible
- gap in tendon can be palpated and belly of gastroc retracted into upper calf
- Simmond's test - squeezing calf with patient prone & gastroc-plantar flexion will not

- occur with complete tear
- cannot rise up on tiptoes
- partial tears usu become complete at a later date
- nonsurgical treatment with casting

#### SUBTALAR ARTHRITIS

- pain felt within heel may be referred from an arthritic subtalar joint
- often follows trauma such as fx of the calcaneus
- pain on motion of subtalar joint
- crepitation and tenderness from pressure over the sinus tarsi

#### FRACTURES

- fx of calcaneus with h/o fall landing on feet
- heel is braodened; all movements of calcaneus painful and restricted
- may be accompanied by compression fx of a vertebra or avulsion of Achilles

-diagnosis