Common Sports-Related Leg Injuries

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Common Injuries of the Leg

Objectives

- To understand the basic anatomy and biomechanics involved in leg injuries.
- To be able to describe the common causes of exercise-induced leg pain and their management.
- To understand the role of imaging studies in the diagnosis and treatment of leg injuries.

Common Injuries of the Leg

- Leg injuries account for up to 12% of injuries presenting in the office setting.
- Sport-specific rates vary.
- For track and field 28% of all injuries are located in the leg

Common Injuries of the Leg

In the military:

1/4 to 1/3 of overuse injuries during training occur in the leg

Causes

More Common

- Stress Fractures
- Contusions
- Fractures
- Medial Tibial Stress Syndrome
- Chronic Compartment Syndromes
- Gastrocnemius strains
- Muscle contusions
- Muscle Cramping
- Delayed onset muscle soreness

Causes

Less Common

- Referred Pain
- Acute compartment syndromes
- Popliteal artery entrapment
- Superficial peroneal nerve entrapment

Other Important Causes Not to Miss!

- Tumors
- Deep venous thrombosis
- Peripheral vascular disease
- Connective tissue and bone diseases

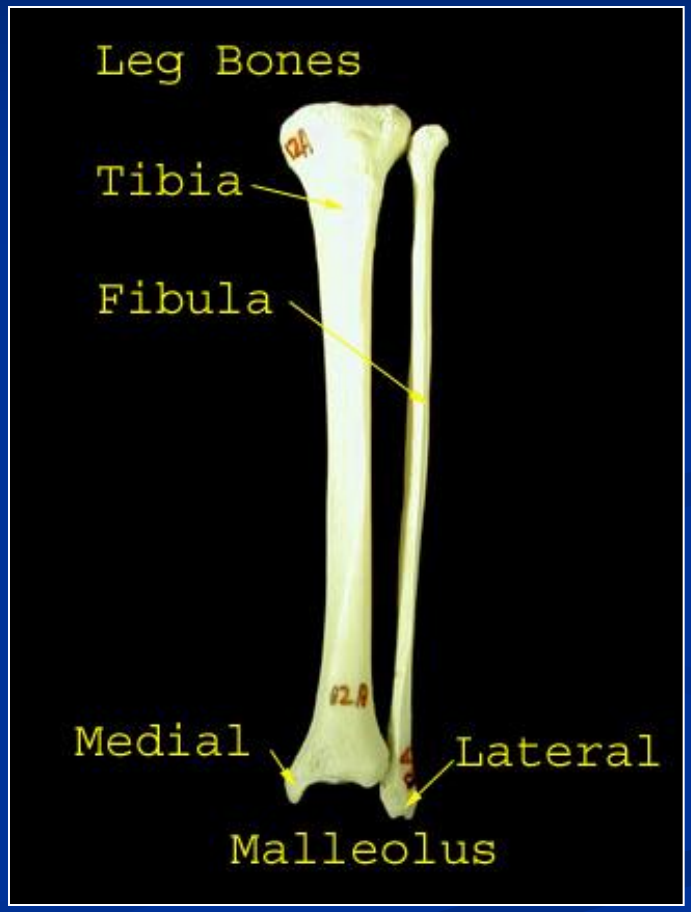
25 July 2022

Burgin had gone into the World Athletics Championships as the fastest man on the planet over 800metres but withdrew ahead of his heat with what he thought was a calf injury.

It later transpired to be deep vein thrombosis (DVT) but there was hope he could recover in time to compete at Birmingham 2022.

Anatomy

- Tibia
- Fibula
- Compartments
  - Anterior
  - Posterior
  - Lateral



Anterior Compartment

Muscles:

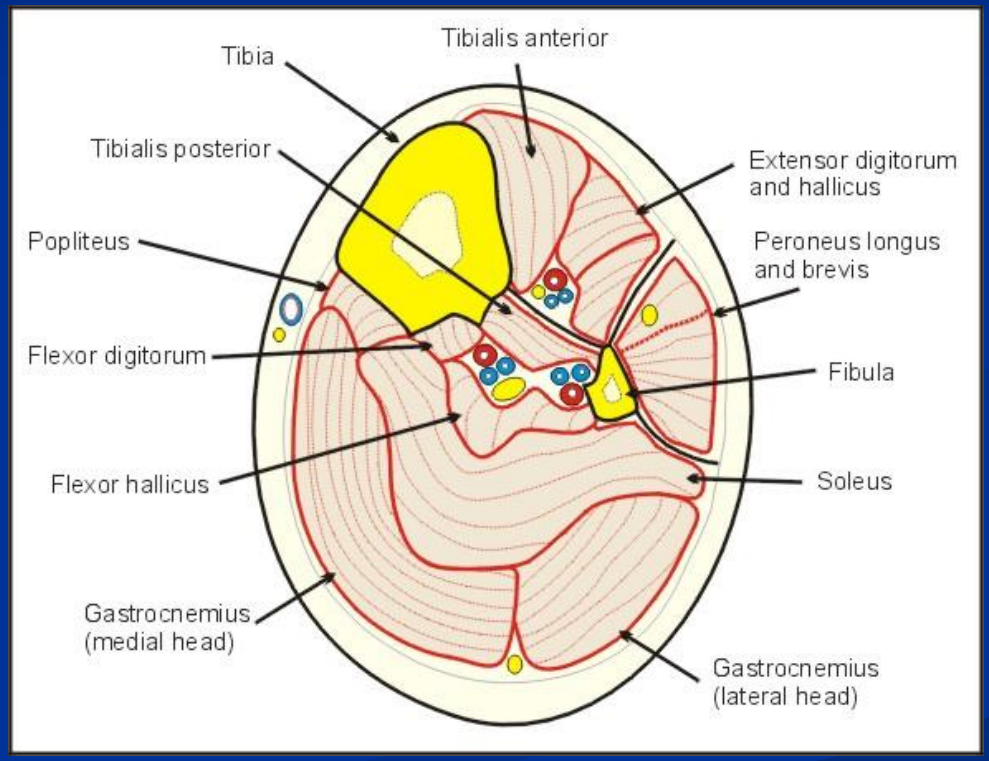
- tibialis anterior
- extensor hallucis longus
- extensor digitorum

Blood supply:

- anterior tibial artery

Innervation:

- deep peroneal nerve



Posterior Compartment

Superficial Muscles:

gastrocnemius,
soleus, plantaris

Deep muscles:

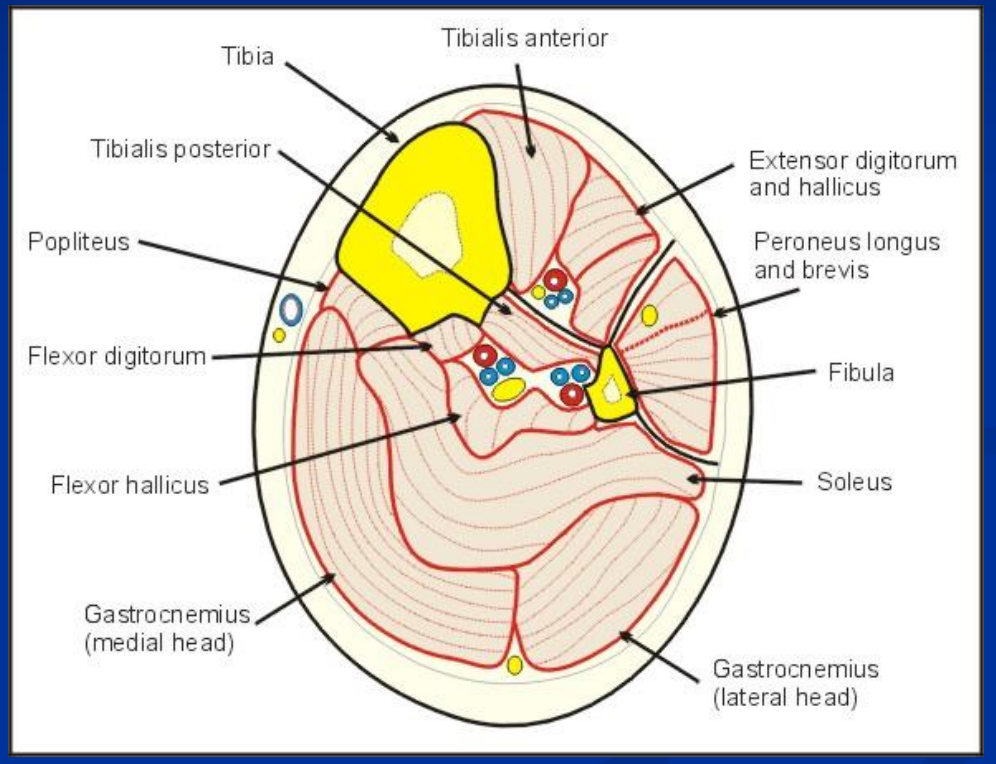
popliteus

tibialis posterior
flexor digitorum longus
flexor hallucis longus

Blood supply:

posterior tibial artery
peroneal artery

Innervation: tibial nerve

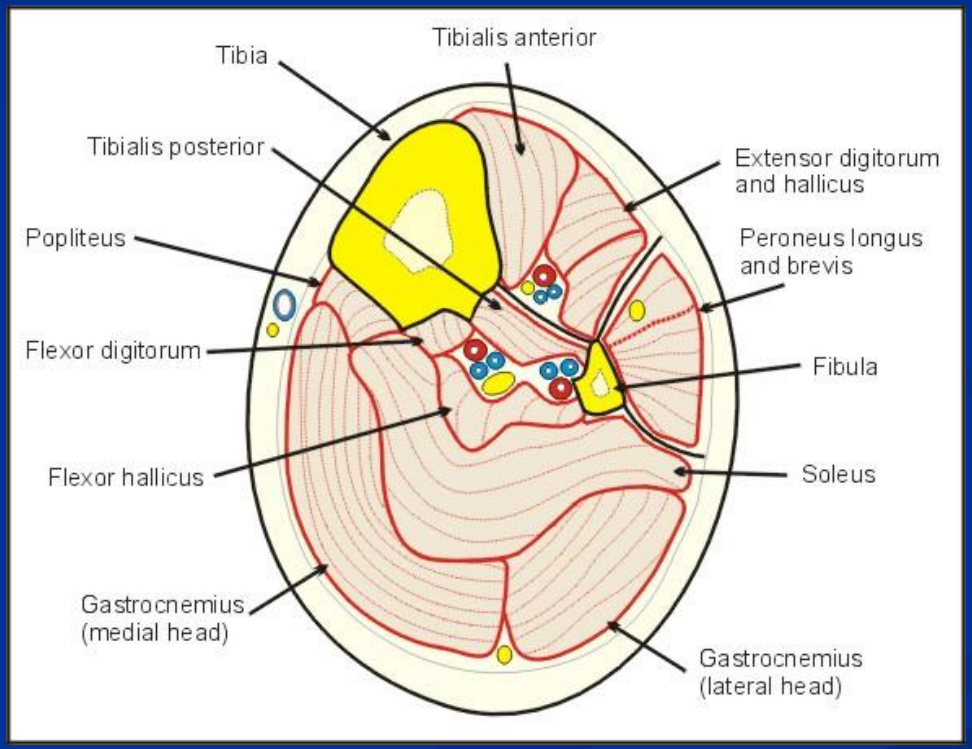


Lateral Compartment

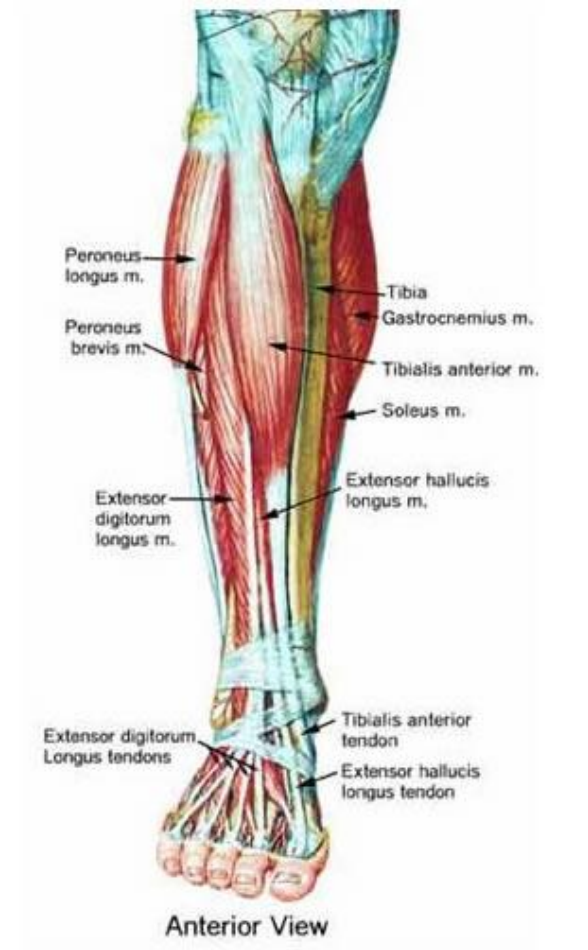
Muscles:
peroneus longus and brevis

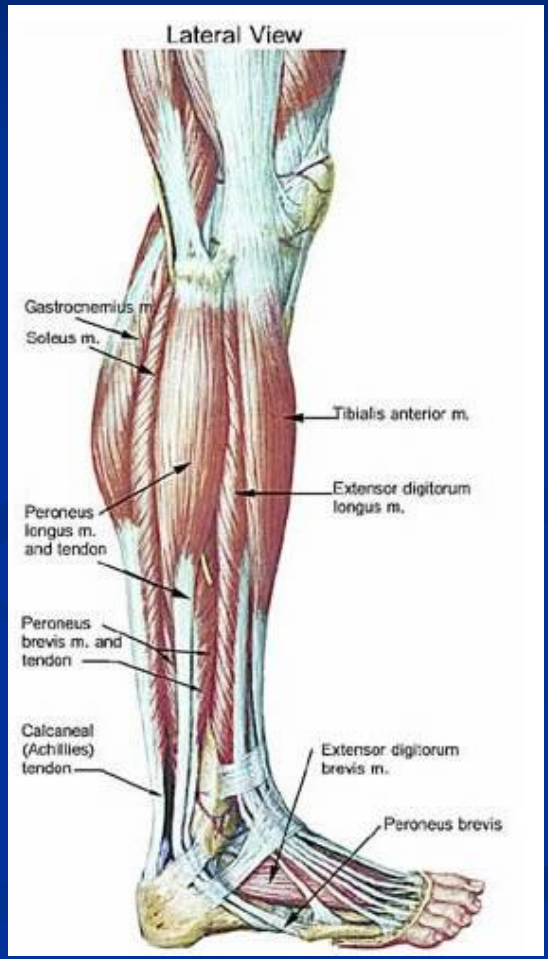
Blood supply:
peroneal artery

Innervation:
superficial peroneal nerve



Leg Anatomy


Peroneus longus m.
Peroneus brevis m.
Tibia
Gastrocnemius m.
Tibialis anterior m.
Soleus m.
Extensor digitorum longus m.
Extensor hallucis longus m.
Extensor digitorum Longus tendons
Tibialis anterior tendon
Extensor hallucis longus tendon
Anterior View


Lateral View
Gastrocnemius m.
Soleus m.
Tibialis anterior m.
Extensor digitorum longus m.
Peroneus longus m. and tendon
Peroneus brevis m. and tendon
Calcaneal (Achillies) tendon
Extensor digitorum brevis m.
Peroneus brevis

Running Gait Cycle

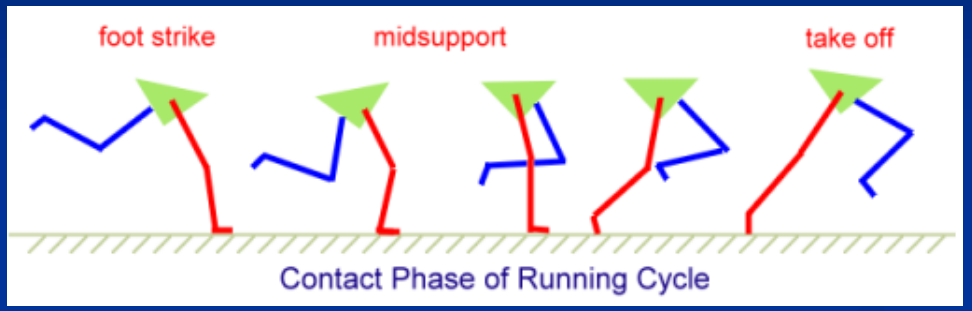
The gait cycle:

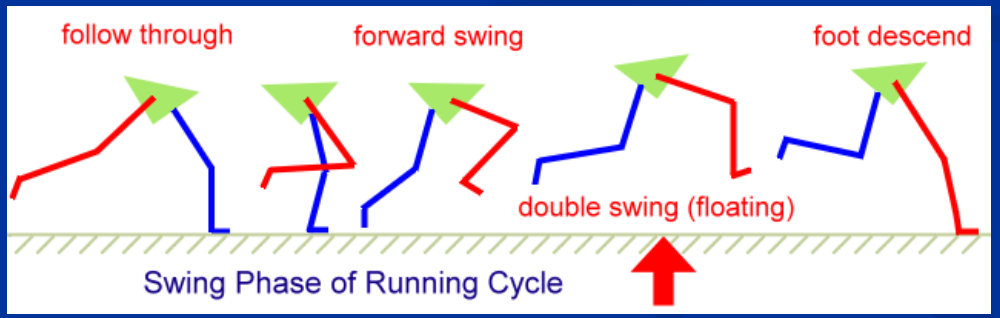
- contact, stance, swing phases

With contact:

- vertical force 2-3X body weight

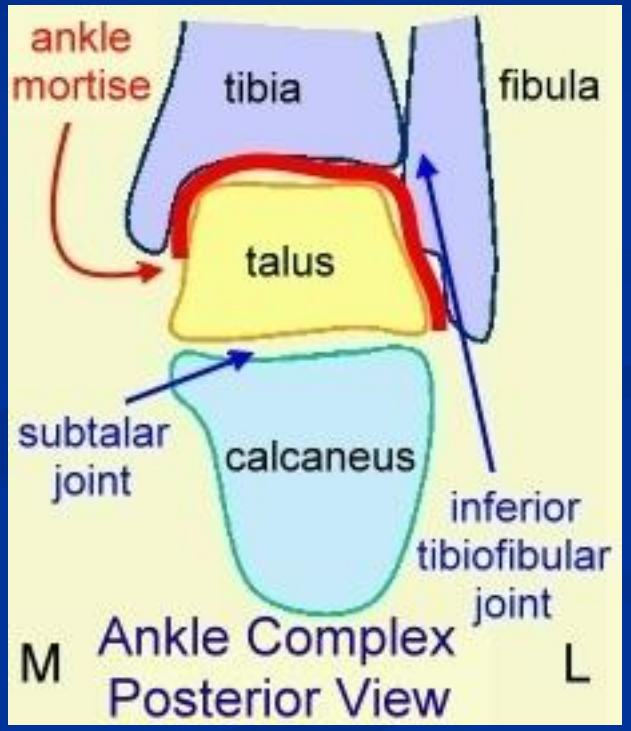
* A 150lb runner would need to dissipate nearly 700 tons of energy in a 10K run





Biomechanics

- Major site of transmission of ground reaction forces is the subtalar joint.
- Variations in the timing and/or magnitude of events at this site may alter force distribution and increase the risk for injury.



Clinical Considerations

History

- Detailed training history
- Prior injuries and their treatment
- Menstrual history
- Footwear
- When does pain occur relative to activity?
- Does pain alter activity?

Clinical Considerations

Physical Examination

- Look for malalignment and joint laxity
- Check strength and flexibility of entire lower extremity
- Localize pain and injured structure
- If asymptomatic, examine after exercise
- Check shoes

Acute Gastrocnemius Strain

- Common cause of acute leg injury.
- Etiology: Knee flexion and ankle dorsiflexion occur simultaneously with muscle contraction

Acute Gastrocnemius Strain

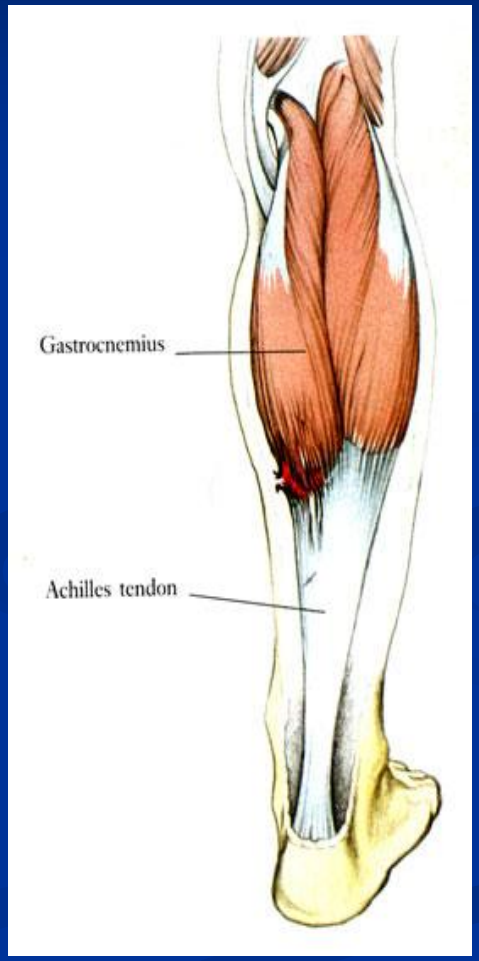
History

- Acute onset of severe posterior leg pain
- Patient may feel as if shot or kicked in leg
- Usually unable to continue the activity after the injury

Acute Gastrocnemius Strain

Examination

- TTP at medial head of gastroc
- Swelling and ecchymoses may be present
- Amount of swelling may make palpation of a defect difficult
- Pain reproduced with passive ankle dorsiflexion with the knee extended
- Patient may be unable to perform a single leg heel raise



Acute Gastrocnemius Strain

Imaging

- Usually not necessary
- In some cases, can be difficult to distinguish from DVT if no clear acute event is described
- Ultrasound and MR imaging can demonstrate injury if needed.

Acute Gastrocnemius Strain

Initial Management

- Ice
- Compression wrap
- Elevation
- Crutches or scooter

Acute Gastrocnemius Strain

Management

- Early active range of motion (not stretching)
- Crutches are often helpful for the first 24-48 hours, sometimes longer.
- Use heel lift when weight bearing begins

Acute Gastrocnemius Strain

Management

- Gradually introduce flexibility and strengthening program
  - Isometrics as soon as tolerated
  - Double leg heel raises on flat surface
  - Progress to single leg, then single leg on step, then add weight.
  - Controlled plyometrics (e.g. hopping)
- Wean heel lift within 1-2 weeks

Acute Gastrocnemius Strain

Return to Play

- A helpful guide is ability to perform controlled hopping and running.
- Time to return varies dependent on severity of injury
  - Mild - 2 weeks
  - Moderate to Severe - 6 weeks or longer
- Flexibility is important, but strengthening is the key!
- No role for bracing

Acute Gastrocnemius Strain

Prevent Recurrence

- Modify risk factors
- Ongoing program to maintain strength and flexibility

Acute Gastrocnemius Strain

Complications

- DVT
- Acute compartment syndrome
- Persisting hematoma

Medial Tibial Stress Syndrome ("Shin Splints")

MTSS:

Exercise-induced pain of the posteromedial border of the tibia; excludes stress fractures, fascial hernias, compartment syndromes

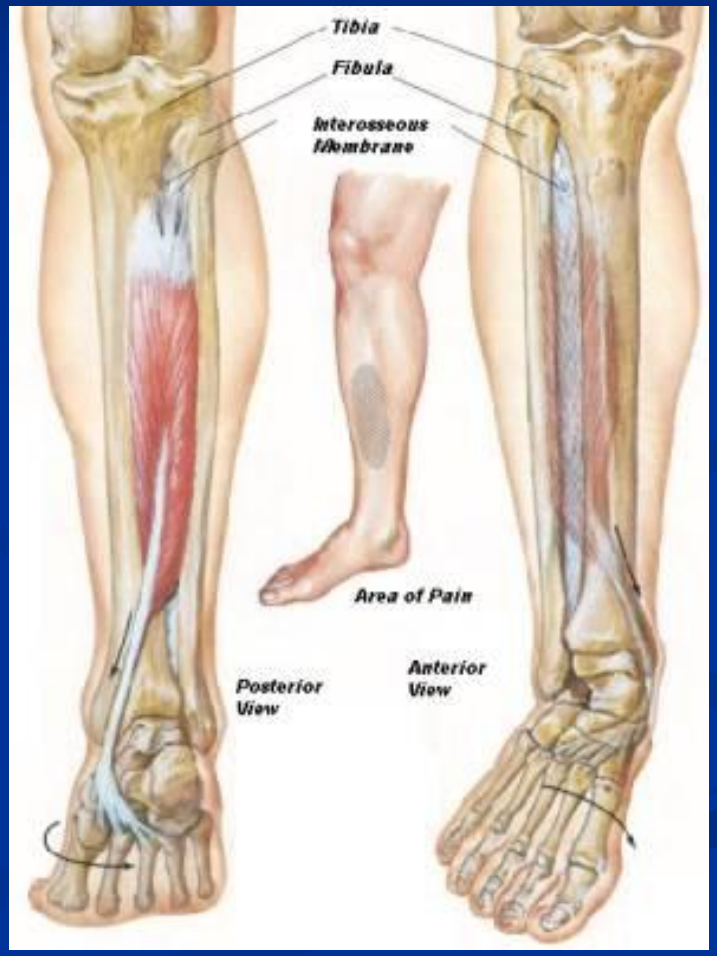
Etiology:

Stress reaction of the fascia, periosteum, or bone, or a combination of these structures at the posteromedial border of the tibia

Medial Tibial Stress Syndrome (MTSS)

History

- Pain occurs with exercise, but may become more tolerable as exercise continues
- May be bilateral
- Look for overuse risk factors



Medial Tibial Stress Syndrome (MTSS)

Examination

- TTP along the posteromedial border of the tibia
- Resisted muscle testing usually does not cause pain
- Pain with single leg hop
- No pain with indirect percussion (heel strike)
- Check for malalignment (esp. pronation), inflexibility, weakness

Medial Tibial Stress Syndrome ("Shin Splints")

- Early reports: the tibialis posterior was the primary structure involved (Slocum 1967, D'Ambrosia 1977).
- Studies using bone scans and anatomic dissection provided evidence that the soleus and its fascia play a direct role. (Holder and Michael 1984, Michael and Holder 1985)
- Anatomic study confirmed that the fibers of the soleus, the flexor digitorum longus, and the deep crural fascia attach along the posteromedial border of the tibia, where sx, exam findings and bone scans have localized the injury. (Beck 1994)
- MR imaging found that of those with MTSS, had edema at the insertions of the soleus, flexor digitorum longus and the tibialis posterior.(Frederickson 1995)

Medial Tibial Stress Syndrome (MTSS)

Imaging

- Usually not necessary
- Radiographs usually normal
- MRI - periosteal edema with associated marrow edema

Medial Tibial Stress Syndrome (MTSS)

Management

- Sport-specific relative rest from impact loading
- Ice massage
- **Long pneumatic splint**
- Maintain conditioning via non-impact activities (cycling, pool running, swimming)
- Soft tissue therapy

Medial Tibial Stress Syndrome (MTSS)

Management

- Consider NSAID's
- Rehab to increase strength and flexibility (force dissipation)
- Consider modification of malalignment
- Calcium and Vit D supplementation
- Evaluate for menstrual dysfunction and/or eating disorders in women

Medial Tibial Stress Syndrome (MTSS)

- **Should patients with MTSS be prescribed orthotic devices to correct malalignment of the foot and ankle?**
  - There is limited prospective evidence that lower extremity malalignment plays a causal role in the development of MTSS.
    - Greater knee tubercle sulcus angle and knee varus may be risks for "shin injury" in runners. (n=90; Wen et al 1998)
    - Royal Australian Navy Recruit School (n= 306; Bonanno et al 2018 BJSM) – 34% reduction in lower ext overuse injuries using OTC insole.
  - Modification of malalignment with orthoses should not be a routine recommendation.
  - Consider on an individual basis.

Medial Tibial Stress Syndrome (MTSS)

Return to Play

- Gradual return to impact activities
- Use symptoms and findings as guide to progression
- Long pneumatic splint may accelerate return

Medial Tibial Stress Syndrome (MTSS)

Prevent Recurrence

- Review causal factors with patient, parent, coach, trainer
- Develop specific plan to avoid re-injury
  - Training
  - Competition schedule
  - Recovery
  - Nutrition
  - Footwear

Medial Tibial Stress Syndrome (MTSS)

Surgical Intervention – Rarely indicated

- Refractory cases may benefit from posteromedial fasciotomy with release of soleus fascial bridge

Bone Stress Injuries

- Etiology: inability of bone to effectively remodel in response to repetitive loading

- Tibia and fibula are among the most common sites for stress fractures
- Tibia 19-55% of all sites
  (Bennel and Bruckner 1997)
- Fibula up to 30%

Tibial BSI

History

- Typically, gradual onset of pain
- Does not dissipate as activity continues
- Eventually limits training and may become painful with daily activities
- Search for risk factors for overuse injuries

Tibial BSI

Examination

- Well localized tibial tenderness
- Pain with single leg hop
- May have pain with indirect percussion
- Check for malalignment, inflexibility, weakness

Tibial BSI

Imaging

- Radiographs- periosteal reaction or lucent fracture line, but often negative initially
- Three phase bone scan- localized uptake in delayed phase, all phases abnormal
- MRI - more specific than bone scan; graded on presence of periosteal edema, marrow edema, fracture line

Magnetic Resonance Imaging Grading of Tibial Stress Injuries

Grade	MR Findings			Clinical Correlation
	Periosteal Edema	Marrow Edema	Fracture Line	
1	Mild to moderate on T2-weighted images	None	None	Stress reaction
2	Moderate to severe on T2-weighted images	Seen on T2-weighted images	None	Stress reaction
3	Moderate to severe on T2-weighted images	Seen on T1 and T2-weighted images	None	Stress reaction
4	Moderate to severe on T2-weighted images	Seen on T1 and T2-weighted images	Visible	Stress fracture

Frederickson. Am J Sports Med 23: 472, 1995

Tibial BSI

Management

- Initial rest from impact activity
- Long pneumatic splint or walking boot will accelerate recovery. Crutches if needed
- Acetaminophen for pain relief
- Avoid NSAIDs
- Maintain conditioning (note: stair climbers and ski machines may be painful)

Tibial BSI

Management

- Rehab to address flexibility and strength
- Consider calcium and Vit D supplement
- Address menstrual dysfunction and/or disordered eating if present
- Consider modification of malalignment

Tibial BSI

Return to Play

- Once pain with daily activities has resolved, begin brisk walking
- Can add Alter G (anti-gravity treadmill)
- Gradually increase time
- Transition to impact running
- Gradually increase duration and frequency if symptom free

Tibial BSI

Return to Play

- Begin faster pace running and sprinting when patient able to jog daily without pain
- Add sport specific skills
- Resume full training when able to perform sport specific activities without symptoms

Tibial BSI

Prevent Recurrence

- MOST IMPORTANT: Review causal factors
- Consider use of custom orthoses

Fibular BSI

- Most occur in the distal shaft
- Can occur proximally in rare instance
- History
  - Gradual onset of lateral leg pain
  - Often can "play through the pain"
  - Identify overuse risk factors

Fibular BSI

Examination

- Localized tenderness over the lateral leg
- May be difficult to palpate due to overlying musculature
- Pain with single leg hop
- Pain with indirect percussion less common
- Assess biomechanics, strength, flexibility

Fibular Stress Fractures

Return to Play

- Most recover more quickly than those with tibial stress fractures
- Some may be permitted to continue play without interruption with use of the long pneumatic splint (Dickson 1987)

Chronic Exertional Compartment Syndromes (CECS)

- Etiology:
  - Excessive increase in intracompartmental pressure during exercise, that normalizes with rest.
  - Pressure increase: ⇧ muscle volume with exercise, and ⇧ extracellular fluid.
  - ? Inhibit muscle perfusion
- Most common sites are anterior and deep posterior compartments

Chronic Exertional Compartment Syndromes (CECS)

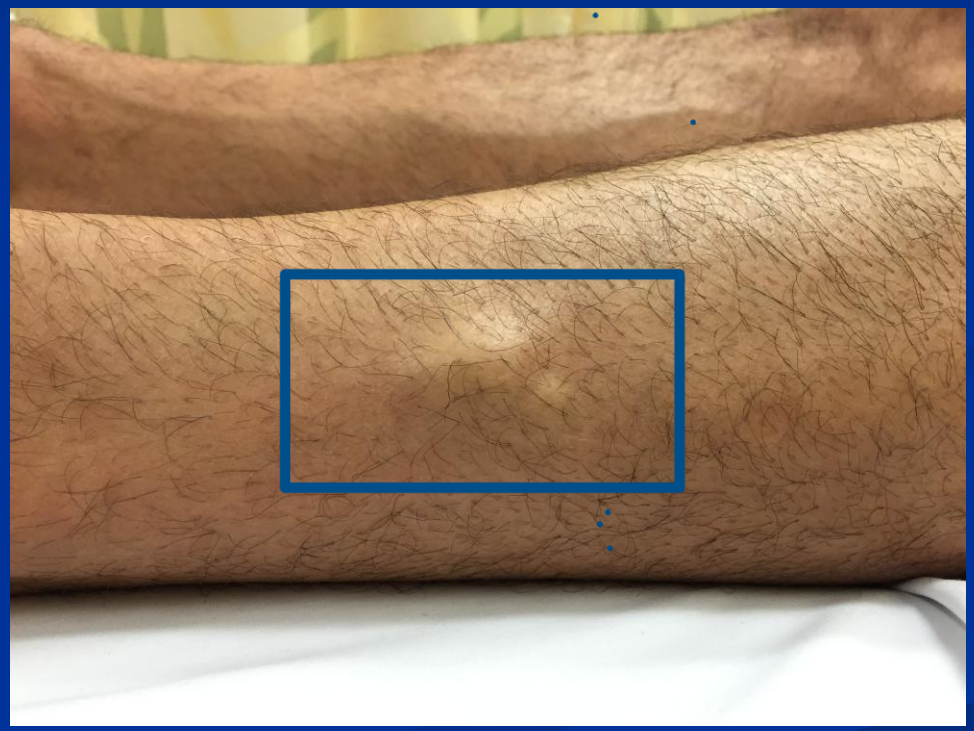
History

- Aching or cramping leg pain or leg tightness over affected compartment, only with exercise
- Transient neurologic symptoms may occur, but pain is often only symptom
- Pain gradually subsides with rest
- Symptoms may be very reproducible (e.g. running a certain distance)

Chronic Exertional Compartment Syndromes (CECS)

Examination

- Usually normal
- Can be helpful to examine after symptoms provoked
- May find palpable tightness over compartment
- Passive stretching may reproduce symptoms
- Pulses are normal
- If present, a palpable fascial hernia is highly suggestive of CECS



Anatomy

Anterior Compartment-

Muscles:

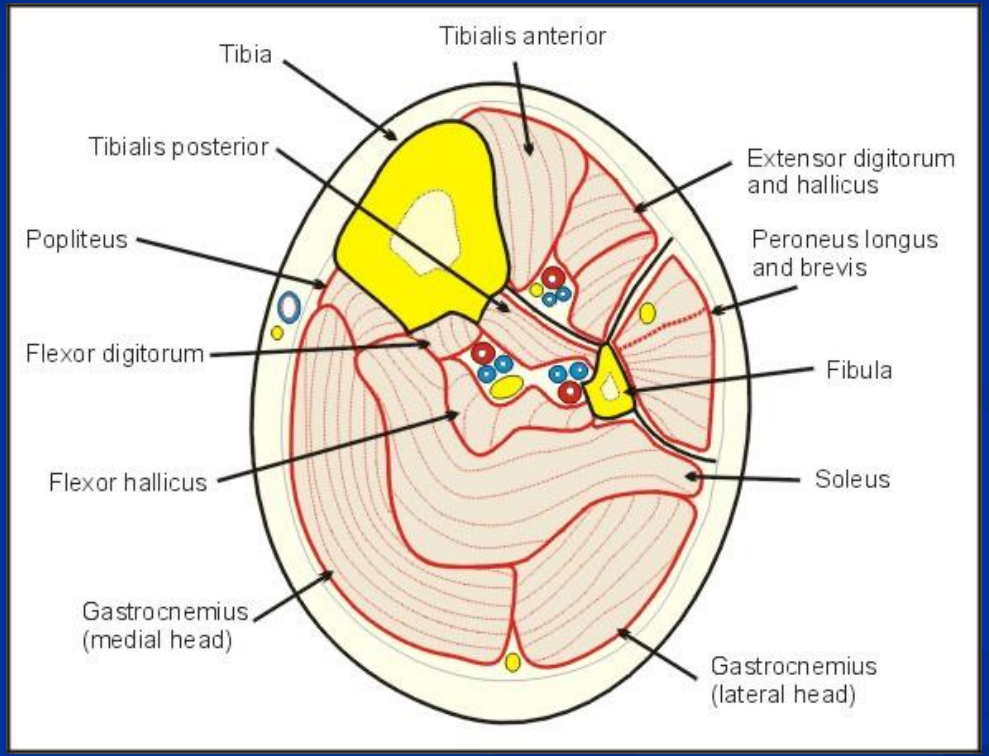
- tibialis anterior
- extensor hallucis longus
- extensor digitorum

Blood supply:

- anterior tibial artery

Innervation:

- deep peroneal nerve



Posterior Compartment- Anatomy

Superficial Muscles:

gastrocnemius,
soleus, plantaris

Deep muscles:

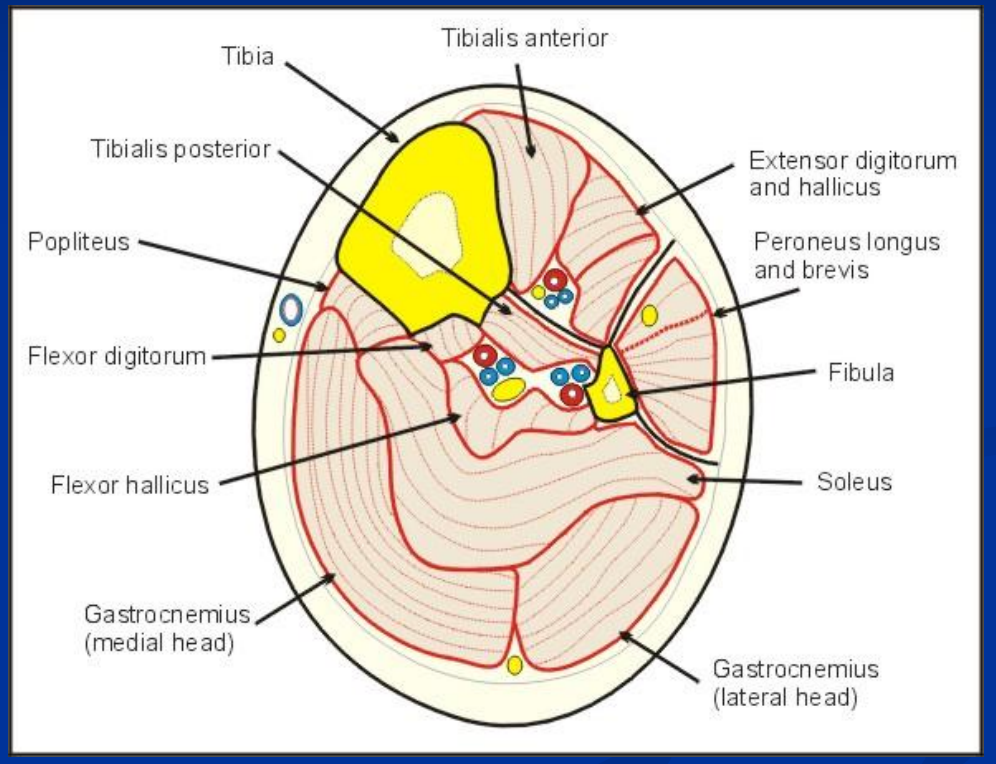
popliteus

tibialis posterior
flexor digitorum longus
flexor hallucis longus

Blood supply:

posterior tibial artery
peroneal artery

Innervation: tibial nerve

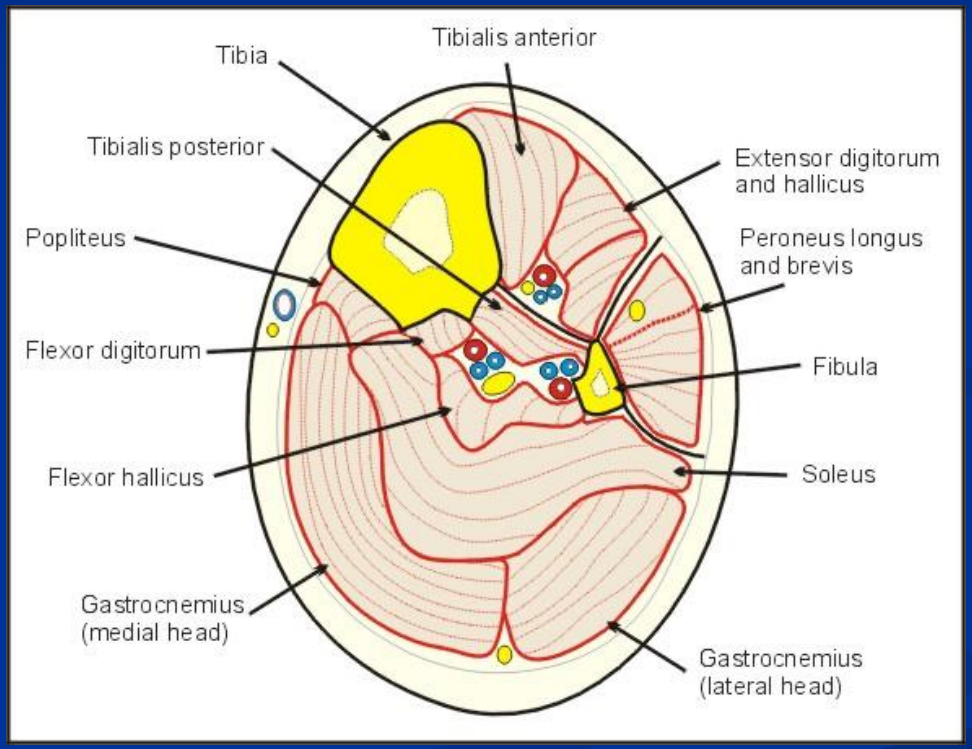


Lateral Compartment- Anatomy

Muscles:
peroneus longus and brevis

Blood supply:
peroneal artery

Innervation:
superficial peroneal nerve



Chronic Exertional Compartment Syndromes (CECS)

Diagnostic Studies

- Radiographs are normal
- Bone scans and MR imaging: may be helpful to rule out other causes of leg pain (stress fractures, MTSS, tumors)

Chronic Exertional Compartment Syndromes (CECS)

Diagnostic Studies

- Intracompartmental pressure measurement is study of choice
  - Diagnostic criteria (Pedowitz, 1990)- one or more findings is diagnostic
    - Resting Pressure 15 ≥ mm
    - 1 minute post exercise 30 ≥ mm
    - 5 minute post exercise 20 ≥ mm

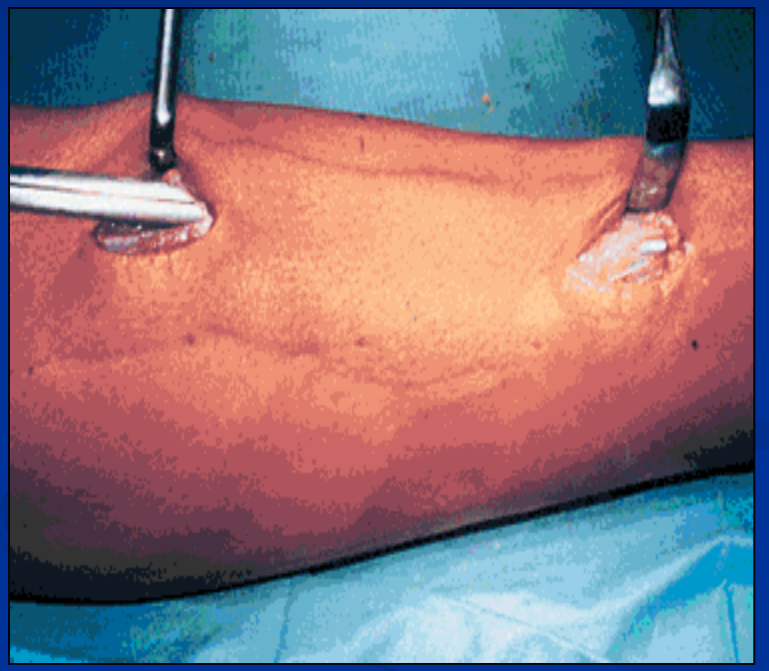
Chronic Exertional Compartment Syndromes (CECS)

Management

- Assess any factors which may have led to the injury
- Reduction in level of exercise
- Symptoms commonly recur with resumption of prior level of activity
- A pilot study of flexibility training and massage therapy showed limited benefit in symptom improvement and did not alter post-exercise compartment pressure measures. (Blackman 2000)

CECS Surgical Indications

- If symptoms recur upon return to activity and the patient does not wish to limit activity, surgery should be considered
- Surgical decompression is 90% successful for CECS of anterior compartment (Schepsis 1993)
- Of 62 patients treated for CECS, 81% (26 of 32) of those with anterior or lateral compartment involvement had significant improvement compared to 50% of those with deep compartment involvement (3 of 6). (Turnipseed 2002)



Approach to Leg Pain

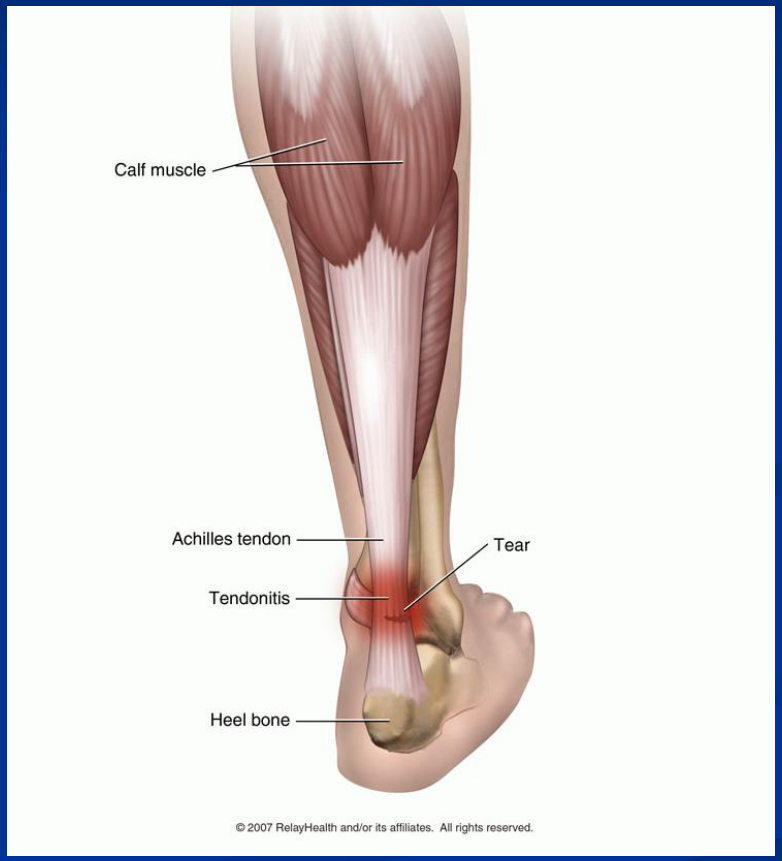
	Stress Fracture	MTSS (Shin Splints)	CECS
Onset	gradual or acute	gradual	gradual
Pain Character	Increases with ongoing activity	Soon after exercise onset, intensity decreases	Pain onset at specific point during running
Exam	Focal TTP	TTP Several cm along posteromedial tibia	May be difficult to localize
Xray **Bone Scan** **MRI**	Often Neg Focal uptake Focal edema, fx line	Neg Diffuse uptake Diffuse edema	Compartment pressure testing
Treatment	REST from impact activity! Protection. Gradual return to activity.	REST from impact activity! Protection. Gradual return to activity.	May require fasciotomy

Achilles Tendonopathy

- Gradual onset
- Pain at onset of run, frequently dissipates during the run
- Sx may be present after sitting or upon awakening in AM

Achilles Tendonopathy

- Typically involves mid-substance
- Can be insertional (at calcaneous)



Tendonopathy not Tendonitis

- Not an inflammatory process.
- Degenerative changes occur.
- Microscopic analysis of chronic tendon injury:
  - Abnormal vascular ingrowth
  - Loss of collagen continuity
  - Increase in fibroblasts
  - No inflammatory cells.

Khan et al. Phys Sportsmed 2000, 28(5).

Exam

- TTP at Achilles
- Palpable tendon thickening
- May feel boggy
- No palpable defects/tears

Thompson's test is negative for Achilles rupture

Imaging

- Usually not needed
- US or MRI can be used if necessary
- US study of choice when imaging desired to guide interventional treatment
  - Fusiform tendon thickening
  - Interstitial (chronic) tears
  - Microcalcification
  - Neovascularization

Treatment

- Ice
- Relative rest – cycling, swimming
- Inspect footwear
- Physical therapy – heel raises, progressive eccentric loading

Treatment- Additional Options

- Topical NTG
  - Mx: NO stimulated increase in collagen synthesis
- Extracorporal Shock Wave Therapy
- Percutaneous US guided needle tenotomy
- US guided sclerosis of neovessels
- Platelet rich plasma
- Autologous blood injection
- Surgical debridement

Acute Exertional Compartment Syndrome

Etiology

- Prolonged and irreversible tissue pressure elevation within the fascial compartment.
- Without rapid decompression , nerve and muscle capillary perfusion is compromised, leading to muscle necrosis, with or without permanent neurologic damage

Acute Exertional Compartment Syndrome

Symptoms

- Severe pain over the involved compartment that develops either during exercise or within several hours following the activity.
- The pain is not relieved with rest.
- Often occurs in an unconditioned individual who performs a large amount of exercise.
- Although not typical, a preceding history of symptoms consistent with CECS has been reported.

Acute Exertional Compartment Syndrome

Physical examination

- Pain out of proportion to the perceived severity of injury.
- The skin may appear shiny and feel warm.
- Paresthesias
- Palpable tension or firmness over the involved compartment.
- Passive muscle stretching increases pain.
- Muscle weakness.
- Pulses are often present. If absent, severe ischemia and/or arterial injury has occurred.

Acute Exertional Compartment Syndrome

Special studies

- AECS is largely a clinical diagnosis.
- Intracompartmental tissue pressure measurements can aid in making the diagnosis, however false positives and negatives do occur.
- Pressure measurements ranging from 30-45mm Hg have been proposed as indications for fasciotomy.
- Because a critical factor in the development of muscle ischemia is the difference between the mean arterial and compartment pressures, intracompartmental tissue pressure measurements should be interpreted in the context of the patient's systemic pressure.

Acute Exertional Compartment Syndrome

Treatment

- Fasciotomy is the definitive treatment for AECS.
- Immediate referral to an orthopaedic surgeon
- All constrictive materials (clothing, splints, dressings, casts, walking boots) should be removed.
- Ice should not be used - it may interfere with the microcirculation.
- Place leg at the level of the heart.
- Early intervention improves outcomes and reduces complications (renal failure from myoglobinuria, arrhythmias, amputation, or death).
- 68% who had fasciotomy within 12 hours after the onset of symtpoms regained extremity function vs. 8% who receive fasciotomy beyond 12 hours.

Popliteal Artery Entrapment Syndrome

- PAES is rare.
- Incidence not known.
- 80% of reported cases have been in men, more than half are under 30 years of age.
- Though both legs may not be symptomatic, the syndrome is present bilaterally in 33%.
- Complications consist of occlusive disease and its complications, including limb loss.

Popliteal Artery Entrapment Syndrome

- Intermittent posterior leg pain or cramping with exercise.
- Paresthesias, coldness, and pallor of the foot may occur.
- Symptoms may develop with walking, but not running.
- Acute occlusion of the artery can cause sudden symptom onset.
- The symptoms may be unilateral, even when both legs are affected.
- The symptoms typically improve with rest.

Popliteal Artery Entrapment Syndrome

- Two types of PAES have been described: anatomic and functional.
- Anatomic or classical PAES
  - Abnormal anatomic relationship of the popliteal artery and the medial head of the gastrocnemius.
  - The Heidelberg classification has three categories:
    - Type I - abnormal course of the popliteal artery - it runs medial to the medial head of the gastrocnemius
    - Type II - abnormal muscular insertion causing compression of a normally situated artery
    - Type III - a combination of Types I and II.

Popliteal Artery Entrapment Syndrome

- "Functional" PAES -described by Rignault as claudication symptoms that occur with an anatomically normal popliteal artery and gastrocnemius.
  - Muscular hypertrophy results in lateral deviation of the popliteal artery and nerve with plantarflexion causing compression against the lateral condyle of the femur

Popliteal Artery Entrapment Syndrome

Physical Examination

- Exam may be normal. Be sure to examine both legs even if only one is sympotmatic.
- Obliteration of the dorsalis pedis pulse with resisted plantarflexion or passive dorsiflexion suggests PAES, but can be observed in normal individuals.
- A popliteal aneurysm or bruit may be present.

Popliteal Artery Entrapment Syndrome

Diagnostic Tests

- Doppler studies normal unless occlusion is present.
- Duplex-scan with pulsed-Doppler and DF and PF may reveal an abnormal popliteal artery course or abnormal spacing between the artery and vein due to an interposing structure..
- MRI and MR angiography have recently been reported to be useful in the diagnosis of PAES.

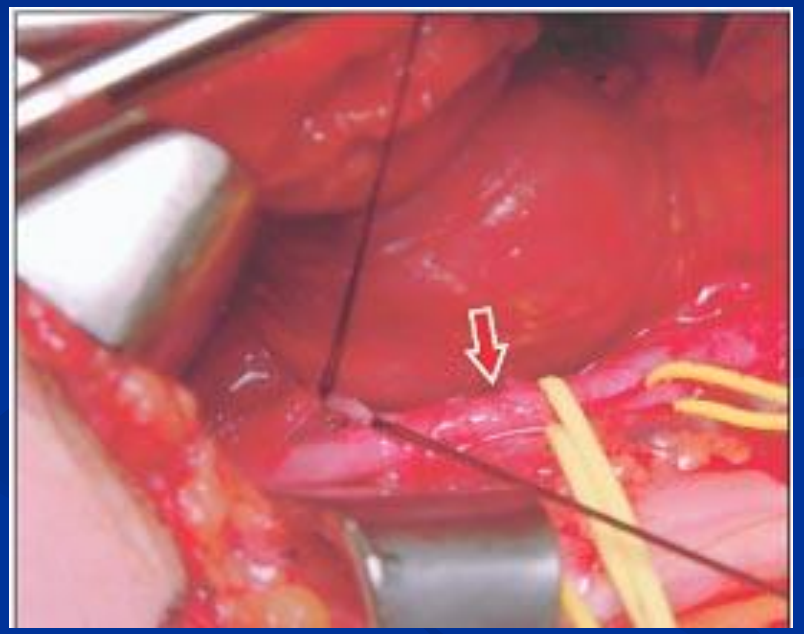
Popliteal Artery Entrapment Syndrome

Treatment

- Surgical release is the most common procedure.
- Thromboendarterectomy and/or grafting procedures are also performed if necessary.
- Complications include graft occlusion and recurrent ischemia.

Popliteal Artery Entrapment Syndrome

- For functional PAES, release of the soleus muscle from its tibial insertions with resection of its fascial band and the plantaris muscle has been described.
- Long term outcome data is limited: Hoelting and colleagues reviewed 19 patients (23 limbs) who had surgery for classic PAES. 16 of the 23 extremities were free of complications an average of 9.5 years post-operative.



Superficial Peroneal Nerve Entrapment

- An uncommon cause of of anterolateral leg pain.
- Among 480 patients studied with chronic leg pain, 3.5% were found to have this syndrome. (Styf and Moberg 1997)

Superficial Peroneal Nerve Entrapment

- Entrapment usually occurs as the nerve emerges from the deep fascia in the lower one third of the leg.
- It then divides into two subcutaneous sensory branches that supply the dorsum of the foot.
- May develop due to :
  - Previous trauma
  - Inversion ankle injuries
  - Muscle herniation through a fascial defect
  - An abnormal course of the nerve
  - A post-operative complication of surgery for chronic anterior compartment syndrome

Superficial Peroneal Nerve Entrapment

- Symptoms
  - Anterolateral leg pain
  - Pain symptoms may include the dorsum of the foot
  - Loss of sensation of the dorsum of the foot may also occur
  - Typically chronic since a delay in diagnosis of months to years is common

Superficial Peroneal Nerve Entrapment

- Styf has described three provocation tests:
  - Pressure applied 8-10 cm above the lateral malleolus, over the anterior intermuscular septum, during active ankle dorsiflexion.
  - Passive plantarflexion and inversion of the ankle.
  - Pressure over the course of the nerve as the ankle is plantarflexed and inverted

Superficial Peroneal Nerve Entrapment

- Radiographs of the leg are normal.
- Nerve conduction studies are also usually normal.
- Intracompartmental pressure measurements may be helpful in ruling out a chronic lateral compartment syndrome.
- A diagnostic injection of lidocaine can be performed at the painful site above the lateral malleolus.
- MR imaging may confirm the entrapment (Daghino 1997)

Superficial Peroneal Nerve Entrapment

- Surgical decompression
- A complete opening of the superficial peroneal tunnel is usually performed.
  - If the peroneal tunnel is absent, fasciectomy is performed.
  - A complete fasciotomy is needed if there is an associated chronic lateral compartment syndrome.
- The benefits are limited.
  - Styf reported 82% were satisfied with the outcome of the procedure at 26 months post-operatively.
  - However, 72% reported residual symptoms, with nearly half reporting pain with walking. Four of 17 were reported as having returned to an unlimited level of activity.