Ultrasound of Lower Extremity Muscle and Ankle Ligament Injury

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Disclosures

- Consultant: Bioclinica
- Contractor: POCUS PRO
- Book Royalties: Elsevier
- Not relevant to this lecture

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Acute Muscle and Tendon Injury

- Direct impact: contusion, muscle belly
- Indirect (strain):
  - Musculotendinous junction
    - Especially muscles than span 2 joints
    - Hamstrings, gastrocnemius
  - Osseous avulsion

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Muscle Injury

- Strain, contusion, or tear
  - Mixed echogenicity
  - Disruption of fibers
  - Perpendicular: avoid anisotropy
- Full-thickness tear
  - Retraction
  - Use dynamic imaging

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Outline

- Quadriceps femoris
- Hamstring
- Calf musculature
- Ankle ligaments

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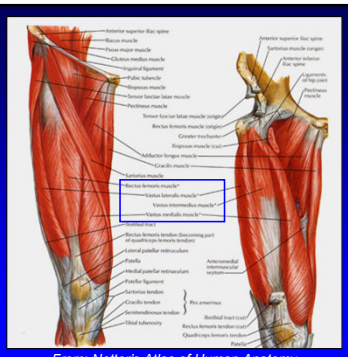
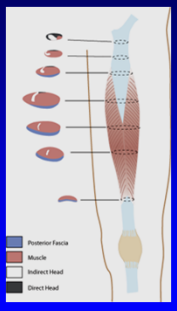


Rectus Femoris



From: Netter's Atlas of Human Anatomy

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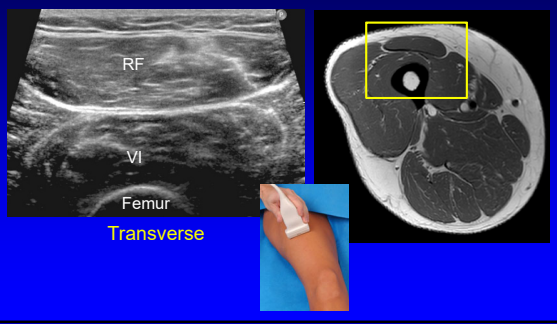
Quads: rectus femoris and vastus intermedius



Transverse

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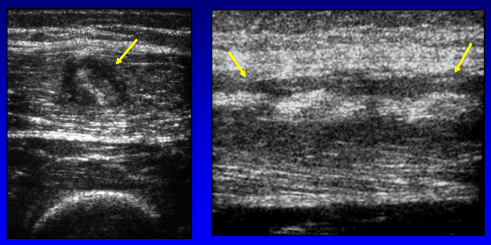
Aponeurosis Tear (Indirect Head): Rectus Femoris



Short Axis Long Axis

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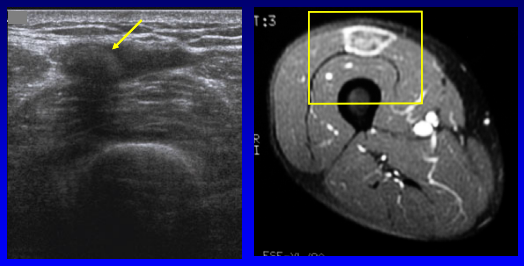
Rectus Femoris Tear: full tear, pseudomass



Short Axis Axial T1w post-gado

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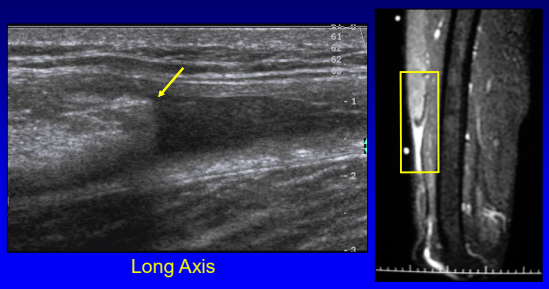
Rectus Femoris Tear: full tear, pseudomass



Long Axis

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Outline

- Quadriceps femoris
- Hamstring
- Calf musculature
- Ankle ligaments

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Sonographic Technique: Thigh

- Posterior:
  - Semimembranosus
  - Semitendinosus
  - Biceps femoris
    - Long and short heads
  - Sciatic nerve
- Transducers:
  - 10 – 12 MHz linear
  - <10 MHz curvilinear if needed

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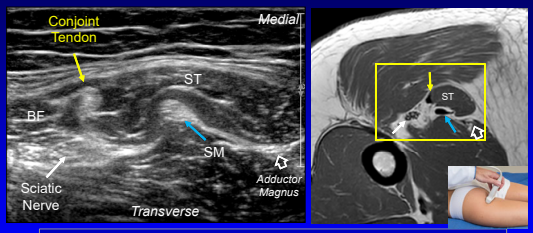
Proximal Hamstring: gluteal fold



Note: Conjoined semitendinosus (ST) and biceps femoris long head (BF) tendon (yellow arrow), semimembranosus (SM blue arrow), and sciatic nerve in a triangle configuration
Toggle transducer to eliminate anisotropy

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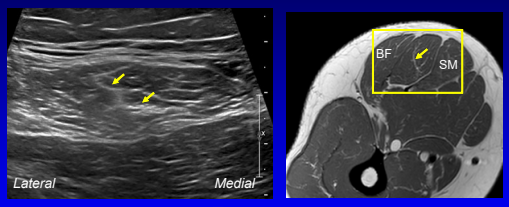
Posterior Thigh: Semitendinosus Raphe



Transverse

Note: hyperechoic raphe or veil that moves obliquely through semitendinosus muscle in proximal thigh

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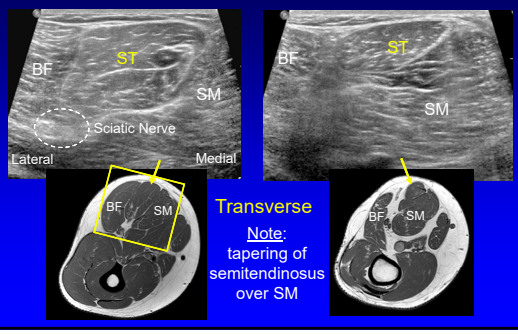
Posterior Mid Thigh: moving distal



Transverse

Note: tapering of semitendinosus over SM

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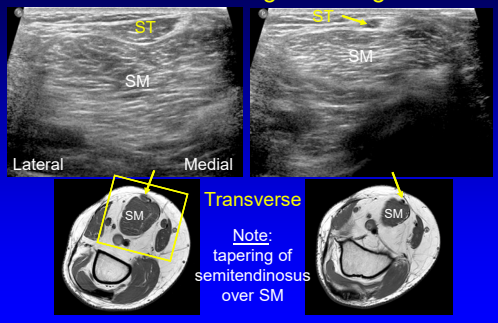
Posterior Mid Thigh: moving distal



Transverse

Note: tapering of semitendinosus over SM

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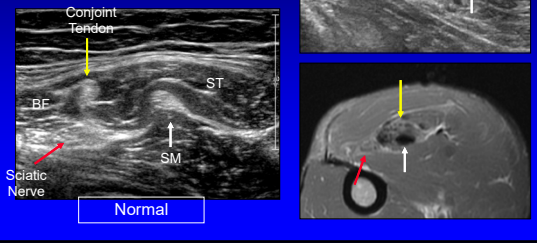
Hamstring Tear:
FTT: Conjoint
PTT: semimembranosus



Normal

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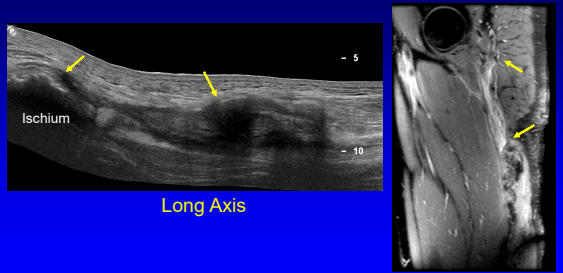
Hamstring: complete tear with retraction



Long Axis

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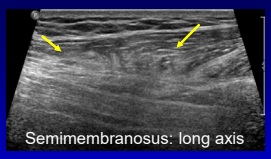
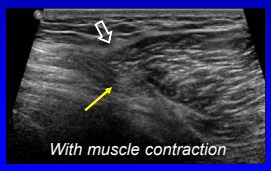
Remote Injury: Scar and Fibrosis

- Hyperechoic
- Disorganized muscle architecture
- Palpable mass with muscle contraction
- "Pseudotumor"



Semimembranosus: long axis



With muscle contraction

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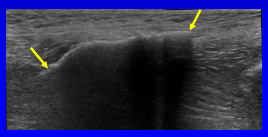
Muscle Injury: remote

- Seroma
- Scar, fibrosis, fat atrophy:
  - Hyperechoic
  - Disorganized muscle architecture
  - Palpable mass with muscle contraction
- Heterotopic ossification

Seroma



Heterotopic Ossification

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Outline

- Quadriceps femoris
- Hamstring
- Calf musculature
- Ankle ligaments

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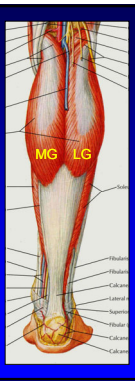
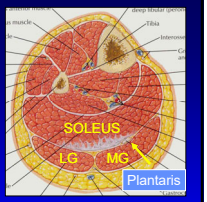
Gastrocnemius

- Medial and lateral heads
- Origin: femur
- Insertion: calcaneus combined with soleus as Achilles tendon (triceps surae)
- Broad anterior or deep distal aponeurosis
- Fast twitch Type 2 fibers crossing 2 joints: injury prone





From: Netter's Atlas of Human Anatomy

Fabella: 10 – 30% of lateral gastrocnemius tendons

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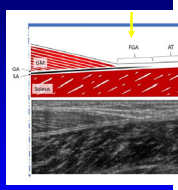
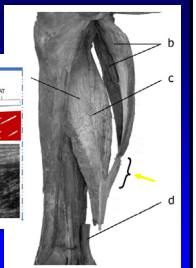
Gastrocnemius

- Aponeurosis of gastrocnemius in contact with aponeurosis of soleus but not connected proximally
- Note "free gastrocnemius aponeurosis" (FGA) (yellow arrow) between gastrocnemius muscle and junction with soleus aponeurosis forming Achilles tendon (AT)



From: Pedret C et al. Scand J Med Sci Sports 2020; 30:2456



From: Blitz NM et al. J Foot Ank Surg 2008; 47:533

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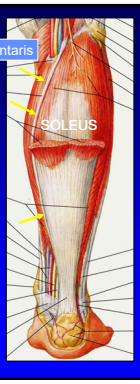
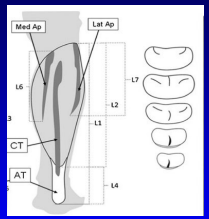
Soleus

- Origin: tibia and fibula
- Insertion: calcaneus combined with gastrocnemius as Achilles tendon
- Central tendon
- Medial and lateral intramuscular aponeurosis
- Slow twitch Type 1 fibers crossing 1 joint: more resistant to injury





From: Balius R et al. Skeletal Radiol 2013; 42:521

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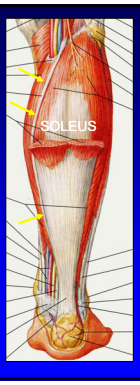
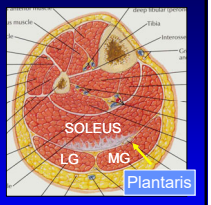
Plantaris

- Origin: lateral femur
- Insertion: calcaneus
- Absent: 6 – 8% of population
- Small proximal muscle belly
- Tendon: between medial head of gastrocnemius and soleus muscle bellies
- Medial and anterior border of Achilles tendon





From: Netter's Atlas of Human Anatomy

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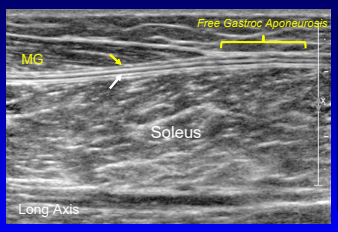
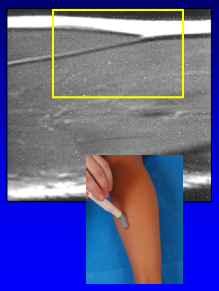
Gastrocnemius and Soleus





Yellow arrow: gastrocnemius aponeurosis
White arrow: soleus aponeurosis

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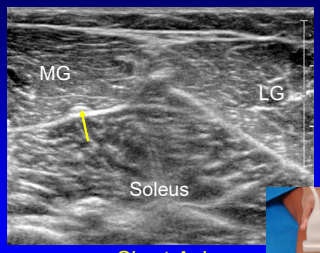
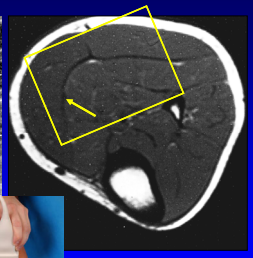
Gastrocnemius, Soleus, and Plantaris





Short Axis

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Calf: *injury*

- Medial head of gastrocnemius: "tennis leg"
  - Most common in general population
- Lateral gastrocnemius: less common
- Soleus: common in Australian rules footballers[1]
  - Especially proximal medial aponeurosis (56%)[2]
- Plantaris:
  - Isolated tear or combined with medial gastrocnemius
  - May be thickened with Achilles tendinosis[3]

[1]Waterworth G et al. Skeletal Radiol 2017; 46:343
[2]Balius R et al. Skeletal Radiol 2013; 42:521
[3]Alfredson H. Br J Sports Med 45:1023

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Imaging: soleus muscle

- Evaluation of soleus with ultrasound is limited
  - Deeper structure
- MRI more sensitive than ultrasound for minor injuries and early detection[1]
  - Edema: subjective subtle increased echogenicity on US
  - MRI may detect asymptomatic findings[2]
  - Intramuscular injury: more likely to miss play[3]

[1]Balius R et al. Skeletal Radiol 2014; 43:805
[2]Brennan JH et al. Skeletal Radiol 2020; 49:563
[3]Waterworth G et al. Skeletal Radiol 2017; 46:343

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Ultrasound: gastrocnemius injury

- Type 1: myoaponeurotic injury (no intermuscular hematoma)
- Type 2: aponeurotic injury (most common)
  - 2A: <50% width; 2B: >50% width
- Type 3: free gastrocnemius aponeurosis injury
  - Longest return to play
- Type 4: mixed type 2 and 3
- Worse prognosis: intermuscular hematoma and asynchronous gastrocnemius-soleus movement (with plantar flexion)

Pedret C et al. Scand J Med Sci Sports 2020; 30:2456

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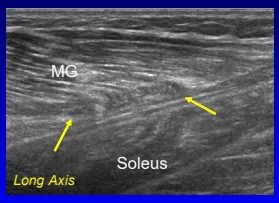
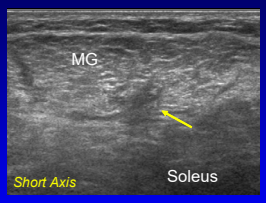
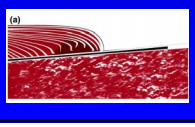
Medial Head of Gastrocnemius Tear: Type 1 Injury







Illustrations from:
Pedret C et al. Scand J Med Sci Sports 2020; 30:2456

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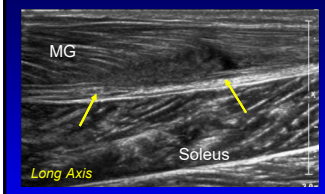
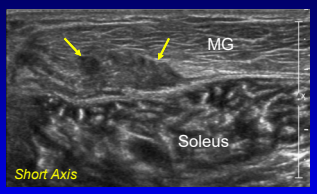
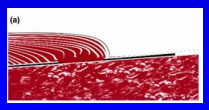
Medial Head of Gastrocnemius Tear: Type 2A Injury







Note: muscle abnormality (myoaponeurosis injury) and adjacent gastrocnemius aponeurosis discontinuity and <50% involvement (short axis)

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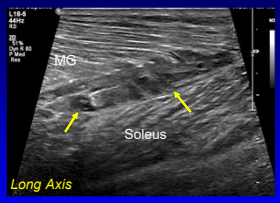
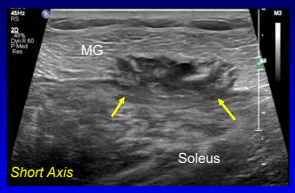
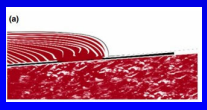
Medial Head of Gastrocnemius Tear: Type 2B Injury







Note: muscle abnormality (myoaponeurosis injury) and adjacent gastrocnemius aponeurosis discontinuity and >50% involvement (short axis)

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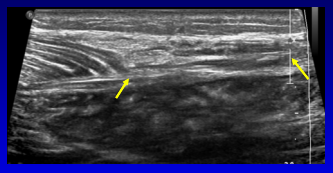
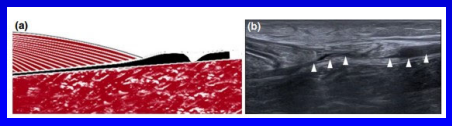
Medial Head Gastrocnemius Tear: Type 3 Injury



Note: injury to free gastrocnemius aponeurosis



From: Pedret C et al. Scand J Med Sci Sports 2020; 30:2456

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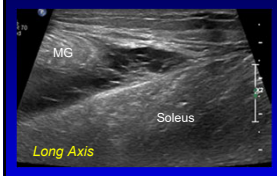
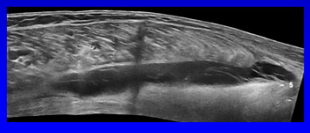
Medial Head Gastrocnemius Tear: Type 4 Injury



Note: mixed Types 2 and 3 injury



From: Pedret C et al. Scand J Med Sci Sports 2020; 30:2456

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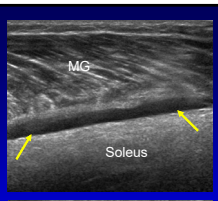
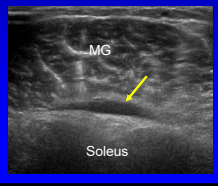
Plantaris Tendon: *tear*

- Between medial gastrocnemius & soleus muscle bellies
- Hypoechoic fluid: tubular
  - *Mid-calf level
- Plantaris tendon fiber disruption
- Normal gastrocnemius muscle and aponeurosis

Leekam RN et al. AJR 1999; 172:185





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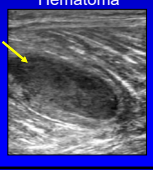
Soleus Injuries

- Ultrasound limited
- Use MRI
- Consider British Athletic Muscle Injury Classification
- Caution: intramuscular hematoma differential diagnosis includes neoplasm
- Differential for calf pain:
  - Ruptured Baker cyst
  - Deep venous thrombosis

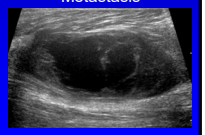
Myofascial Tear

From: Balius R et al. Skeletal Radiol 2014; 43:805

Hematoma



Metastasis



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Outline

- Quadriceps femoris
- Hamstring
- Calf musculature
- Ankle ligaments

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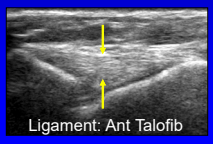
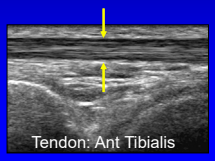
Technique: *ligaments*

- Hyperechoic
- Fibrillar echotexture
  - More compact than tendon echotexture
- Anisotropy



Ligament: Ant Talofib



Tendon: Ant Tibialis

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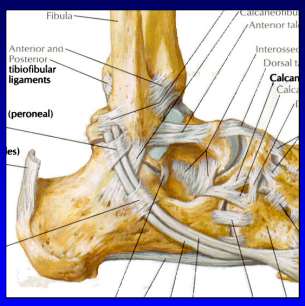
Technique: *lateral*

- Anterior talofibular
- Calcaneofibular
- Posterior talofibular
- Anterior tibiofibular
- Posterior tibiofibular



From: Netter's Atlas of Human Anatomy

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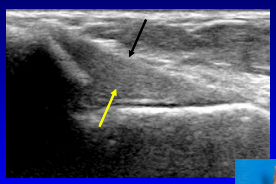
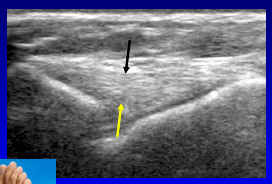
Anterior Talofibular Ligament



Anisotropy



Long Axis

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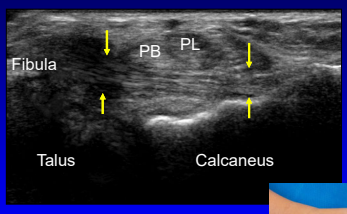
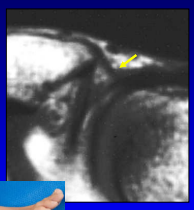
Calcaneofibular Ligament





Long Axis

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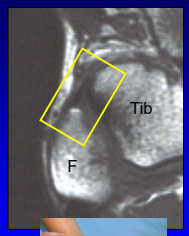
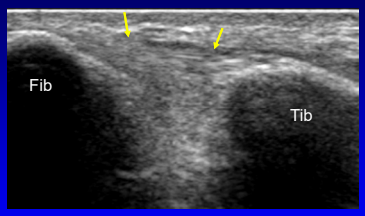
Anterior Inferior Tibiofibular Ligament





Long Axis

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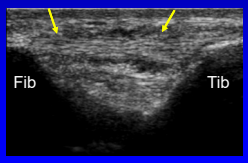
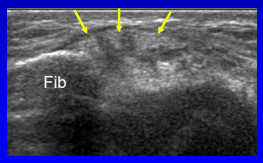
Inferior Tibiofibular Ligament

- Several bands
- Accessory inferior band (Bassett ligament)
  - Seen in 80 – 90%: more horizontal
  - Potential site of impingement





Radiology 2010; 254:827

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Trauma: *ligament*

- Lateral:
  - Anterior talofibular: isolated tear in 66%
  - Calcaneofibular
    - 20% calcaneofibular + anterior talofibular
  - Posterior talofibular: dislocation
  - Anterior tibiofibular: high ankle sprain

Helgason. Radiol Clin N Am 1998; 36:729

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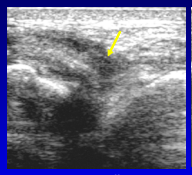
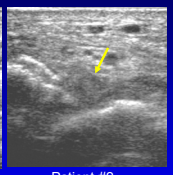
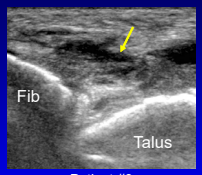
Anterior Talofibular Ligament Tear



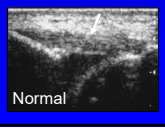
Patient #1



Patient #2



Patient #3



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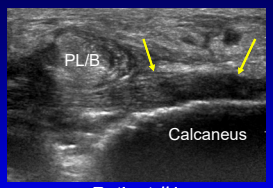
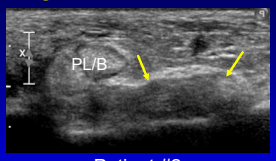
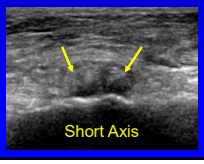
Calcaneofibular Ligament Tear



Patient #1



Patient #2



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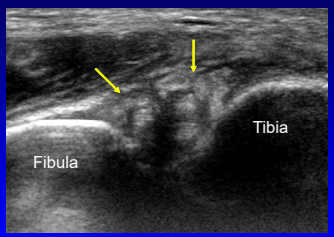
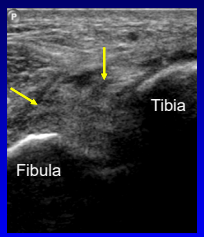
Anterior Inferior Tibiofibular Ligament Tear



Patient #1



Patient #2

Long Axis

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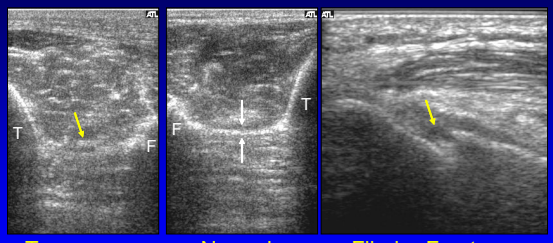
Maisonneuve Fracture



Transverse Normal Fibular Fracture

Durkee, J Ultrasound Med 2003; 22:1369

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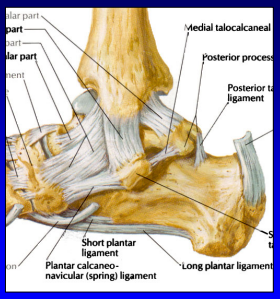
Technique: *medial*

- Deltoid Ligament:
  - Coronal:
    - Tibiocalcaneal
  - Anterior:
    - Tibionavicular
    - Anterior tibiotalar
  - Posterior:
    - Posterior tibiotalar



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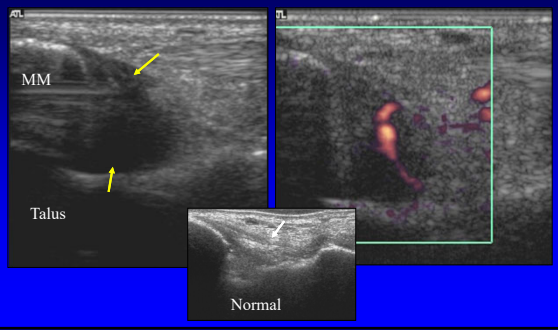
Deltoid Ligament Tear



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Take Home Points

- Rectus femoris:
  - Central aponeurosis injury
- Hamstring:
  - Complex anatomy
- Calf:
  - Medial gastrocnemius
- Ankle ligaments:
  - ATAF most common; ATIF- high ankle sprain

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Syllabus on line and other educational material:
www.jacobsonmskus.com

Twitter handle: @jjacobsn

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