

Muscle/Tendon Injuries & Non-traumatic Muscle Disease

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Disclosures:

- None

Outline

- Muscle injuries
 - Direct
 - Indirect
 - Sequelae
- Non-traumatic muscle pathologies
 - MR imaging features
 - Role of MRI

Background

- One of the **most common** sport injuries
- Can result in recurrent injury
- **<5% imaged**



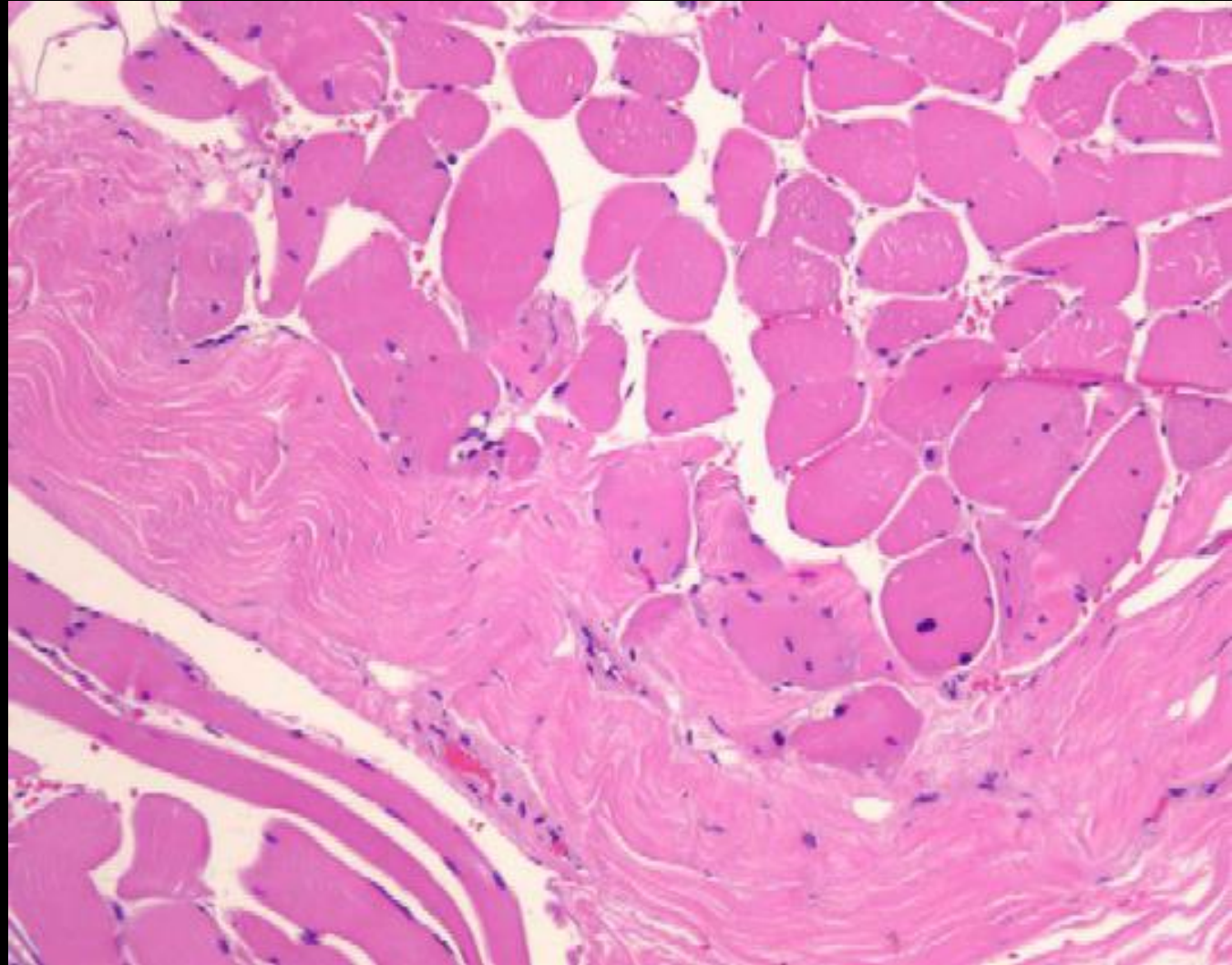
Classification of Muscle Injuries

- Indirect
 - DOMS
 - Myotendinous strains
 - Avulsion
- Direct
 - Contusions
 - Laceration
- Chronic
 - Scarring
 - Atrophy
 - Myositis ossificans
- Other
 - Muscle hernia



Muscle Strains and Avulsions

- Most common type of muscle injury
- Common sites of injury age dependent
 - Adolescents – apophyses
 - Adults – MTJ
- MTJ is the weak link



MTJ Injury – Risk Factors

- Long fusiform
- Cross 2 joints
- Muscle fiber type
 - Type I: Slow twitch
 - Slow contraction
 - Resistant to fatigue
 - Type II: Fast twitch
 - Intense activity
 - Short duration



MTJ Injury – Risk Factors

- Types of contraction
 - Isometric
 - Concentric
 - Eccentric

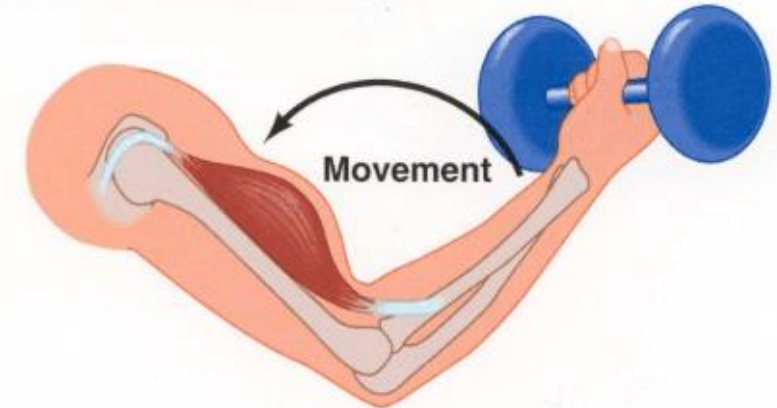
Isometric contraction

Muscle contracts
but does not shorten



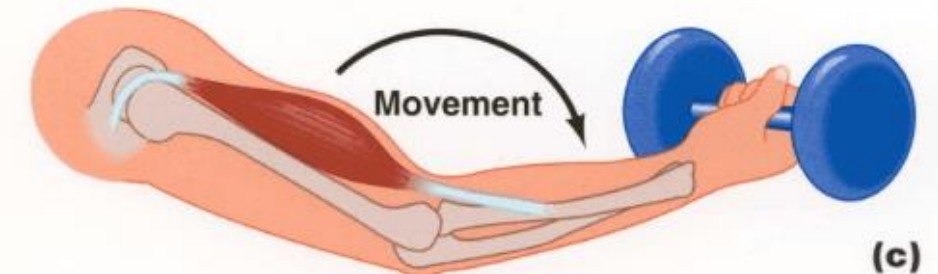
(a)

Concentric contraction



(b)

Eccentric contraction

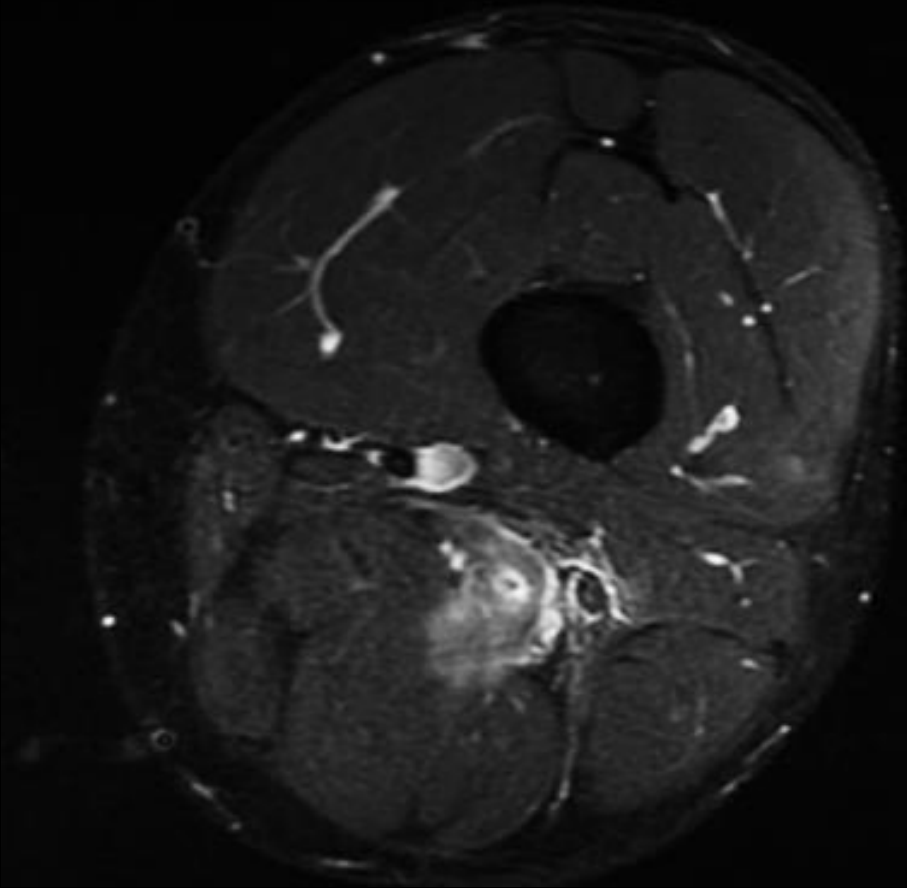


(c)

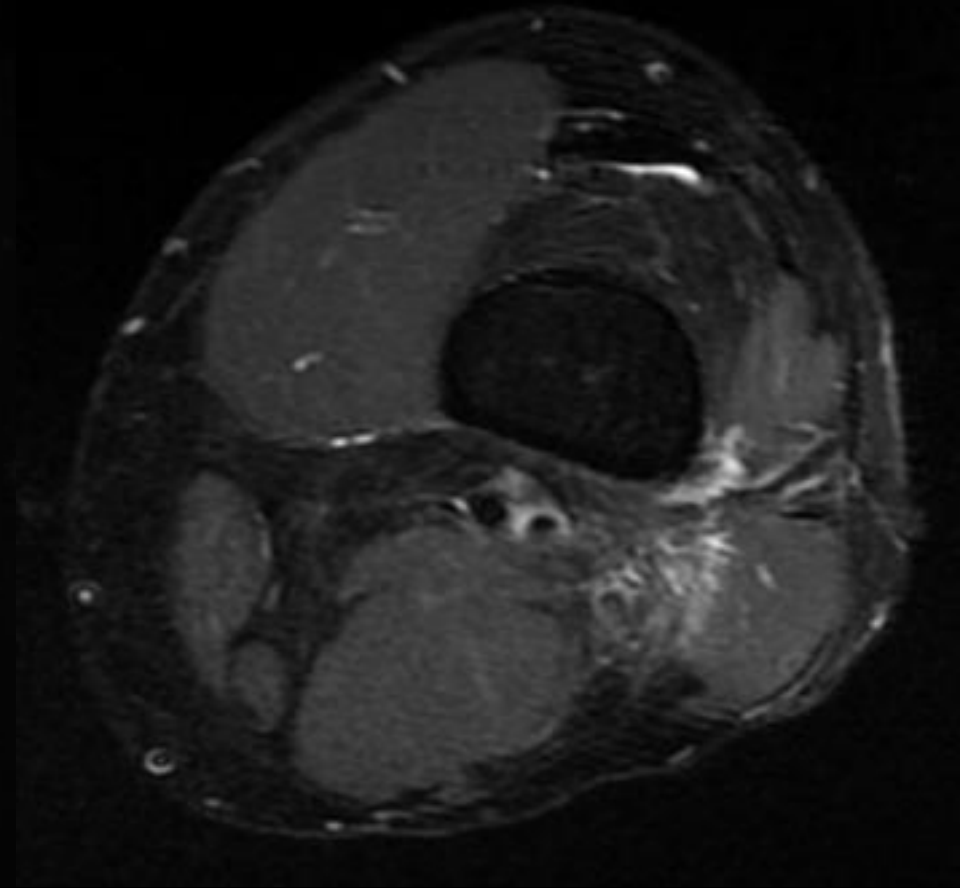
MTJ Strain

- Characteristic locations
 - Hamstrings
 - Rectus femoris
 - Gastroc-soleus complex
 - Adductors
- Immediate symptoms
 - Pain / swelling
 - Weakness
 - Loss of motion
- Clinical evaluation accurate





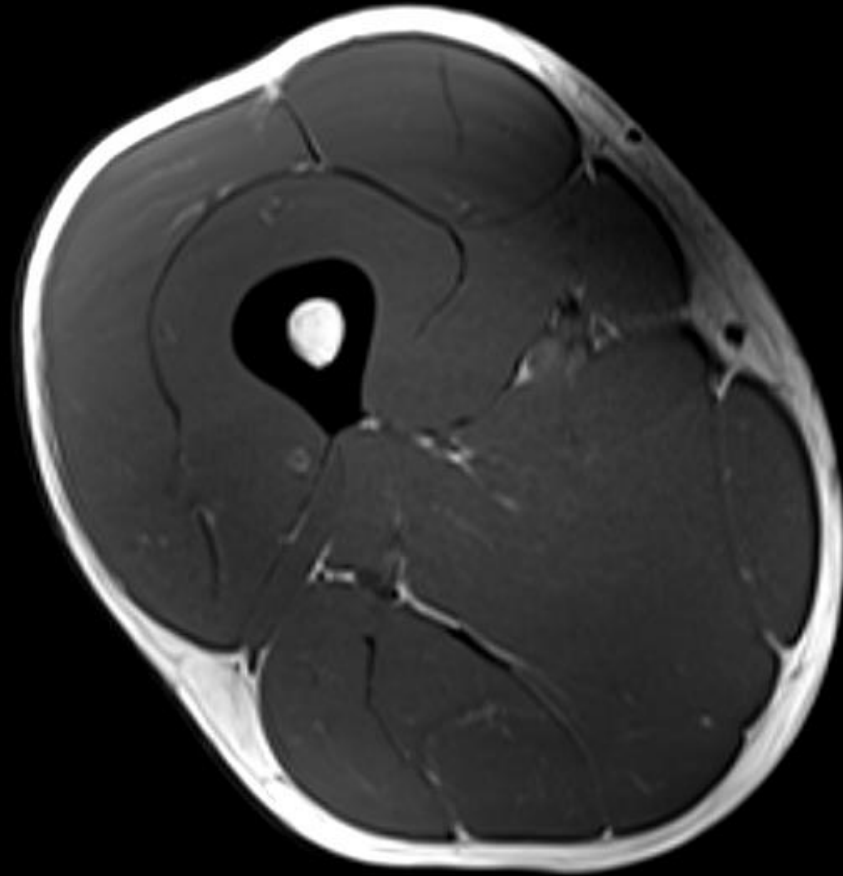
Patient #1
Semimembranosus



Patient #2
Biceps Femoris

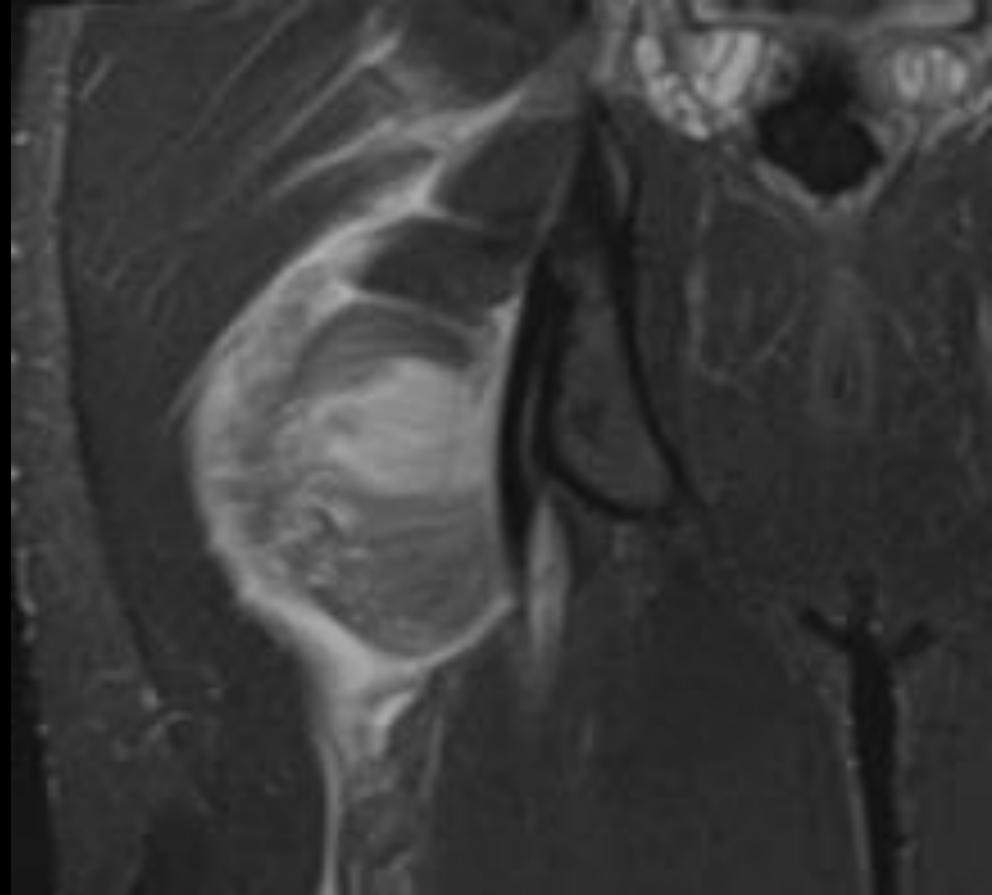
Muscle Injuries – Role of Imaging

- Elite athletes
 - Confirm diagnosis
 - Atypical features
 - Identify surgical cases
 - Assess severity
 - Assess complication
 - Prognosis



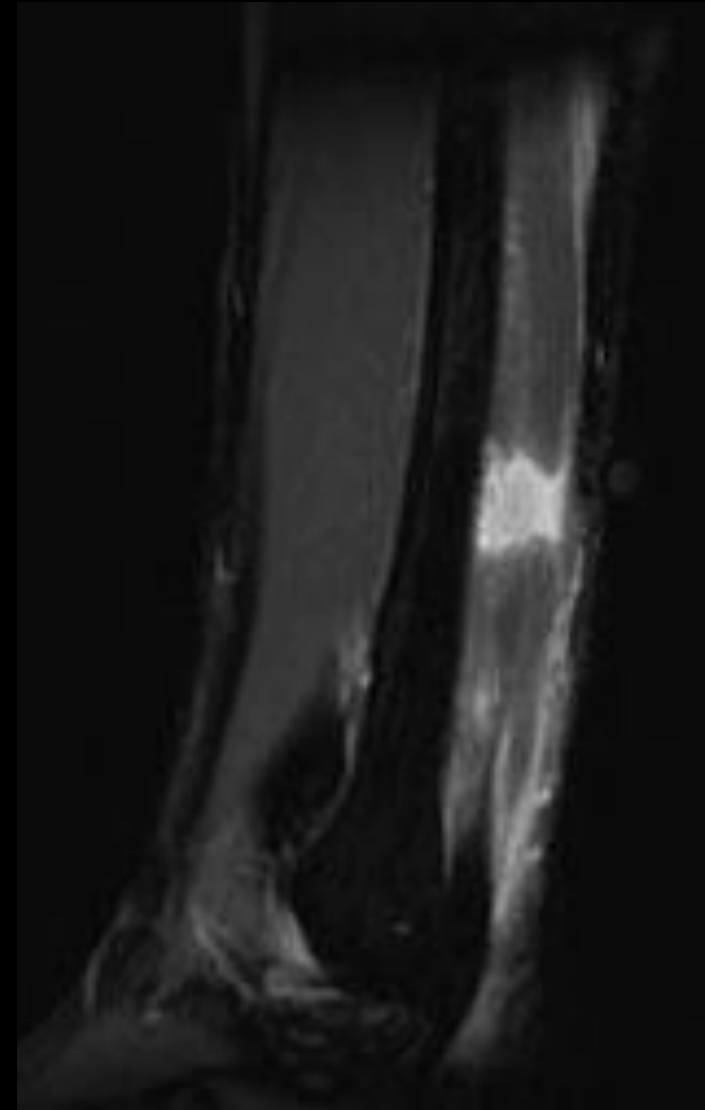
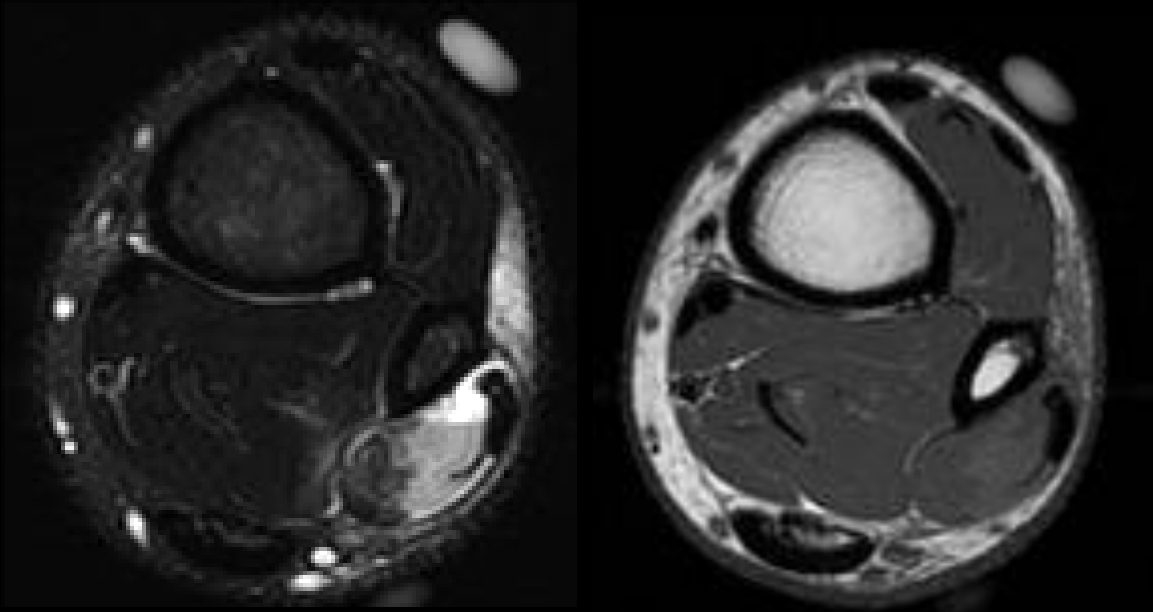
Muscle Injuries – Role of Imaging

- Confirm diagnosis
 - Atypical location
 - Atypical features
 - Periarticular



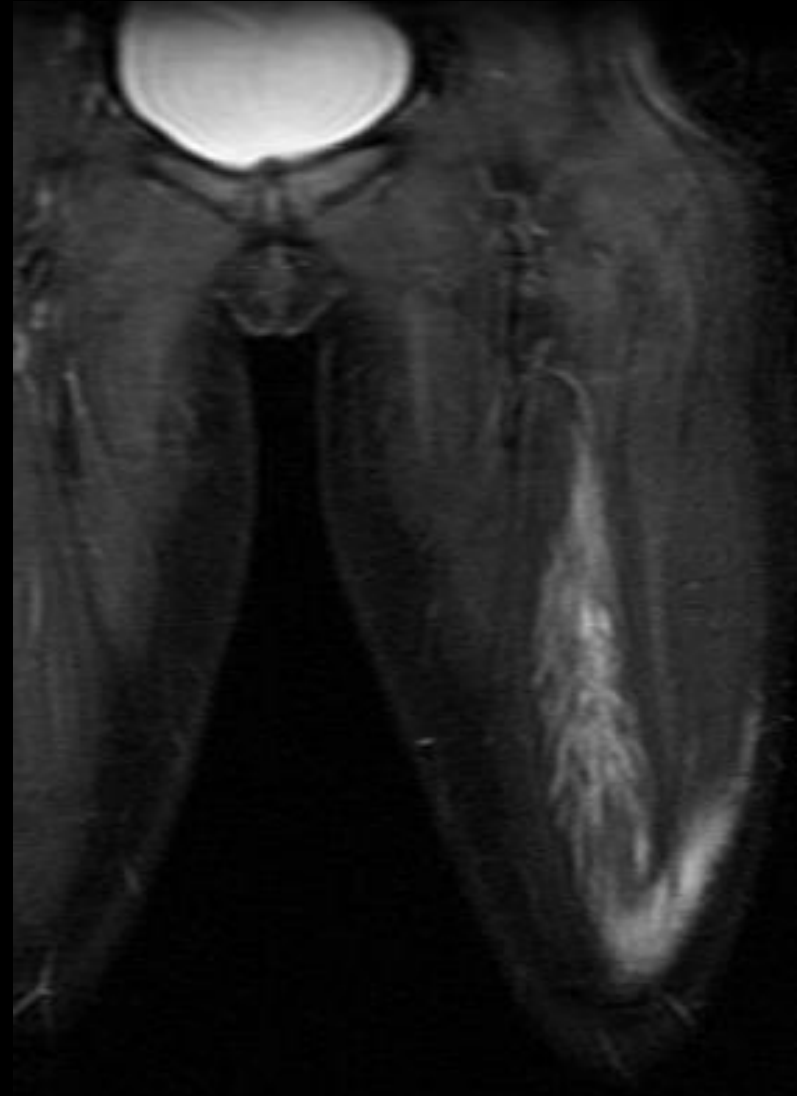
Muscle Injuries – Role of Imaging

- Identify potential surgical candidates



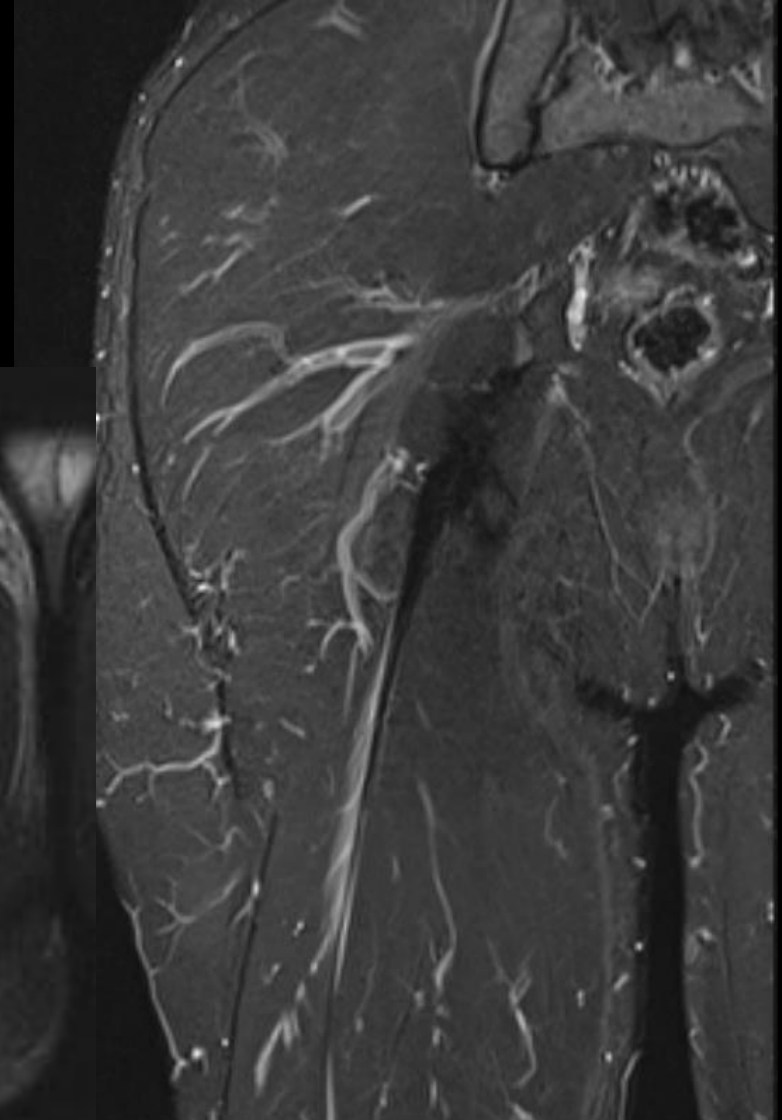
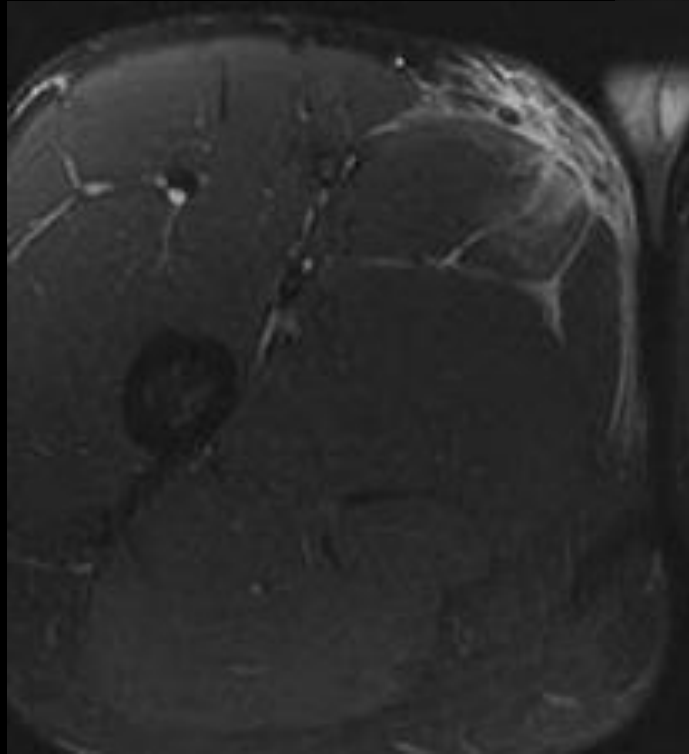
Muscle Injuries – Role of Imaging

- Assess severity
 - Grade
 - Extent



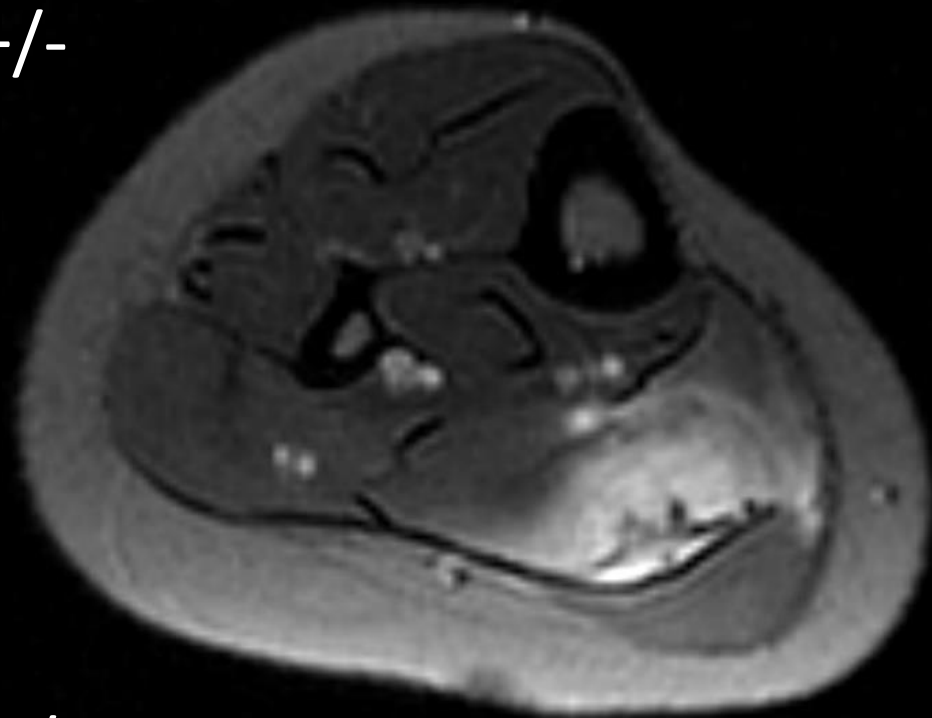
MTJ Strain – Grade I

- Microscopic tear / stretch injury of MTJ
- Pain on stretch or stress
- MRI
 - Edema
 - Feathery



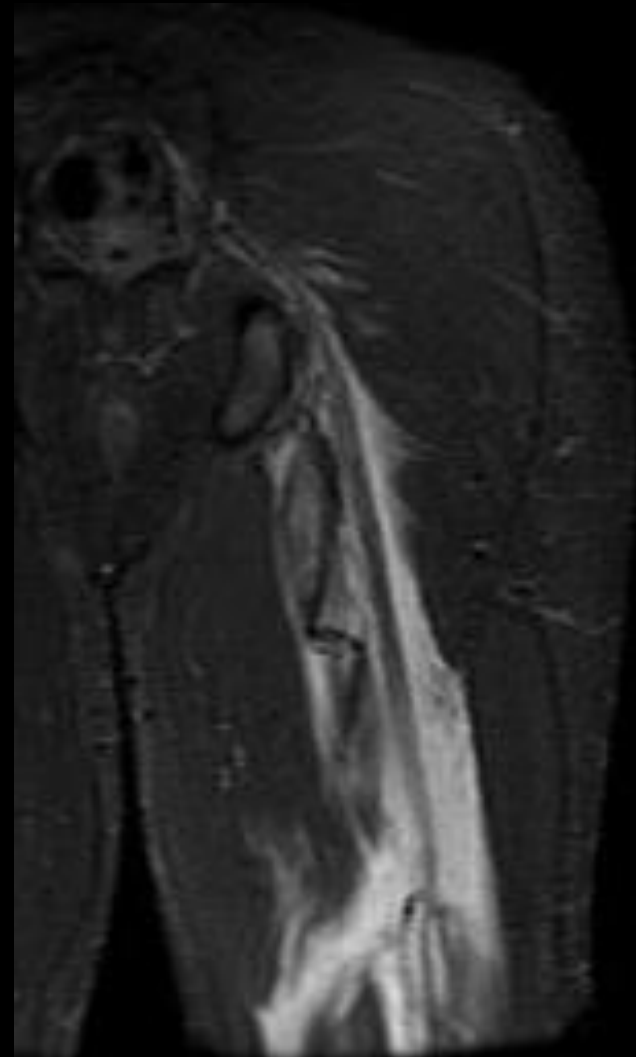
MTJ Strain – Grade II

- Grade II
 - Partial tear of MTJ +/- gap
 - Decrease strength
 - Bruising
- MRI
 - Hematoma
 - Intermuscular
 - Intramuscular
 - Partial discontinuity / laxity



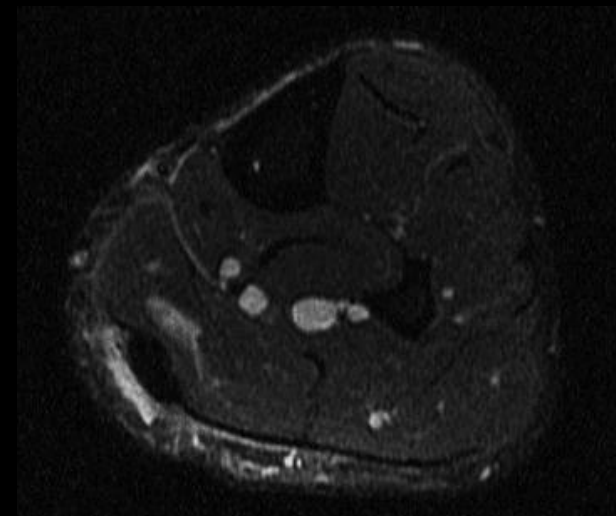
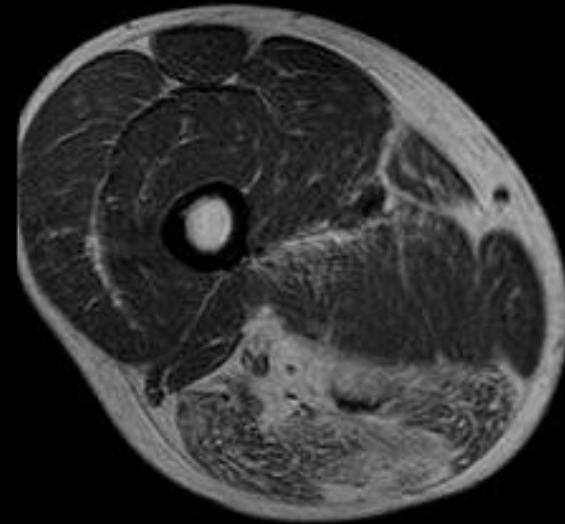
MTJ Strain – Grade III

- Complete rupture or avulsion
 - Palpable gap
 - Significant weakness and loss of motion
- MRI
 - Complete discontinuity
 - Retraction
 - Extensive haemorrhage



Muscle Injuries – Role of Imaging

- Identify complicating factors
 - Hematoma
 - Atrophy
 - Scar



Assessing Prognosis

1. Time to return to play
2. Risk of recurrence

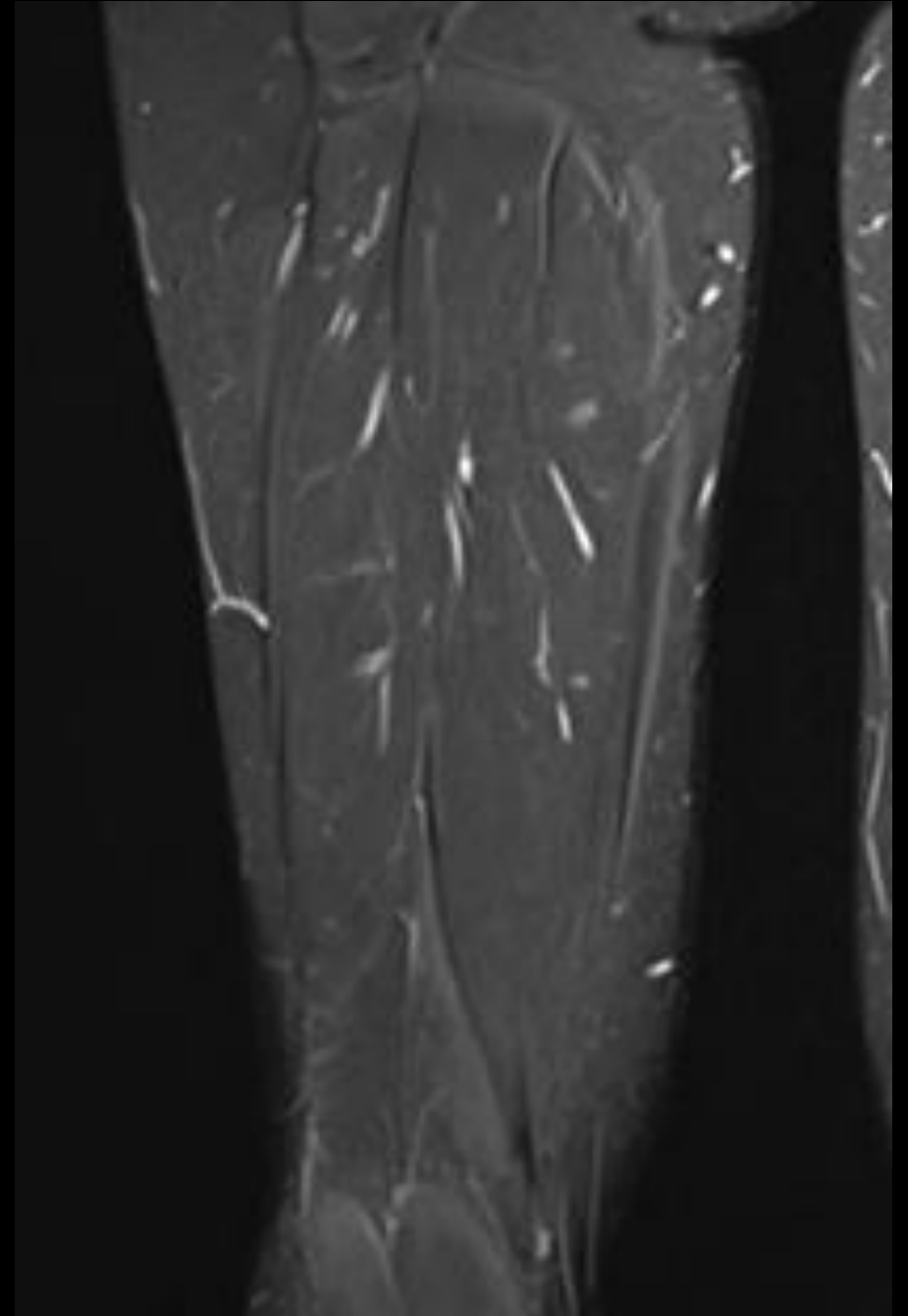
- Multifactorial:
 - Muscle
 - Conditioning
 - Injury pattern
 - Specific sports



Prognostic Factors

Time to Return to Play

- Abnormal vs normal MRI:
 - Normal MRI < 1 wk
 - Nerve irritation



Prognostic Factors

Time to Return to Play

- Grade:

- Hamstrings in soccer
 - Grade 1: 2.5 wks
 - Grade 2: >3.5 wks
 - Grade 3: 10 wks
- Hamstrings in hockey
 - Grade 1: 2 weeks
 - Grade 2: 6 weeks
 - Grade 3: 10 weeks

- NFL:

- Grade 1: No missed games

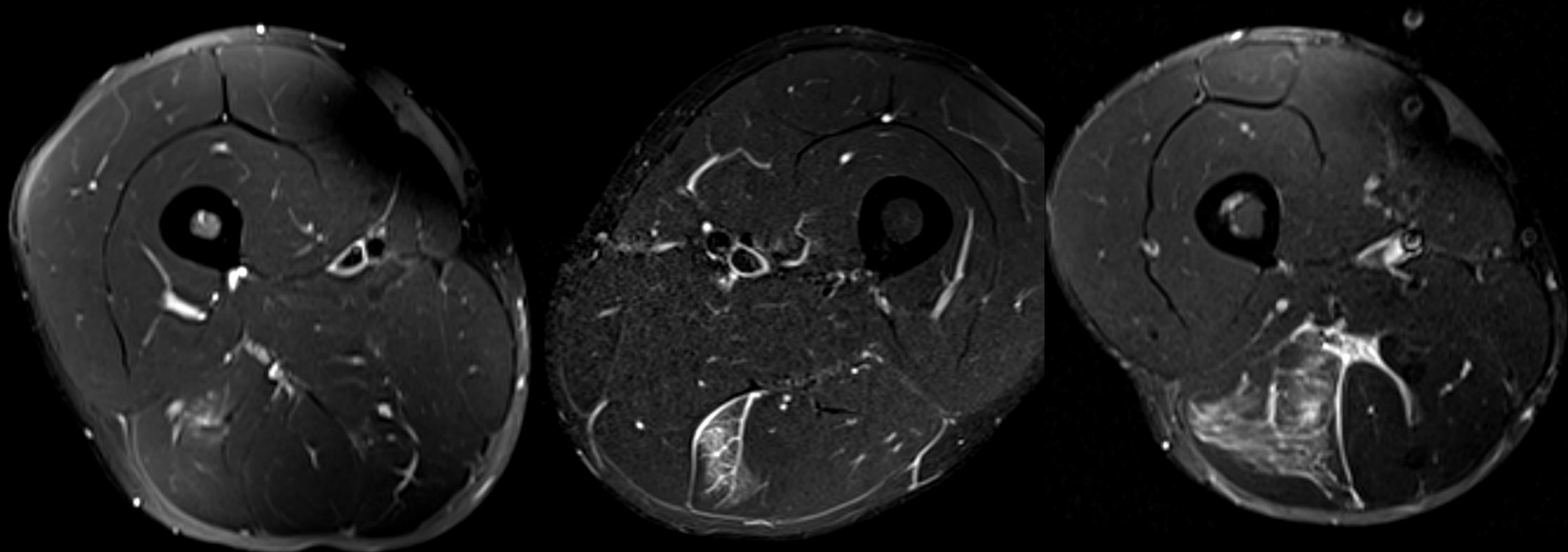
- Sprinters

- Grade 1: >5 weeks



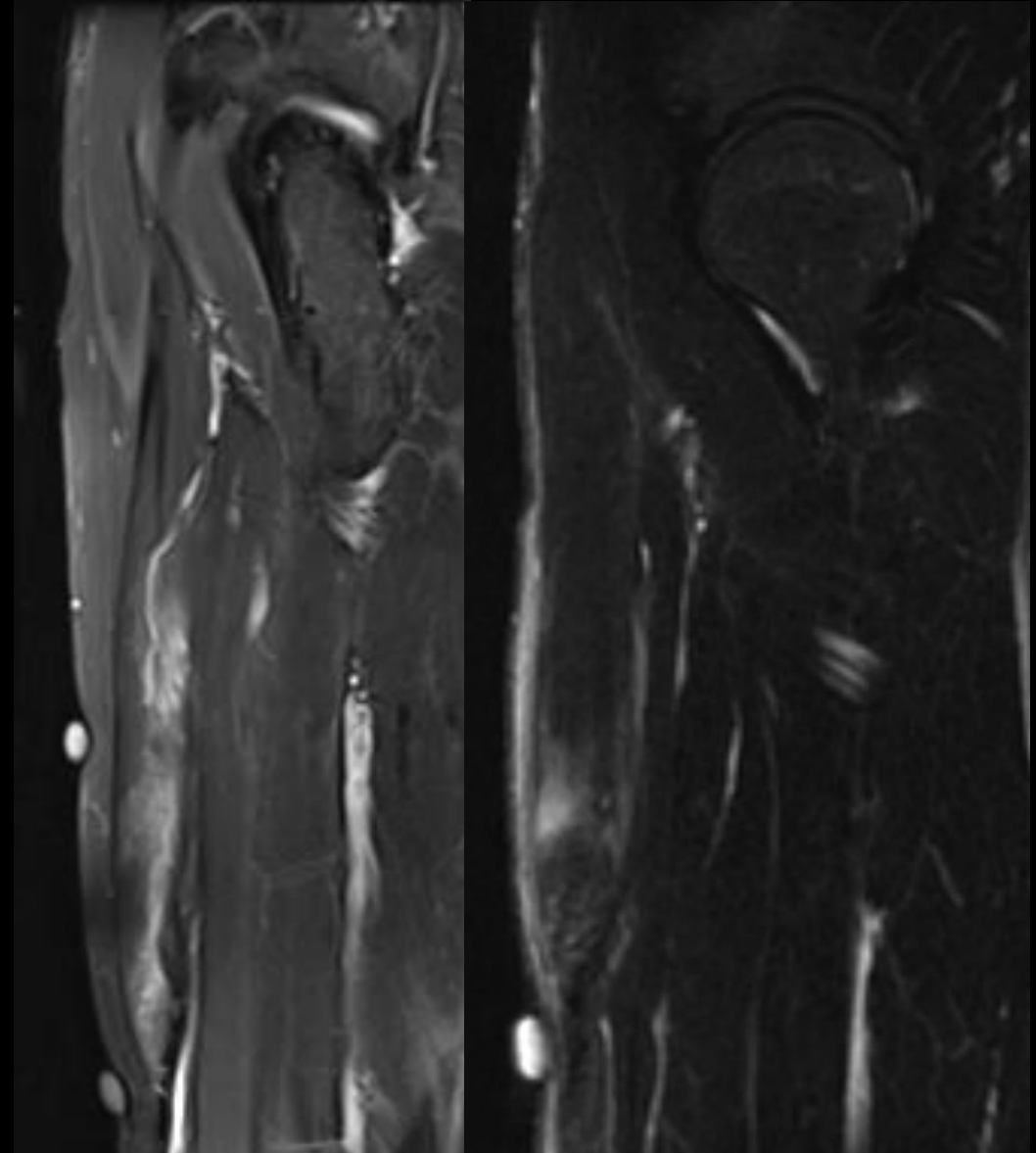
Prognostic Factors – Time to Return to Play

- Cross-sectional area:
 - Hamstring:
CSA > 55% at least 6 weeks

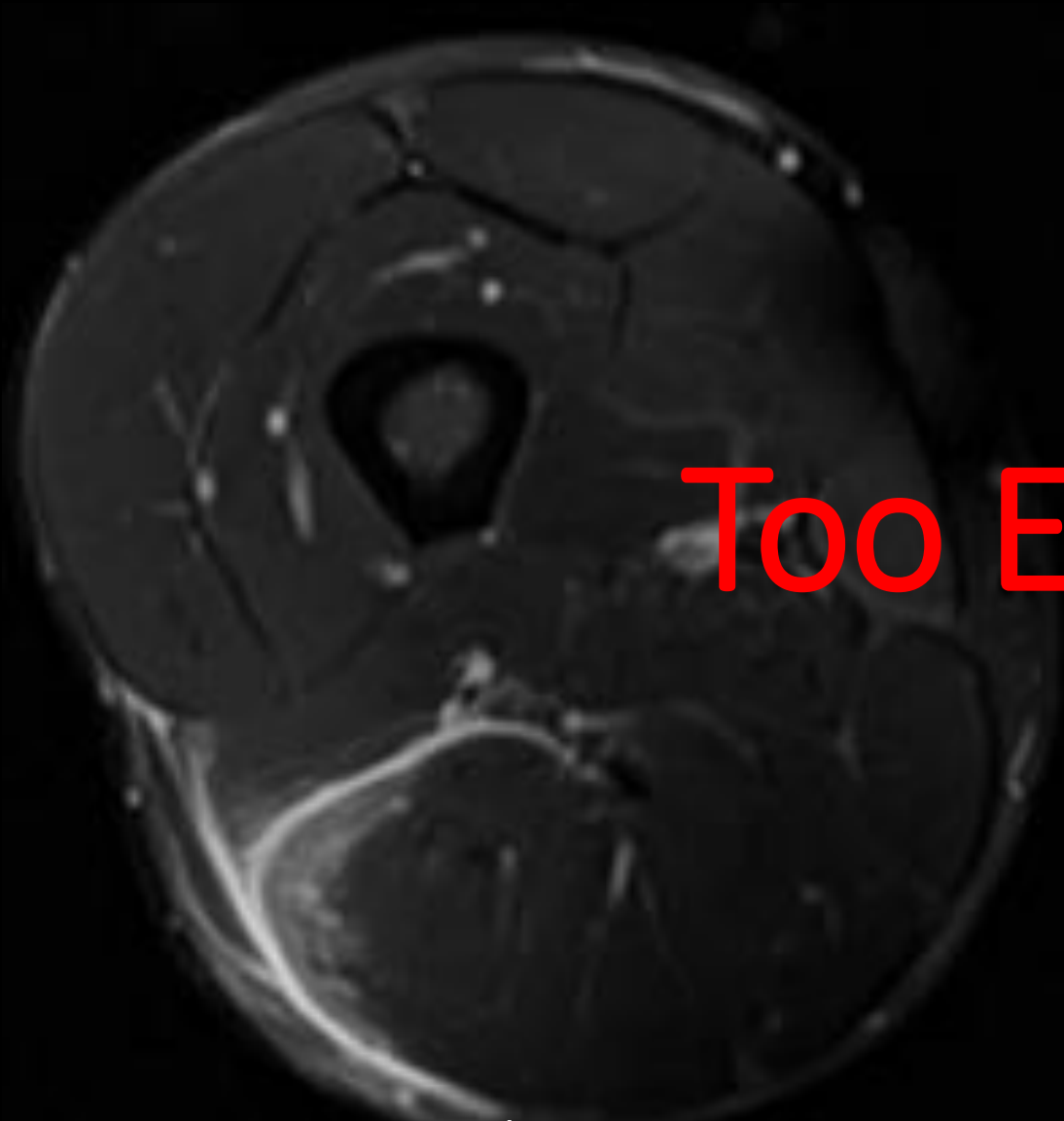


Prognostic Factors – Time to Return to Play

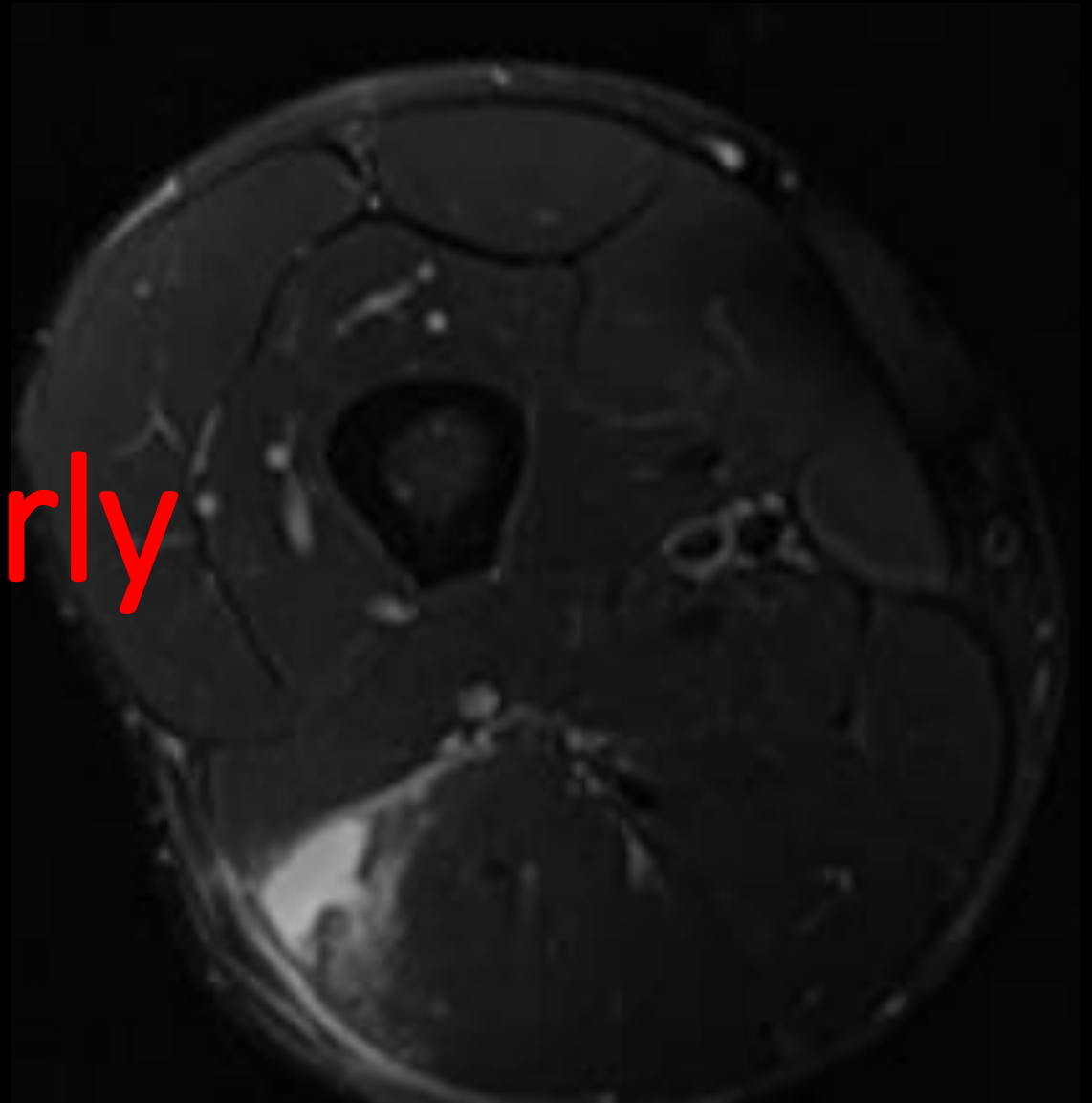
- Length of tear
 - Rectus femoris tear
 - Aussie rules > 13cm:
> 4 weeks
 - Soccer 4cm: 5 weeks



Biceps Femoris Injury - Soccer



Initial Injury

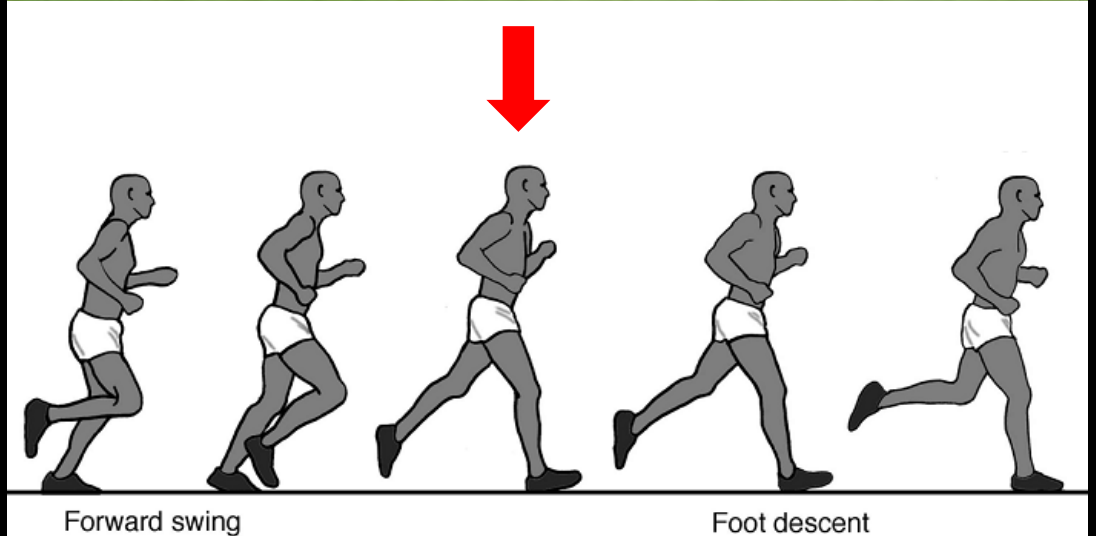


Return-to-Play Injury

Too Early

Hamstring Injuries

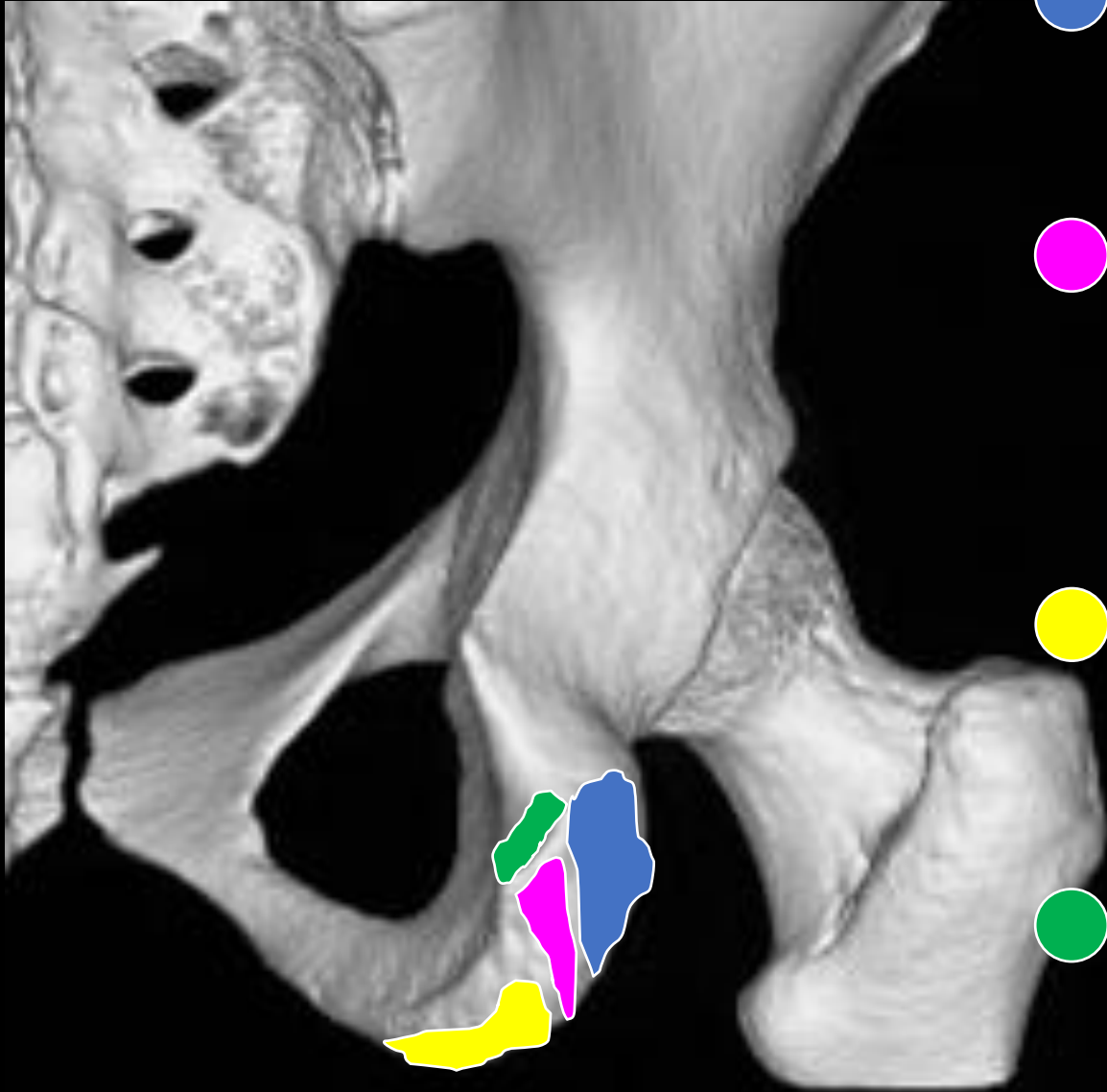
- Most common muscle injury
- Sprinting, jumping
- Injury during the **late swing phase**



Hamstring Injuries

- Single muscle injury: 60%
- **BF most common: 75%**
- Perifascial / epimysial edema
- 10-15% proximal avulsion
- Edema 6-10 wks to resolve
- **30-40% cases normal MRI**



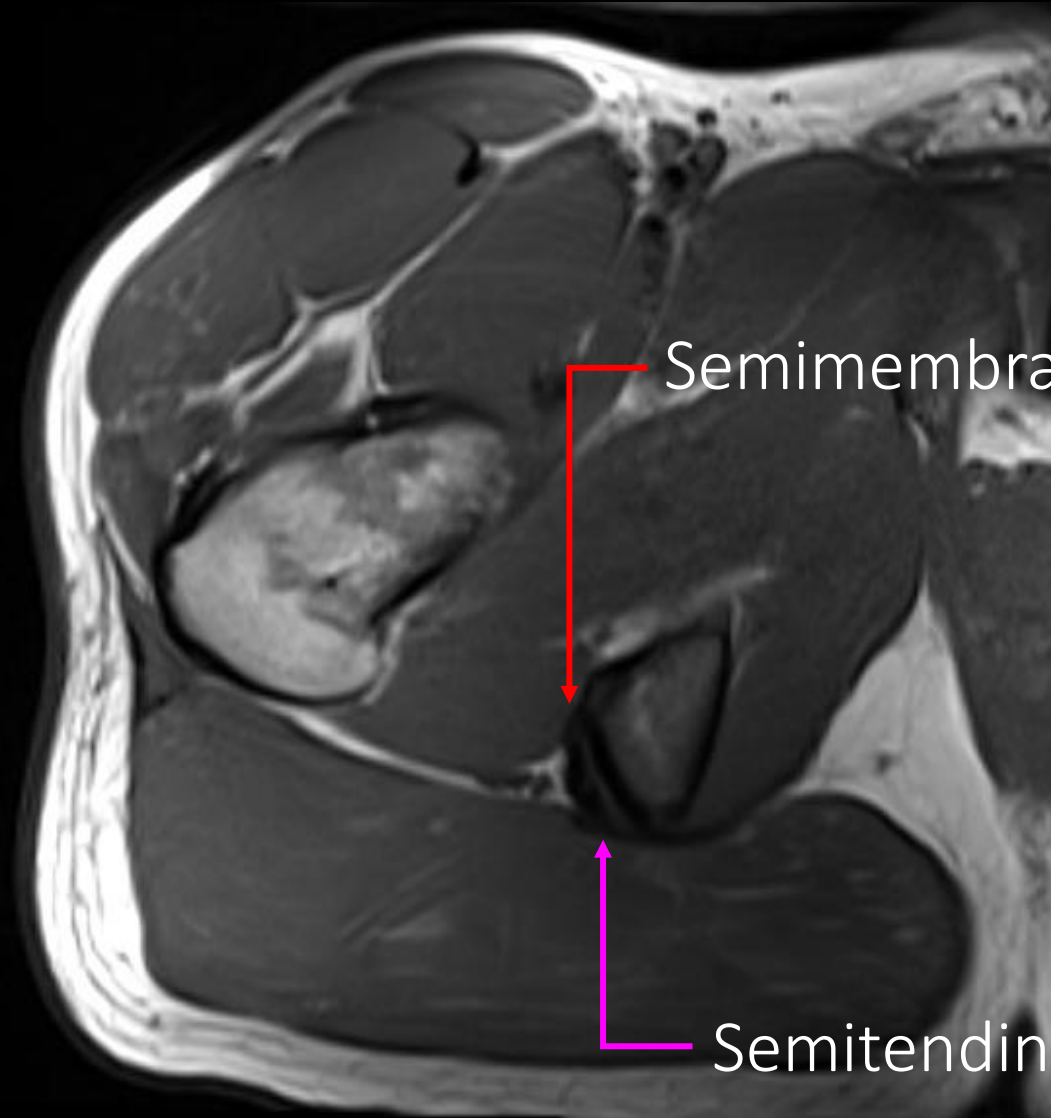


● Superolateral Facet
- Semimembranosus

● Inferomedial Facet
- Semitendinosus
- Biceps femoris
(long head)

● Adductor Magnus
- medial and
anterior to

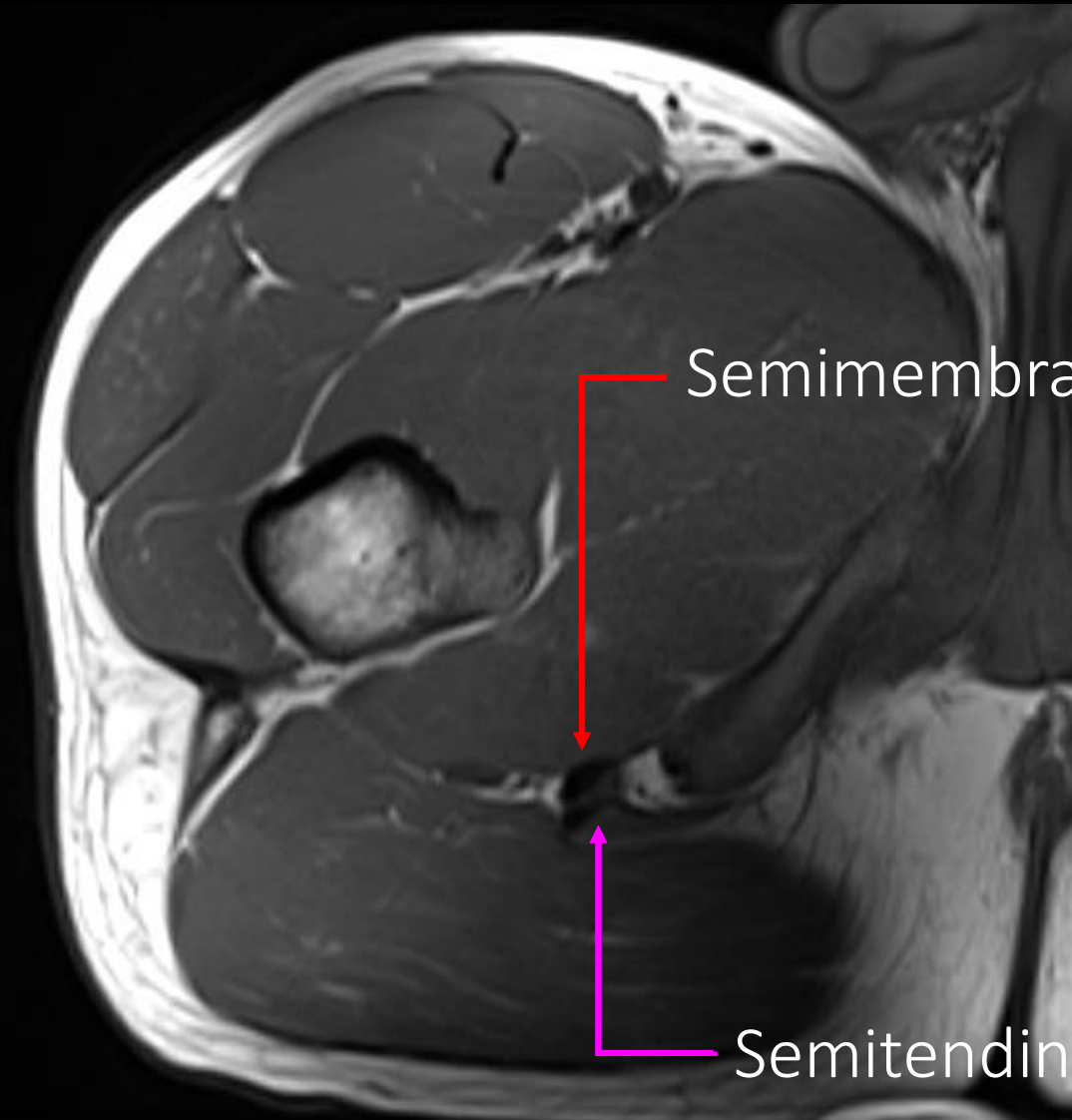
● biceps
Sacrotuberous
ligament



Semimembranosus

Semitendinosus

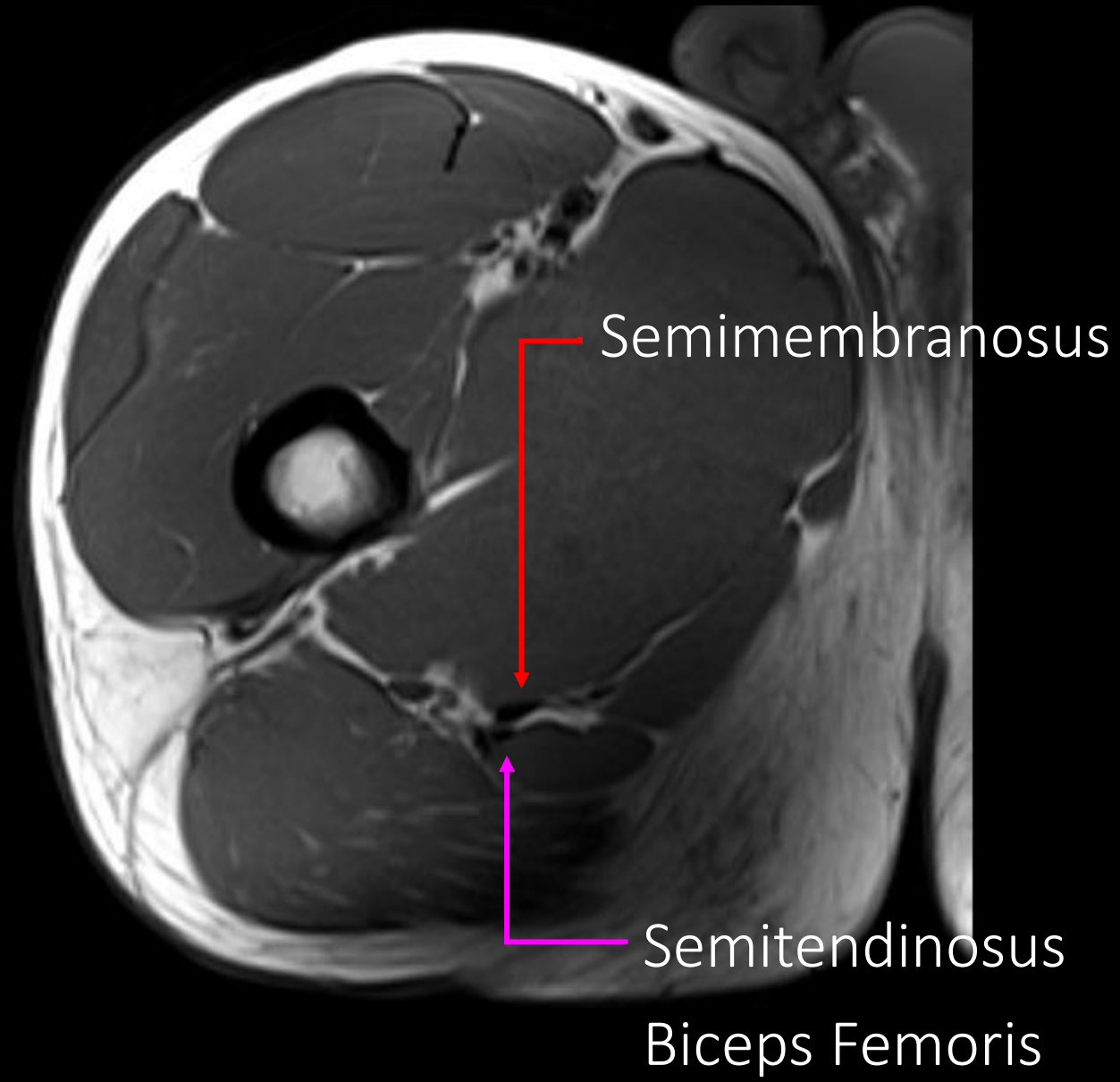
Biceps Femoris

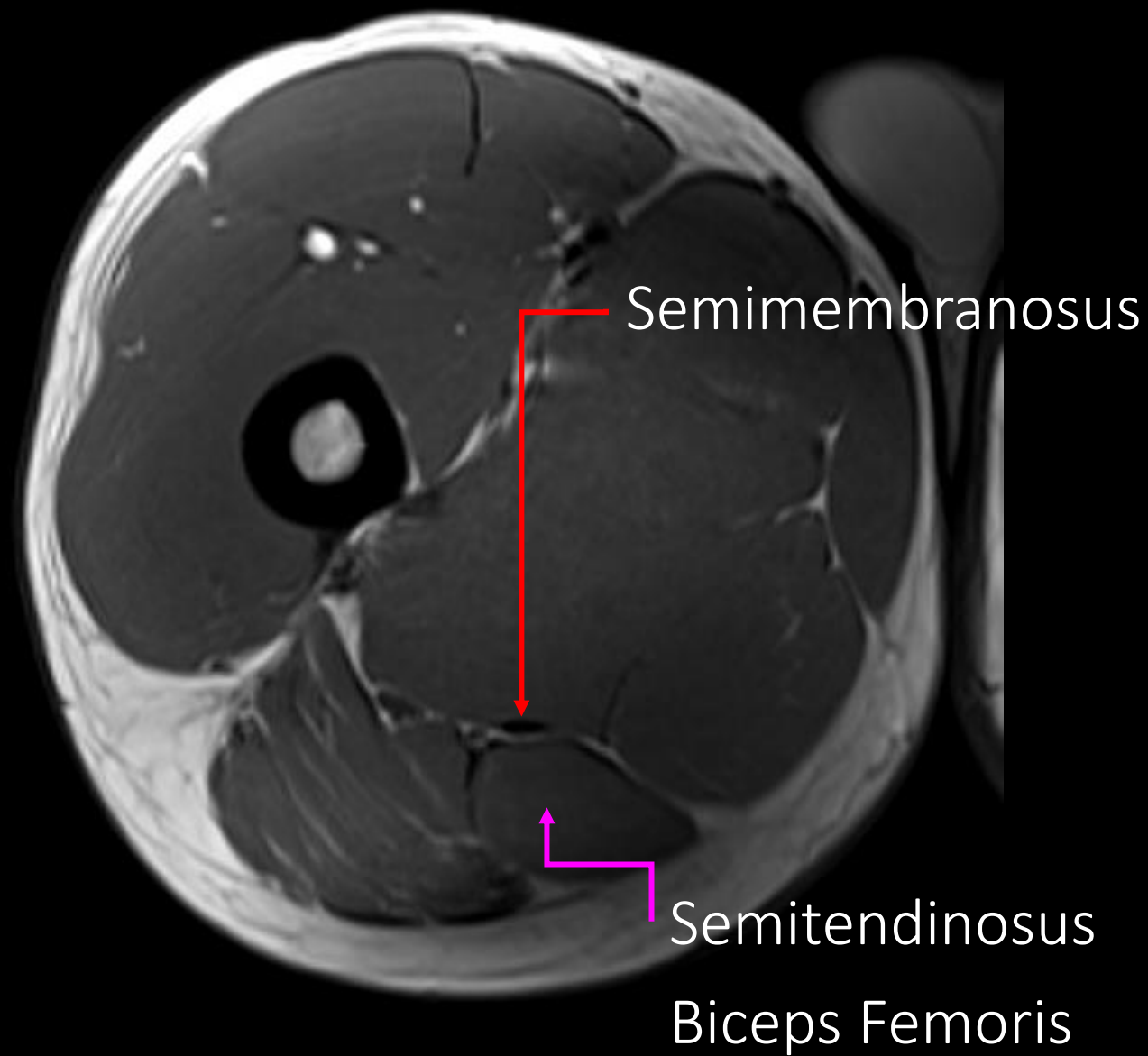


Semimembranosus

Semitendinosus

Biceps Femoris



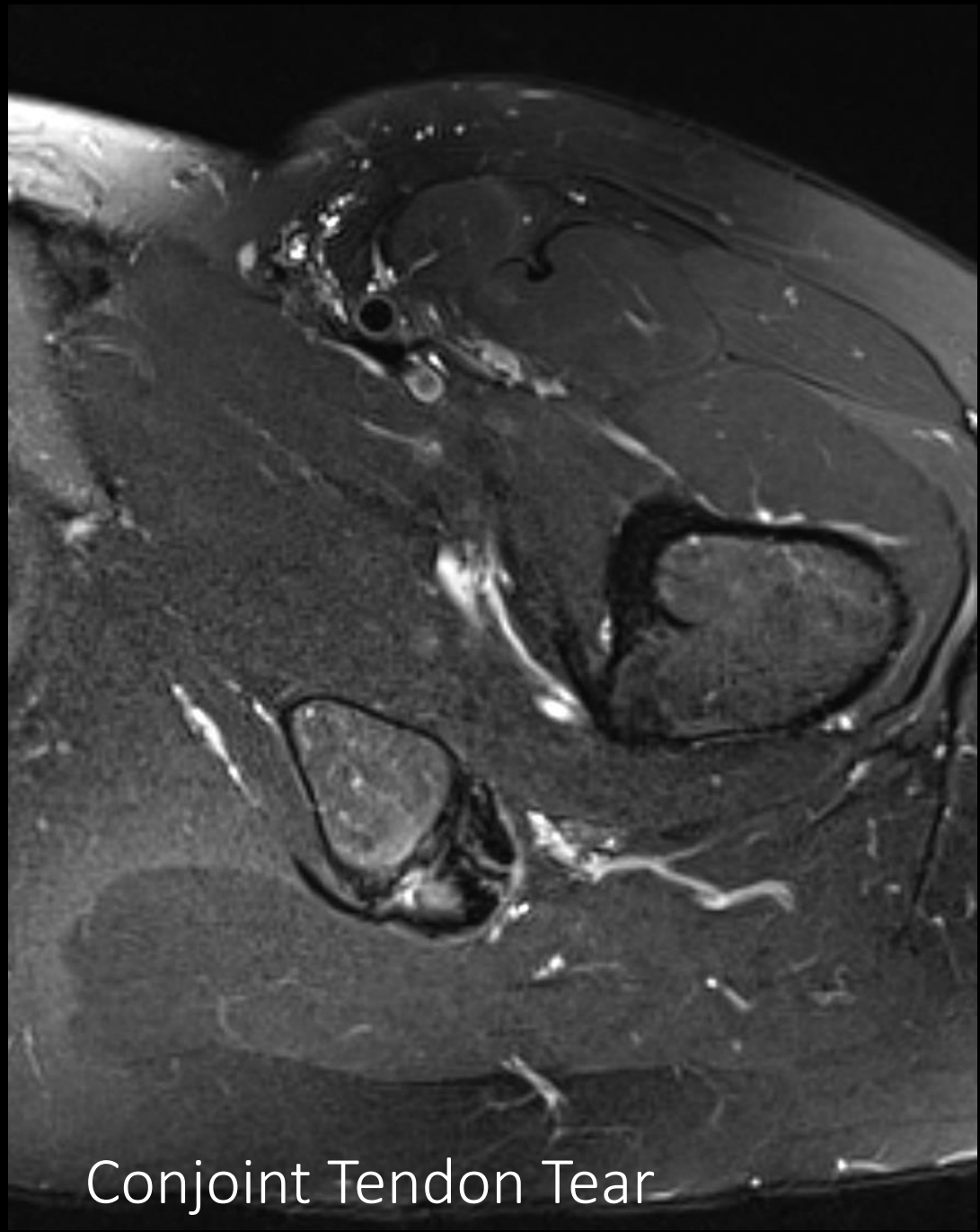
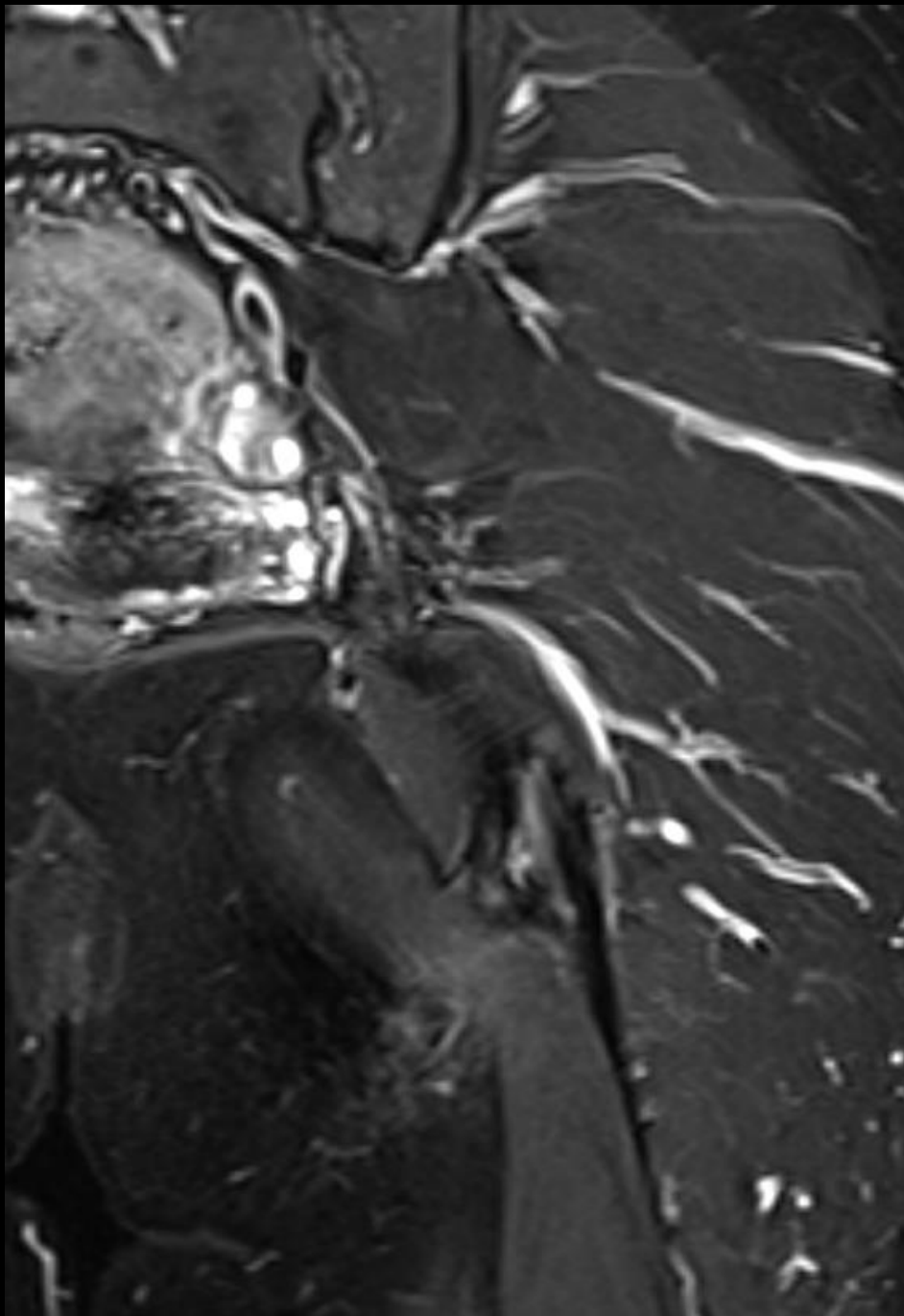


Hamstring Injuries

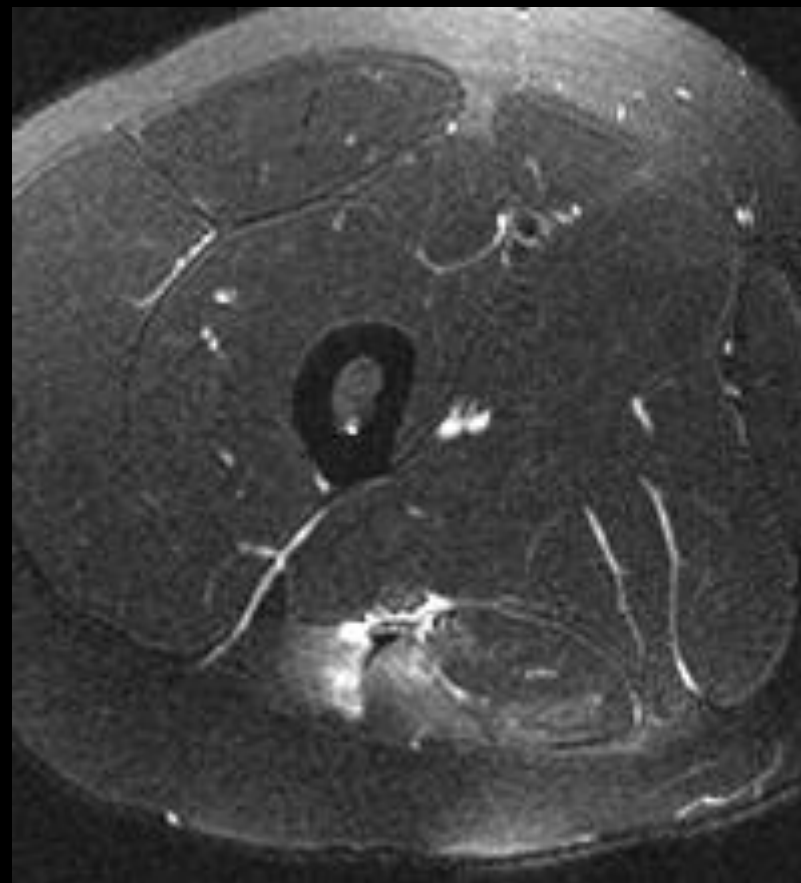
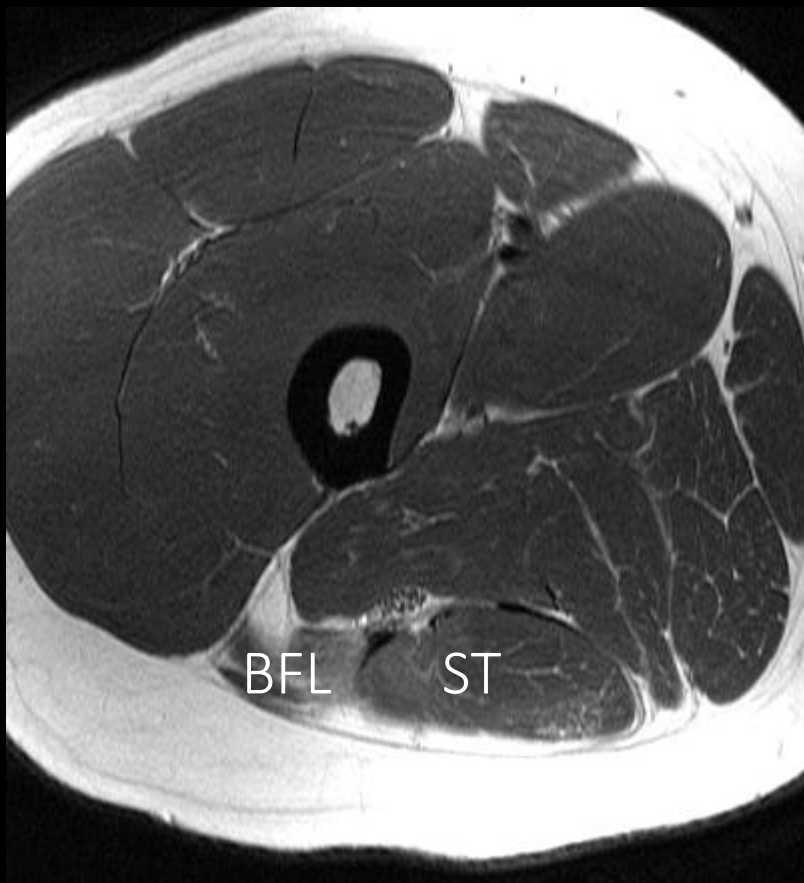
- Strain = partial tear
 - treatment = conservative
 - musculotendinous junction (MTJ)
 - microscopic tearing of myofibrils
 - increased T2 signal at MTJ
 - represents hemorrhage (< 24 hrs)
 - followed by inflammation

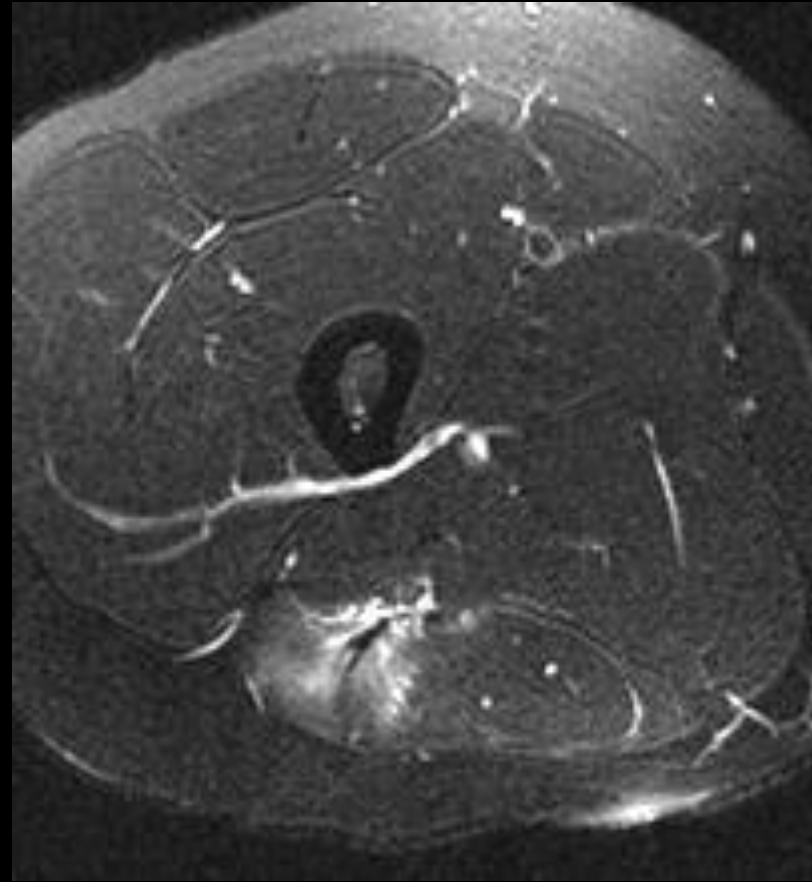
Hamstring Injuries

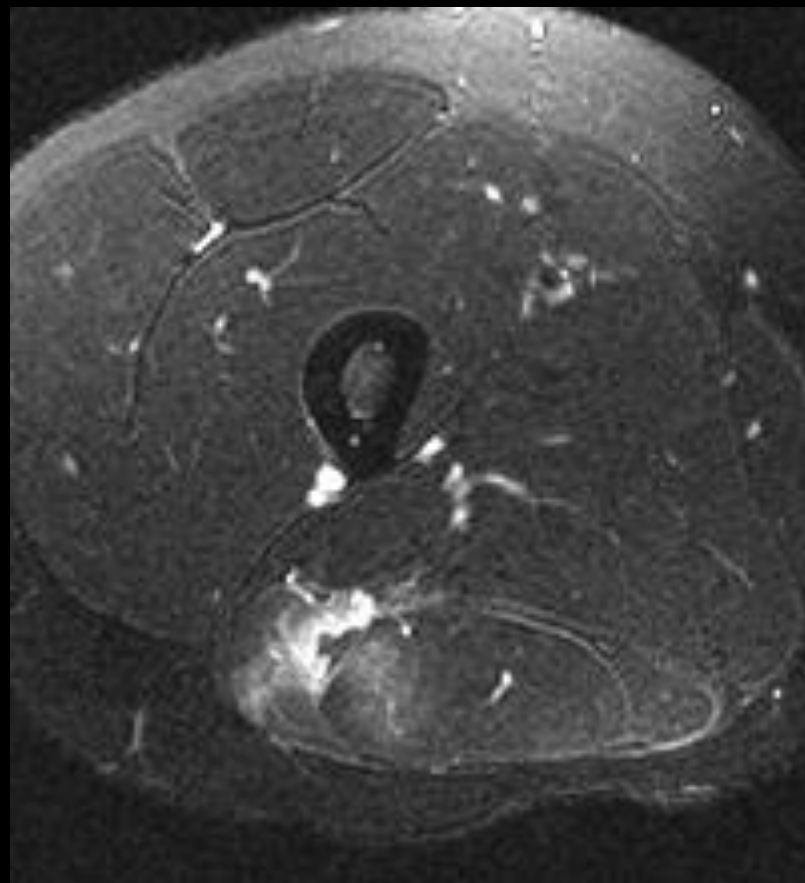
- Avulsion = complete tear
 - treatment = surgery
 - tendon origin
 - adults = complete tendon tear
 - children = apophyseal avulsion fx
 - proximal >> distal
 - almost always involves conjoint tendon
 - complete tear
 - role of MR:
 - 1) confirm injury
 - 2) determine degree of retraction
 - 3) define anatomy for repair

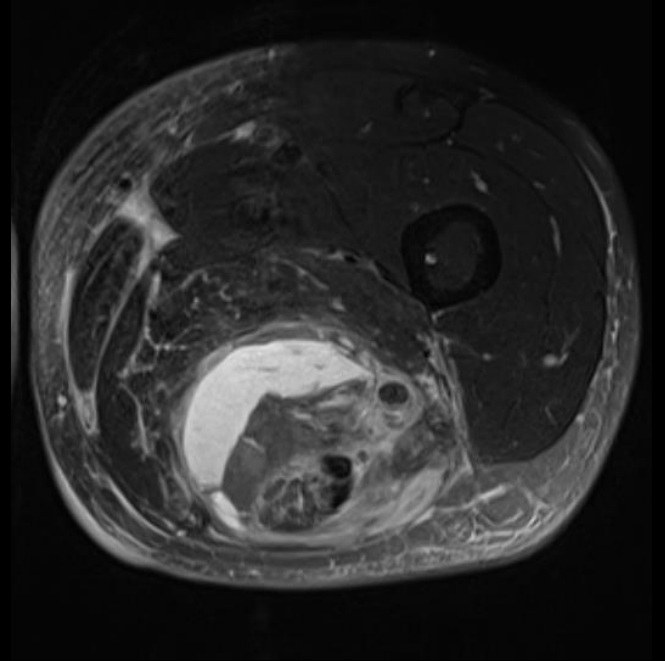
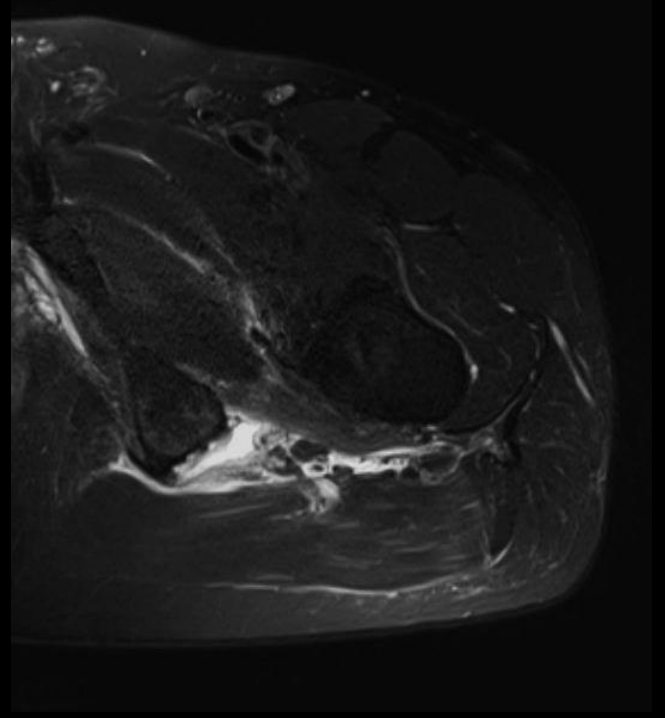
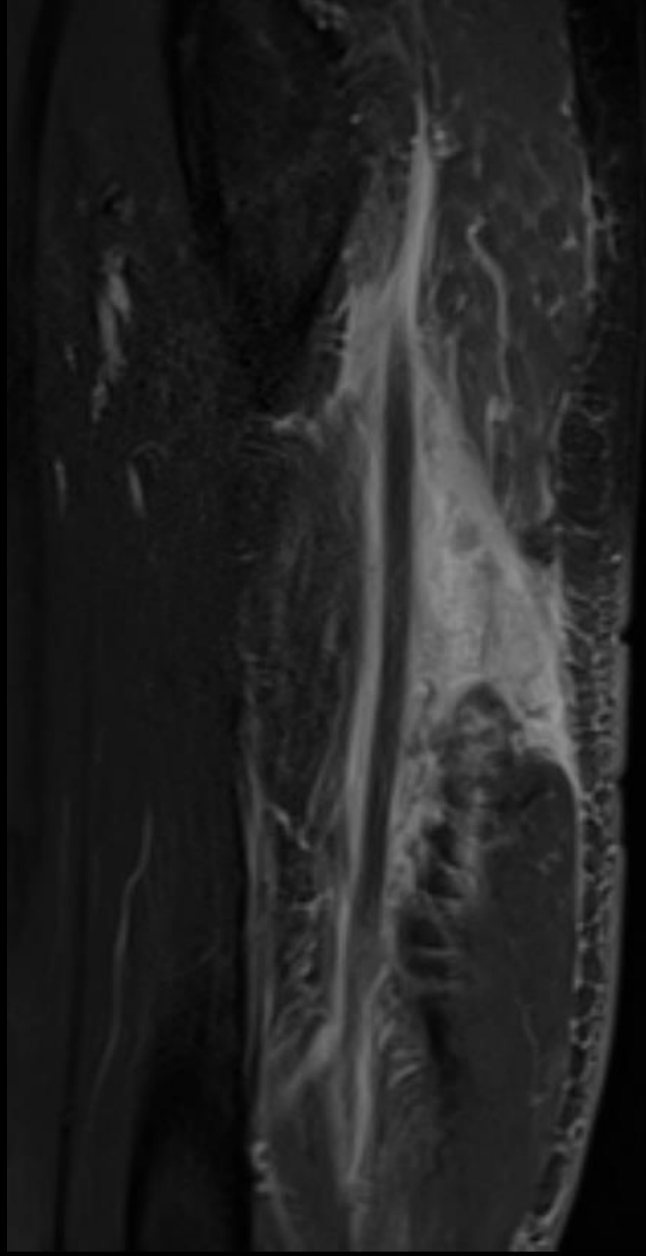
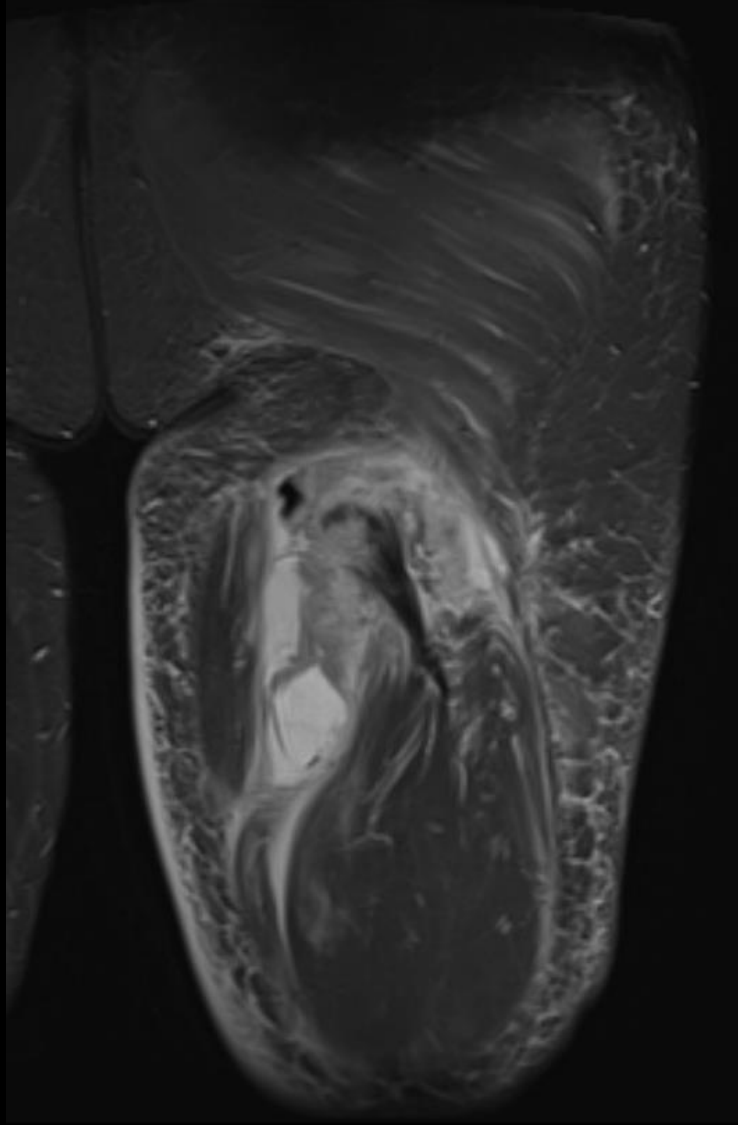


Conjoint Tendon Tear



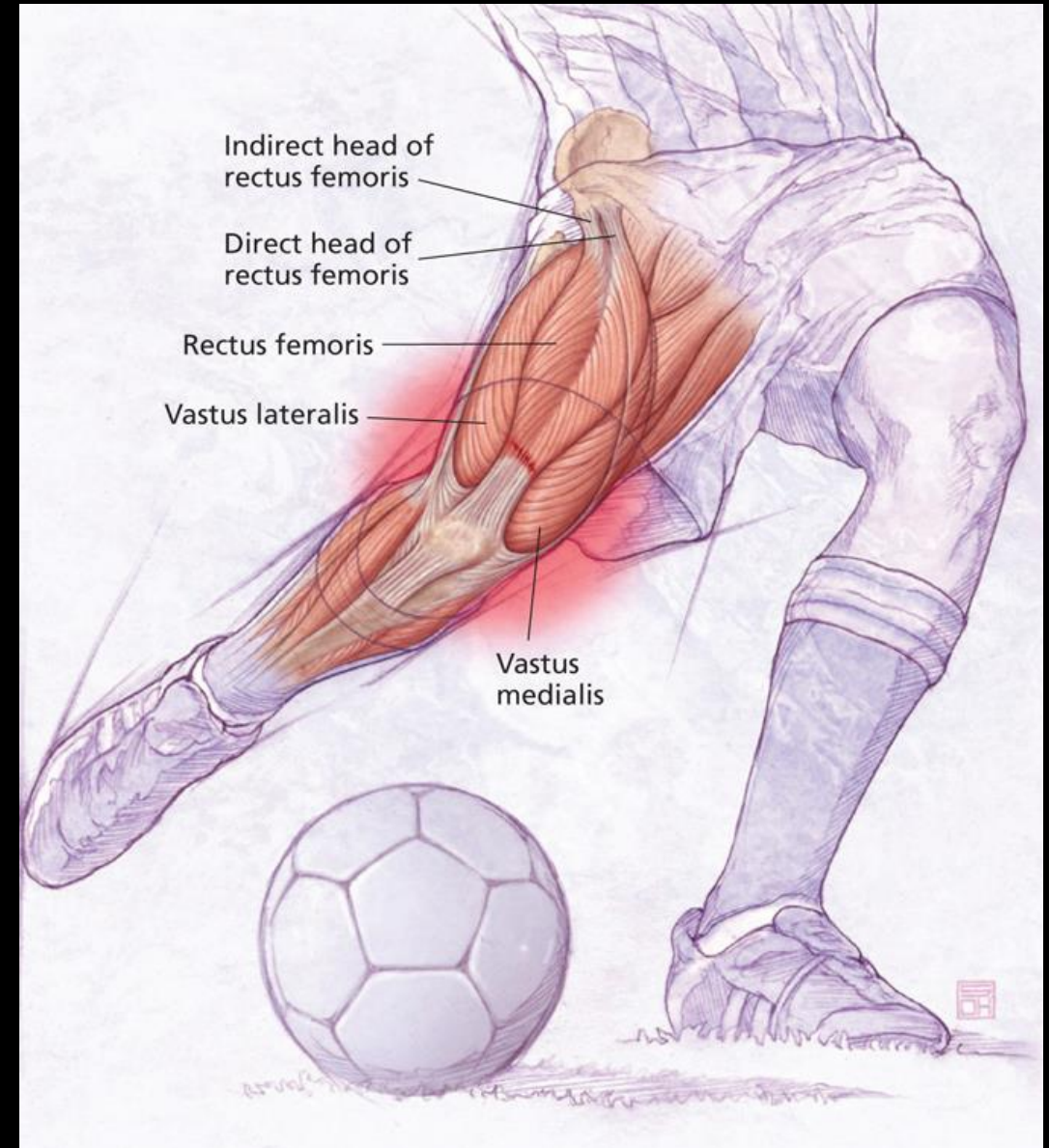


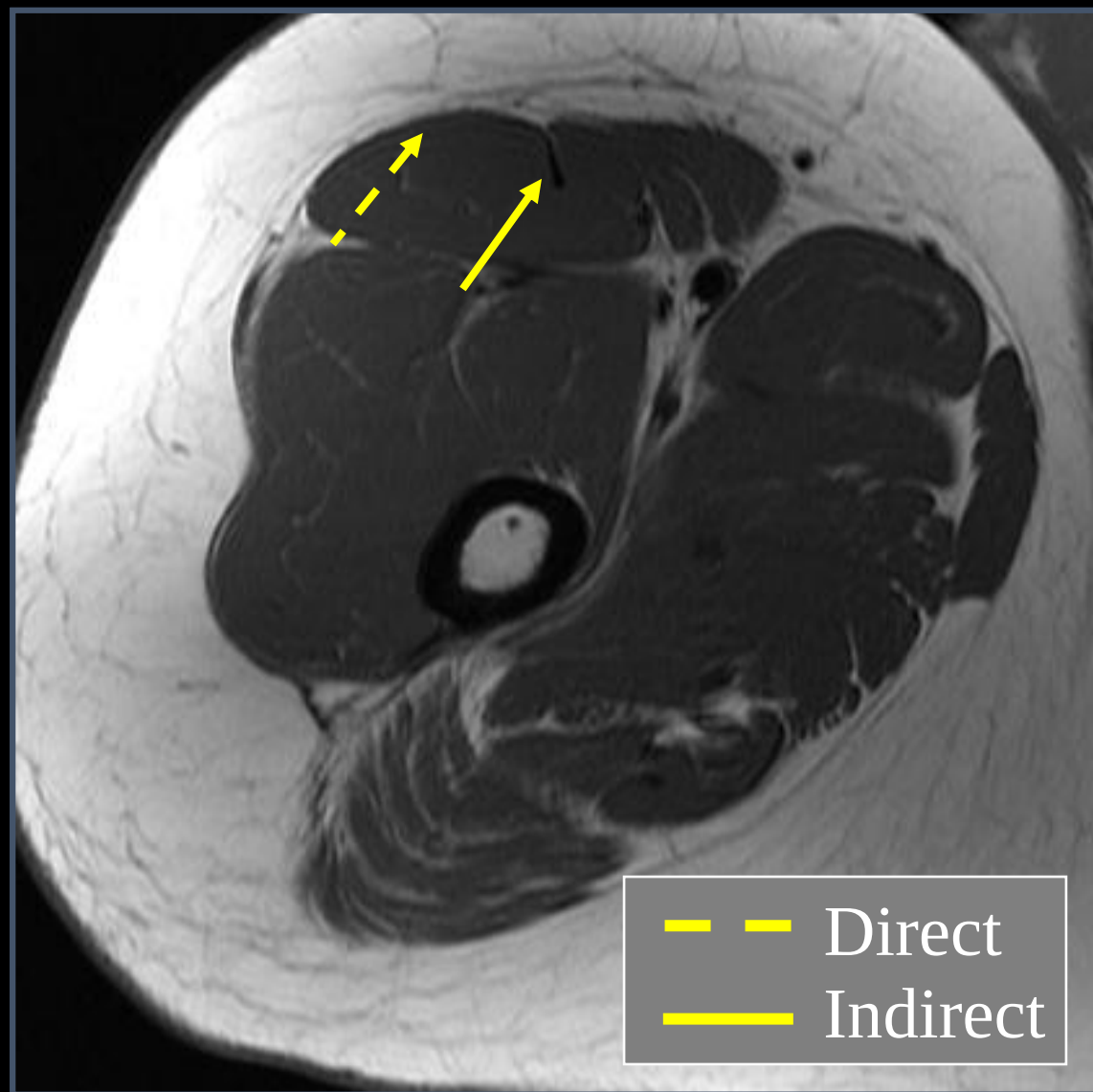




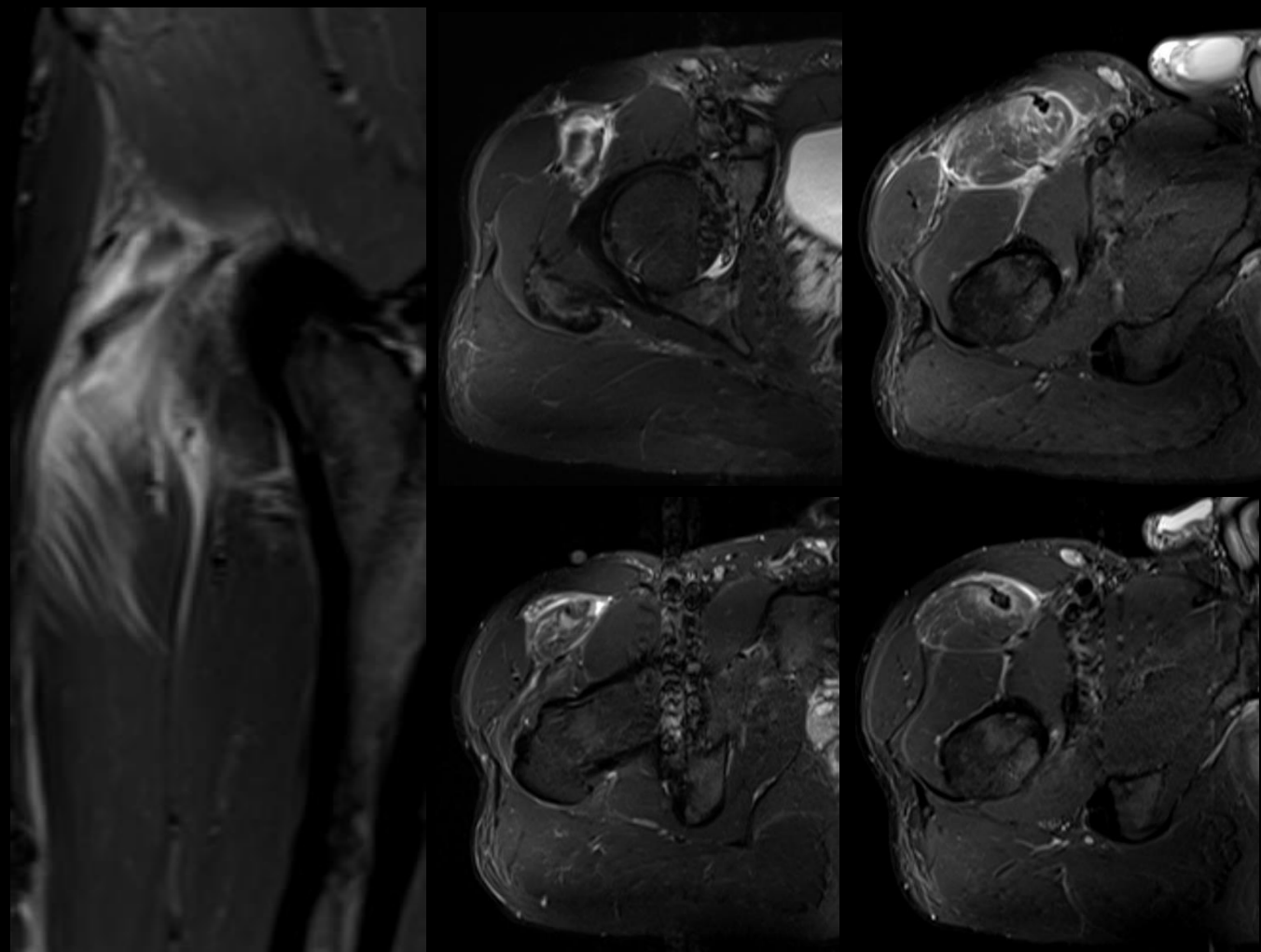
Rectus Femoris Tears

- Sprinting and kicking
- Palpable mass
- **2 Heads**
 - Direct head
 - Superficial
 - Reflected (Indirect) head
 - Intramuscular
- Distal Tendon

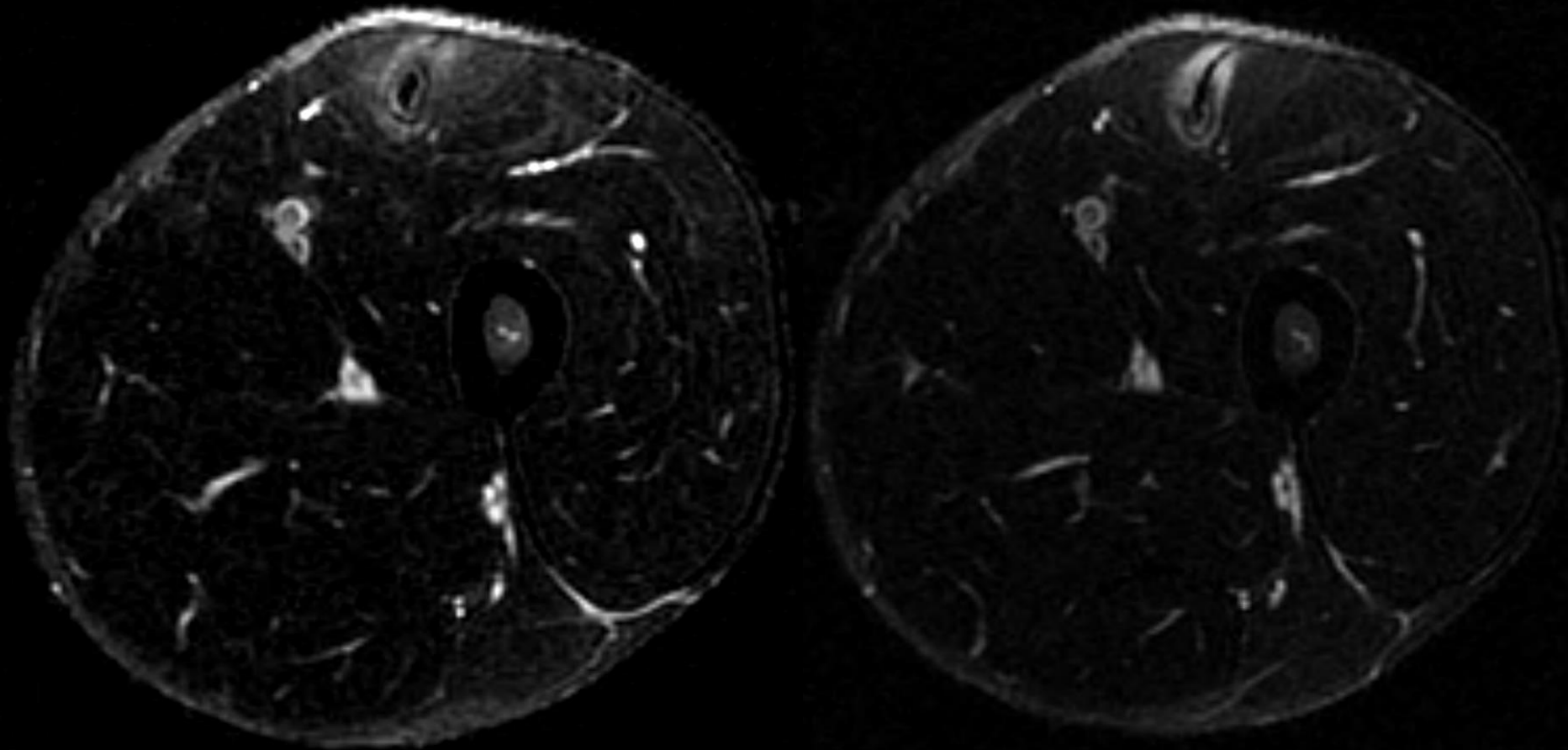




Proximal Rectus Tendons



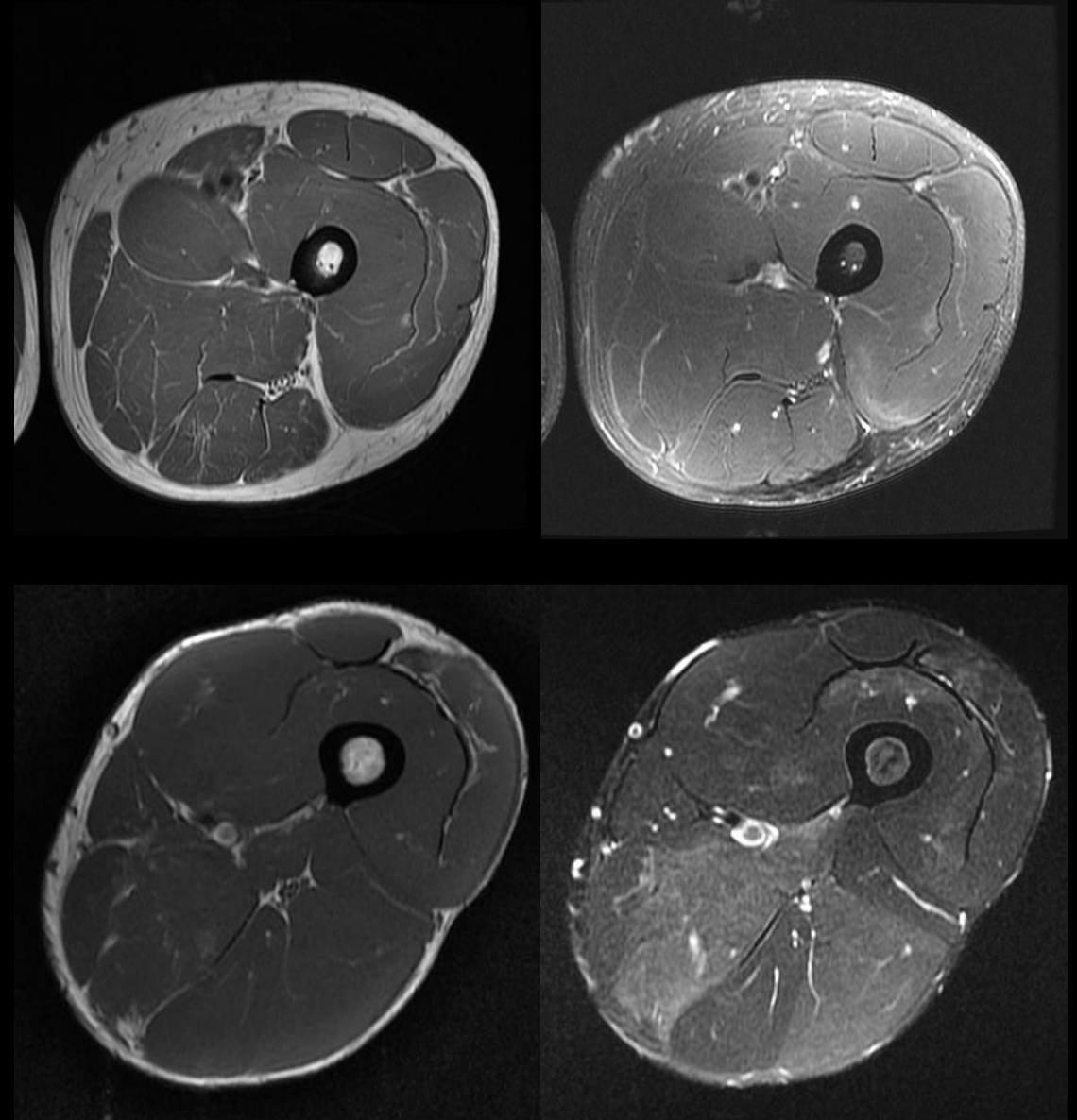
High Grade Proximal Tear Rectus
Tendons



Indirect Head Tear: “Internal Degloving Injury”

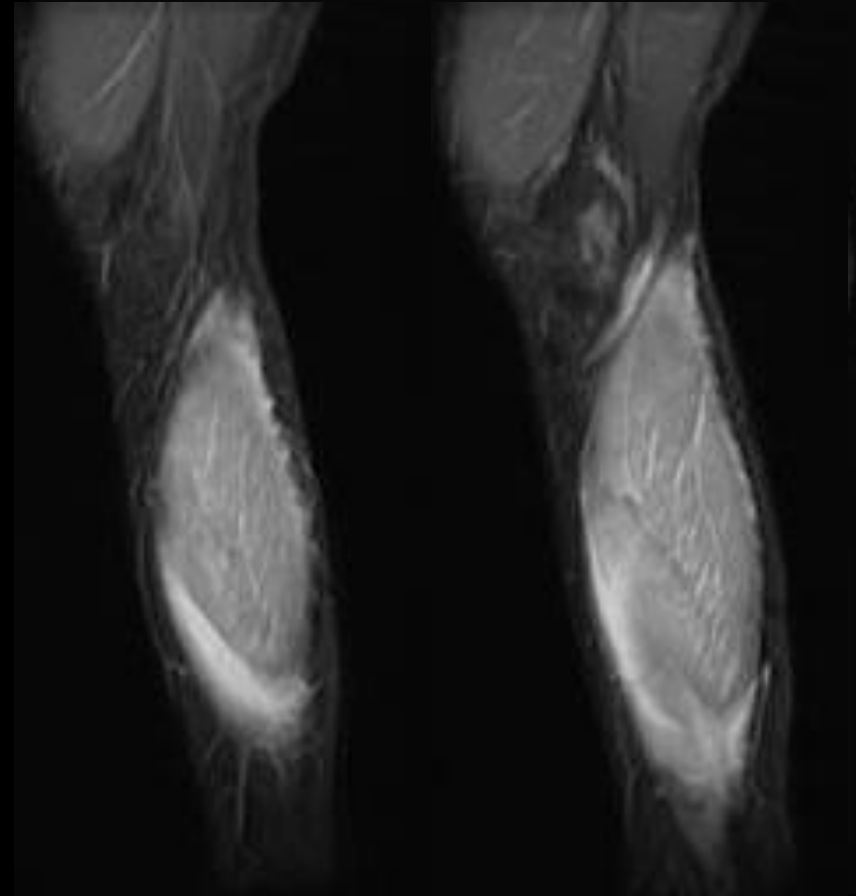
Delayed Onset Muscle Soreness (DOMS)

- Indirect muscle injury
- **Reversible** disruption of muscle elements at a microscopic level
- Eccentric loading
- Insidious onset
- **Peak 48-72 hours**
- **Settles over 7-10 days**



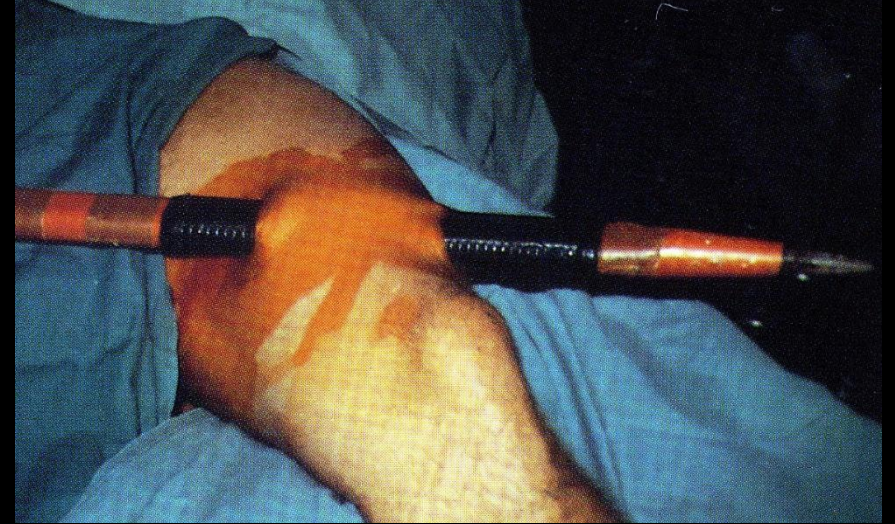
Delayed Onset Muscle Soreness (DOMS)

- MRI
 - Non-specific
 - Diffuse or patchy peritendinous high T2
 - +/- perifascial fluid
 - May last for 6 weeks



Direct Muscle Trauma - Penetrating Trauma

- Muscle lacerations
- **Rare in sport**
 - Skates
 - Javelin
- Superficial muscles
- Sharp margins



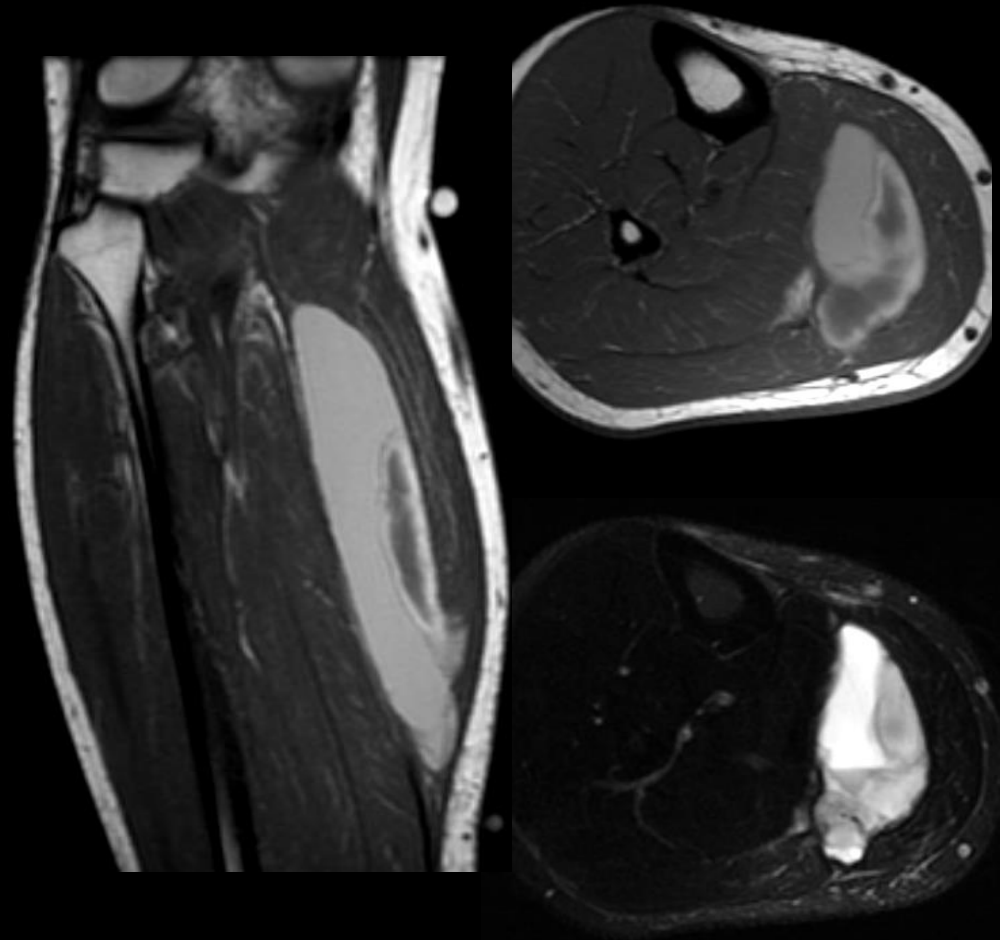
Direct Muscle Trauma - Blunt Trauma

- Contusions and hematoma
 - Intramuscular
 - Intermuscular
- Quads
- Depth of injury



Direct Muscle Trauma - Blunt Trauma

- MRI
 - Variable appearance depending on age
 - High T1
- Slow resolution
 - 6-10 weeks
 - esp. intramuscular



Myositis Ossificans

- Benign proliferation of cartilage and bone
- Various etiologies
 - Trauma – 75%
 - Burns
 - Immobility
- Lack of history of trauma in 40%

Myositis Ossificans

Clues:

- History
- Zonal mineralization
- Intralesional fat
- Corticomedullary architecture (when mature)
- Edema relative to mass



HETEROTOPIC BONE FORMATION PATHOLOGY

Vascularized granulation tissue maturing to bone

Zonal pattern of maturation

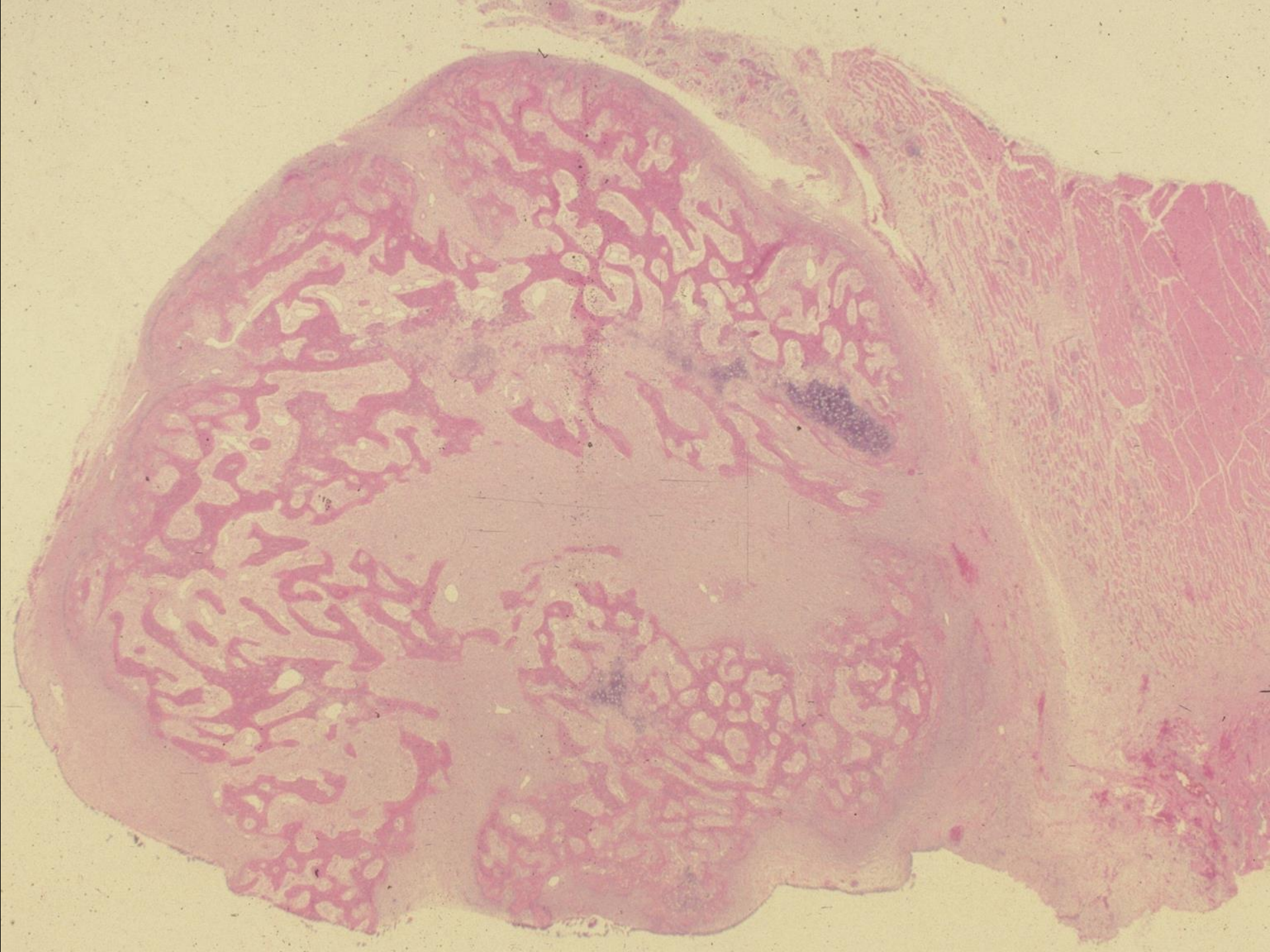
- Central immature osteoid/fibroblastic tissue

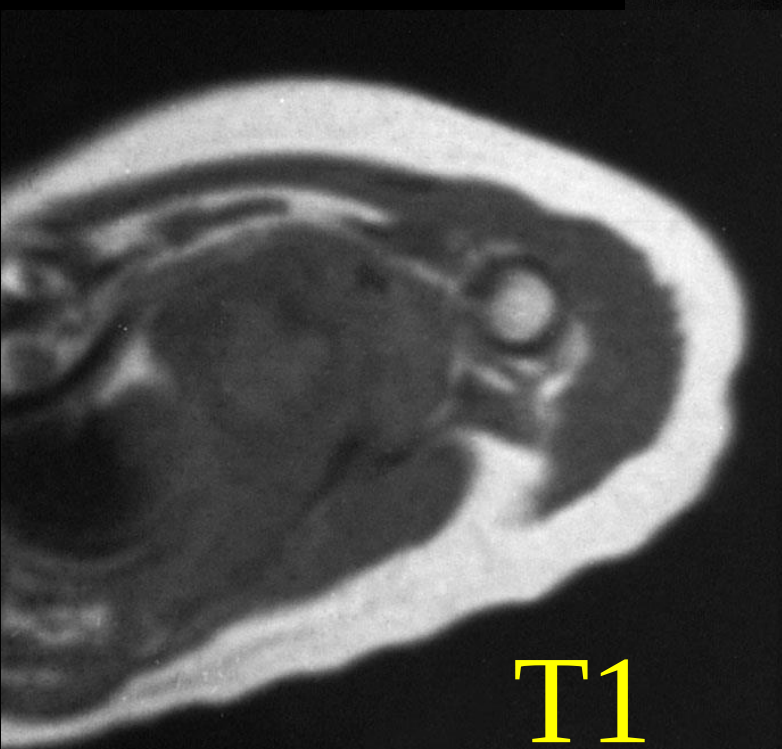
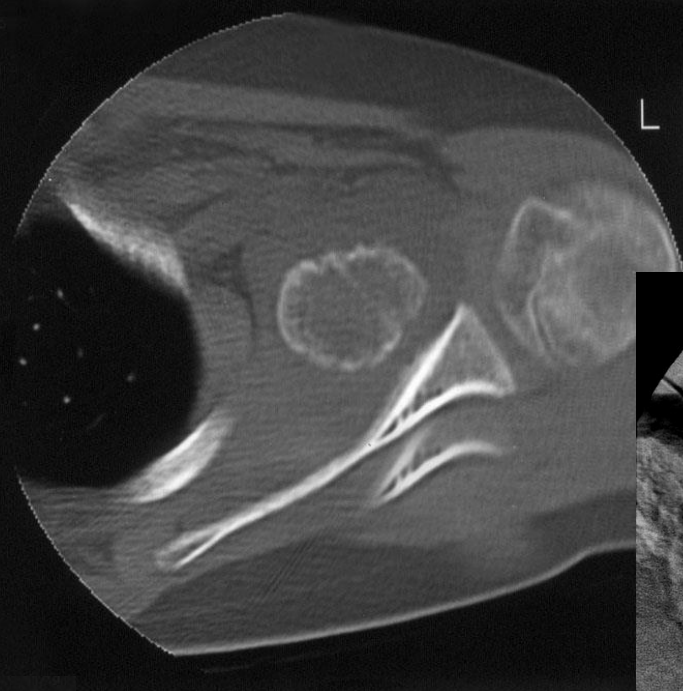
- Periphery calcifying osteoid to mature lamellar bone

Cortical bone with further maturation

Second zone of surrounding edema

USP6 gene rearrangement positive in up to 73% cases

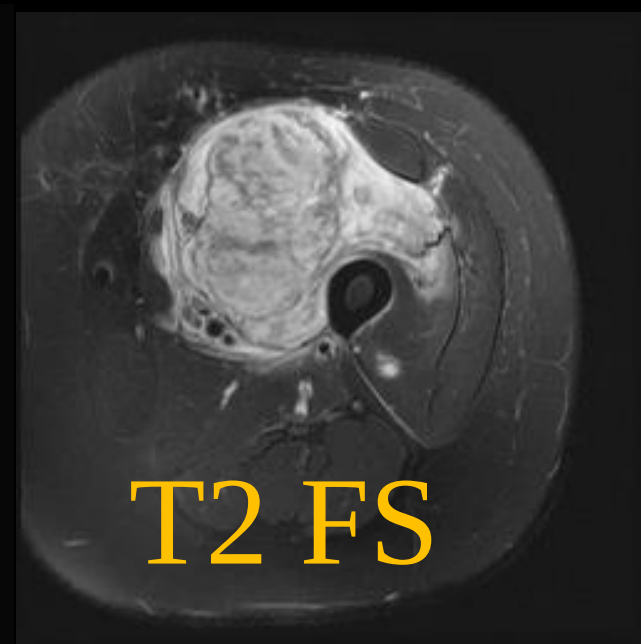
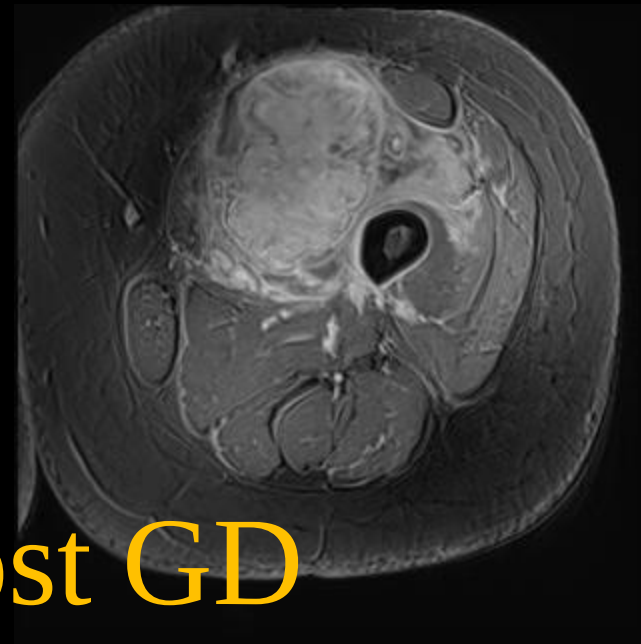
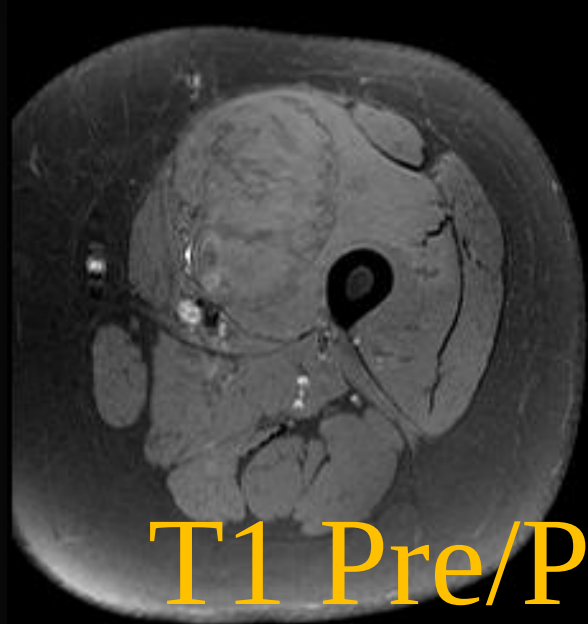
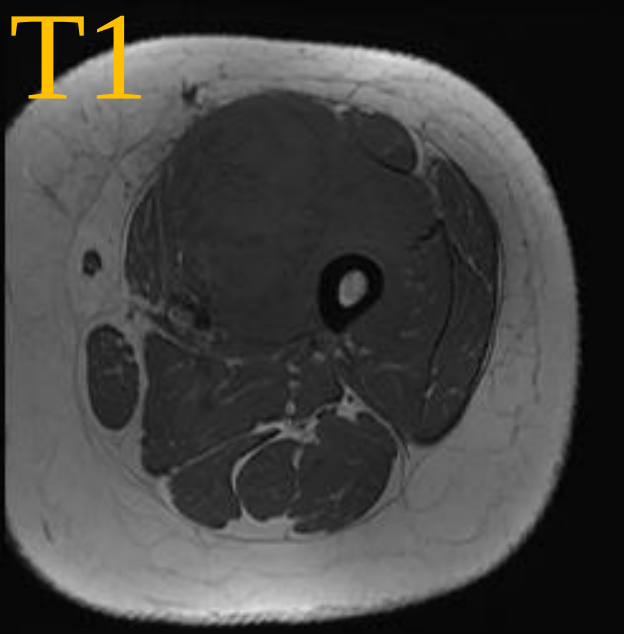




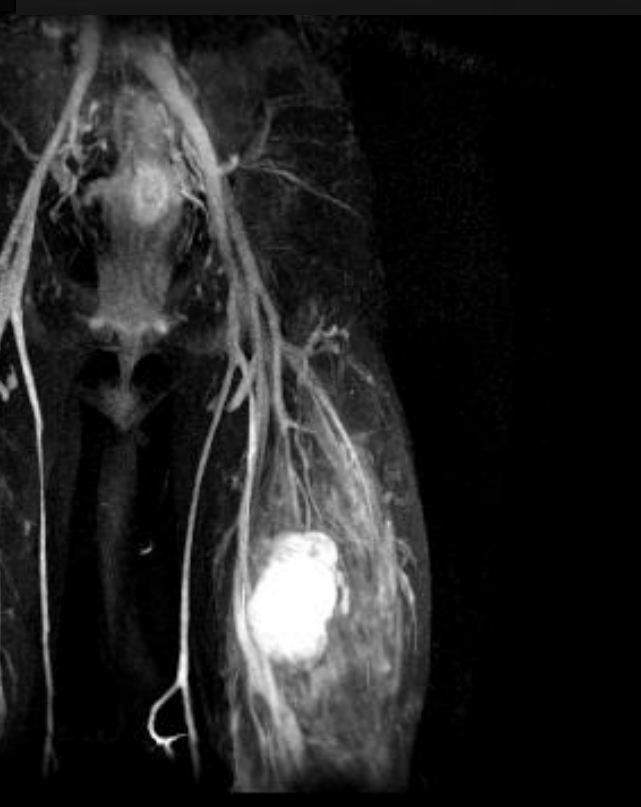
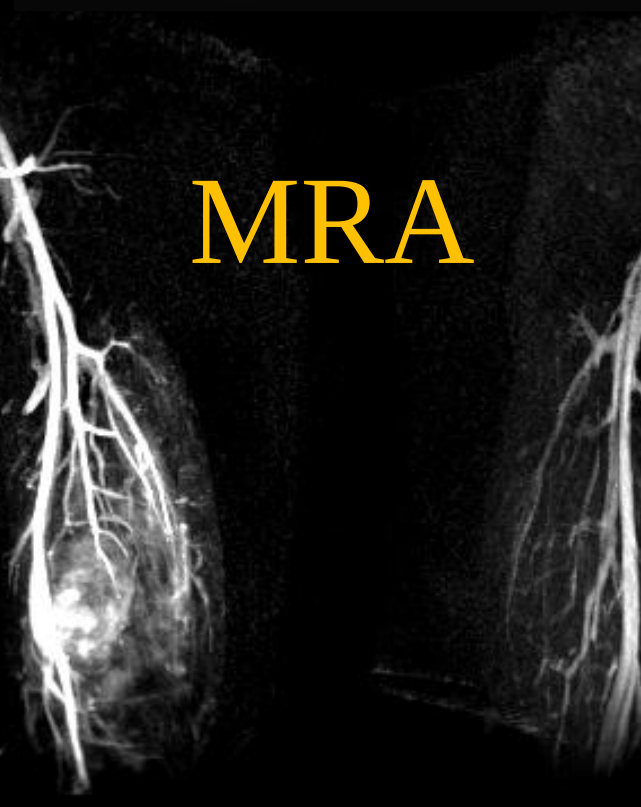
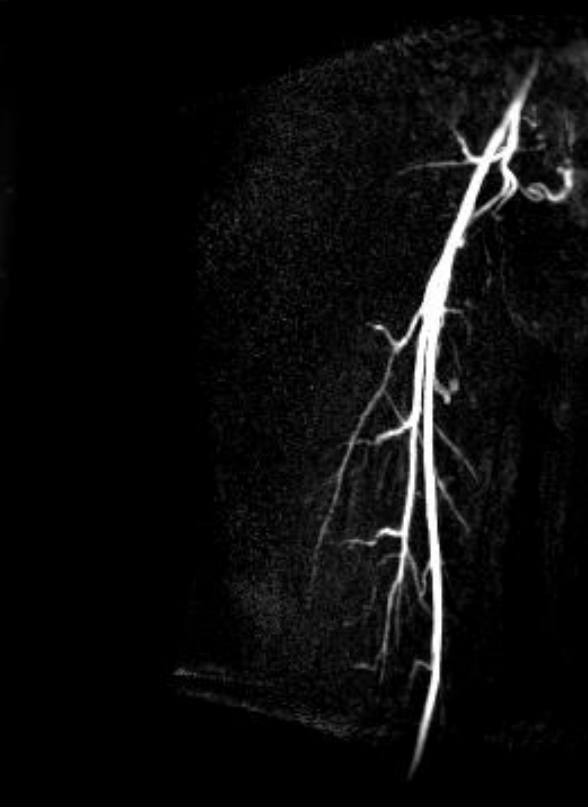
T1

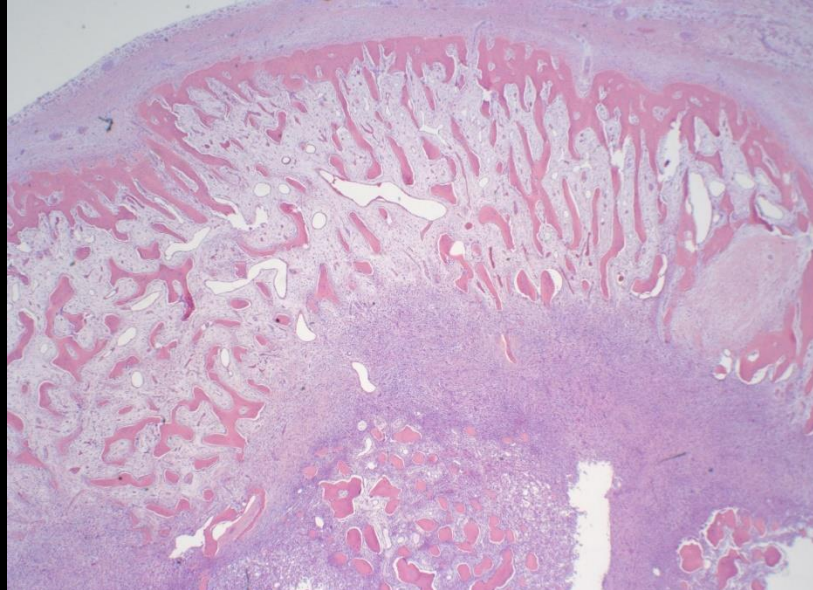


STIR



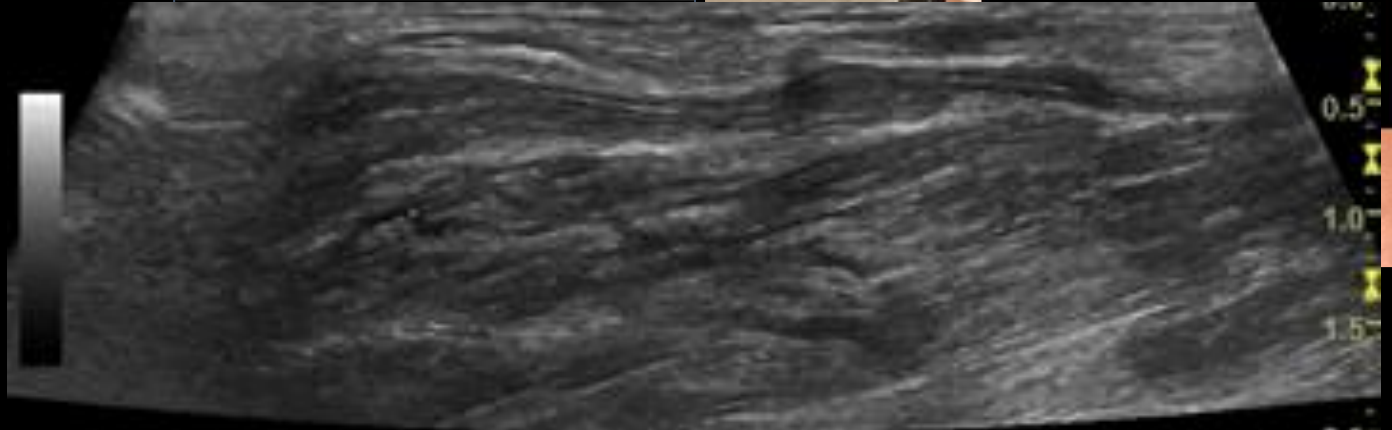
T1 Pre/Post GD





Muscle Hernias

- May be preceded by blunt trauma
- Exertional pain and prominence
- Clinically obvious
- Rarely incarcerated
- MRI
 - Marker
 - Focal bulge of muscle signal
 - ? Contraction
- US
 - Dynamic
 - Exercise study
 - Visible reduction manoeuvres



Non-Traumatic Muscle Pathology

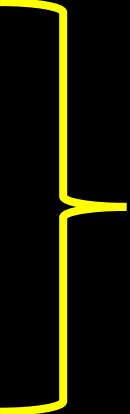
Abnormal Muscle Signal Intensity

- Inflammatory
- Infectious myositis
- Subacute denervation
- Compartment syndrome
- Rhabdomyolysis
- Radiation therapy
- Diabetic myonecrosis
- Early myositis ossificans

Inflammatory Myopathy

- Types:

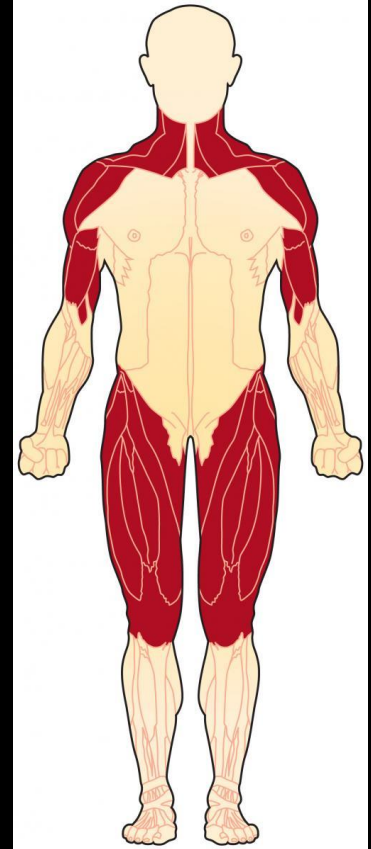
- Dermatomyositis
- Polymyositis
- Inclusion body myositis
- Immune Mediated Necrotizing Myopathy
- Connective Tissue Disorders
 - SLE, Sjogrens, systemic sclerosis, MCTD
- HIV
- Statins (& other drugs)



Idiopathic

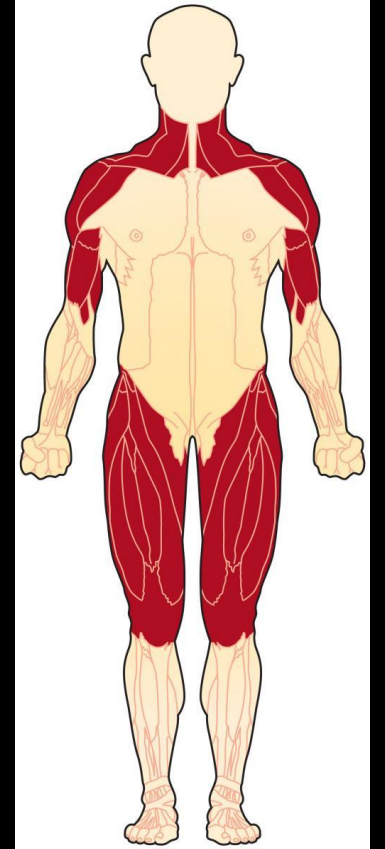
Polymyositis / Dermatomyositis

- Autoimmune
- Gradual weakness
 - Thighs / pelvis girdle then upper extremity
- Age
 - Polymyositis: 4th decade
 - Dermatomyositis
 - Childhood
 - 5th decade: associated with malignancies
 - Breast, prostate, lung, ovarian, GI



Polymyositis / Dermatomyositis

- Bilateral symmetric edema
 - PM: muscle >> fascia; diffuse muscle edema
 - DM: fascia first; muscles more patchy edema/MTJ
- Proximal muscles
- Fatty infiltration chronic cases
- Dermatomyositis
 - Adductors common
 - Calcification
 - Skin/subcutaneous > PM
 - Atrophy less common than polymyositis



POLYMYOSITIS/DERMATOMYOSITIS CLINICAL

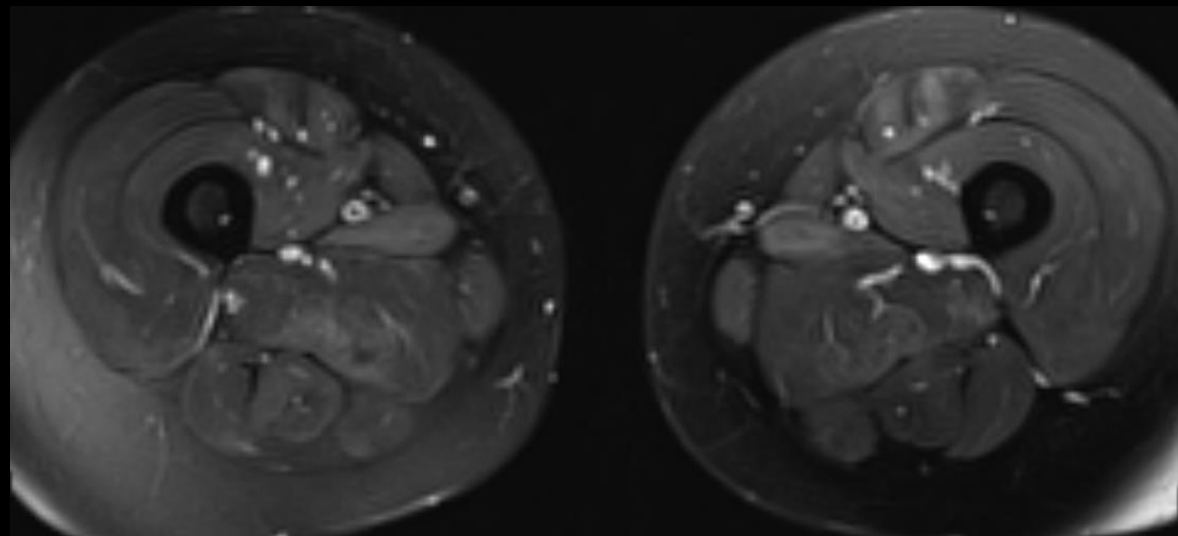
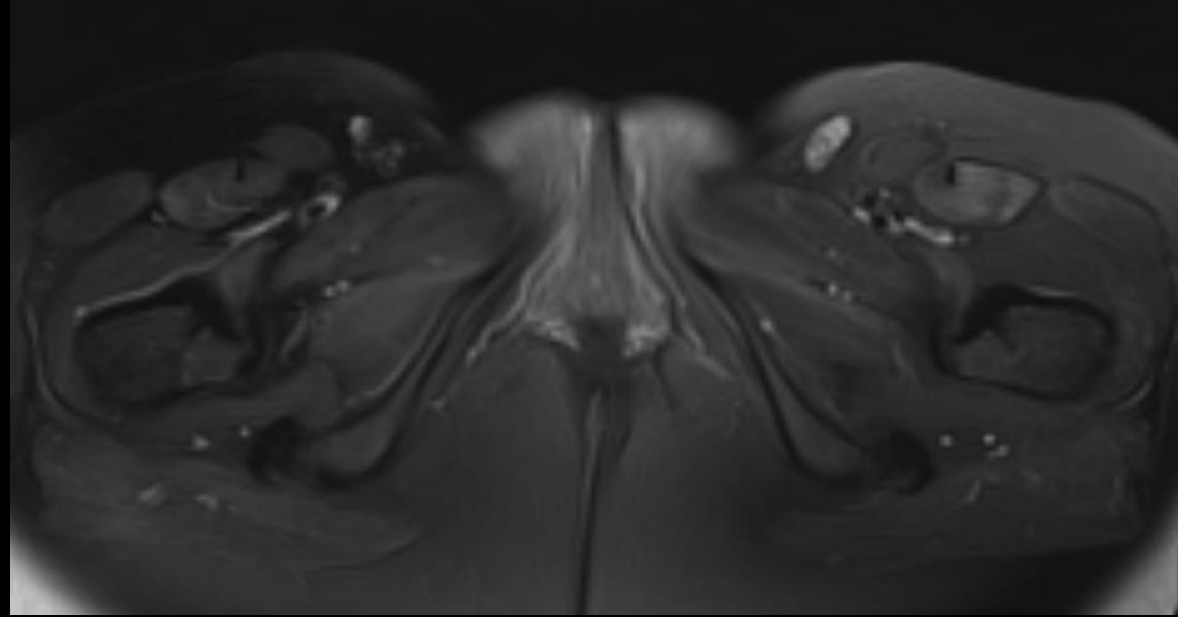
- Typical polymyositis (35% cases; 3rd-5th decade)
 - M>F (2:1)
 - Gradual weakness thigh, later upper extremity
- Typical dermatomyositis (25% cases; 5th-6th decade)
 - F>M; skin and muscle abnormalities
 - Upper extremity muscles/chest
- Typical dermatomyositis with malignancy
 - Over 40 years of age
 - Lung, prostate, pelvis (female), breast, GI

POLYMYOSITIS/DERMATOMYOSITIS CLINICAL

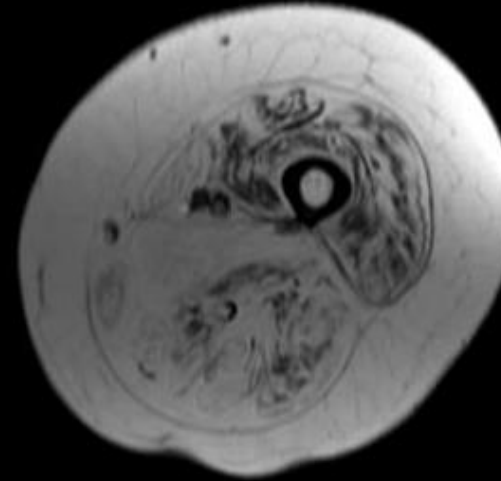
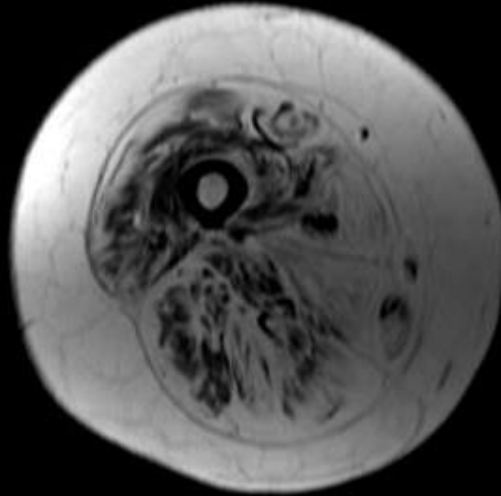
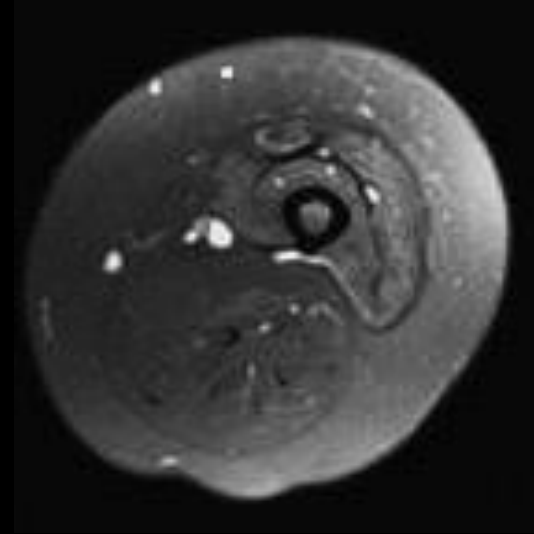
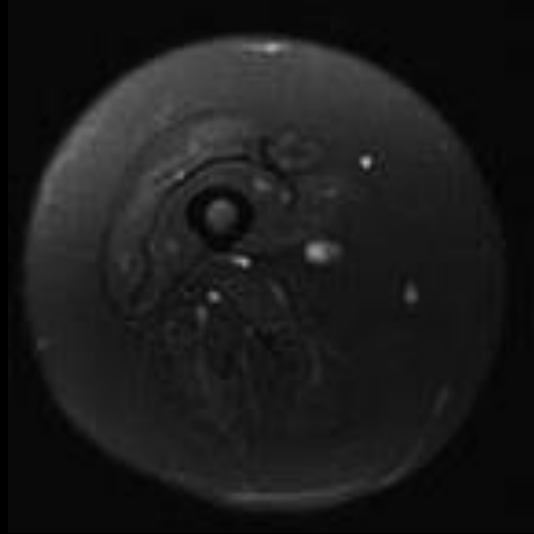
- Childhood dermatomyositis (20% cases)
 - 5-10 years; F>M
 - Proximal muscle weakness; skin edema/calcification
 - May be fulminant or slowly progressive
- Acute myolysis (3% cases; 1st–2nd decade)
 - Intermittent may be fatal
- Polymyositis with other collagen vascular disease (10%)

POLYMYOSITIS/DERMATOMYOSITIS IMAGING

- Soft tissue calcification – nonspecific
 - Along fascial/muscle planes (dermatomyositis)
- Arthralgia with subluxations
- MRI – T1W normal acutely later fat atrophy
 - T2W/STIR edema in involved muscles
 - Direct biopsy to affected muscles
 - Improvement delayed versus clinical
 - High signal rim about fascia (dermatomyositis)



Polymyositis



Polymyositis – Late (extensive fatty atrophy)

R
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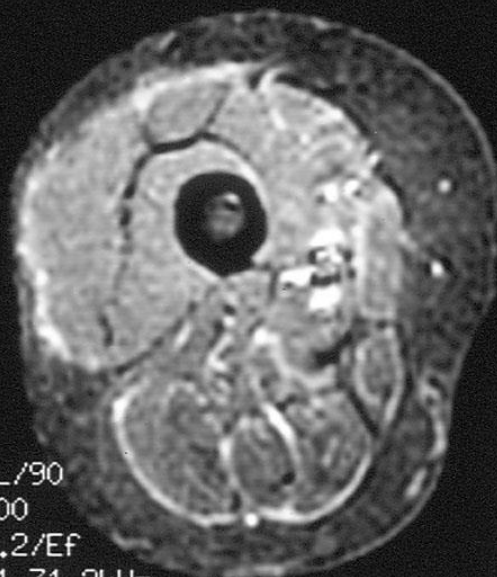


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TE:42.2/Ef
EC:1/1 31.2kHz
TI:150

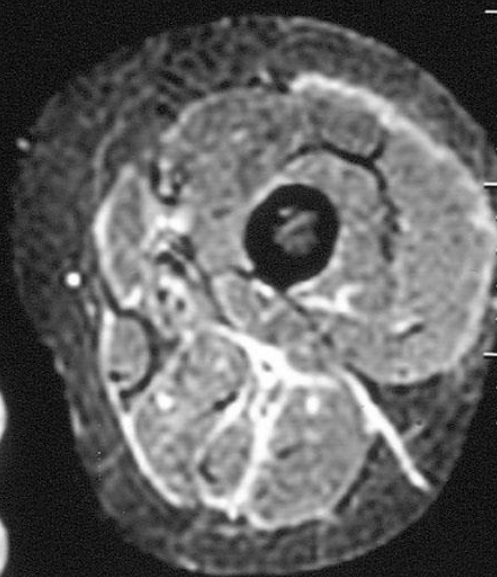


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T2



XL/90
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2.2/Ef
/1 31.2kHz
50



38x28.5

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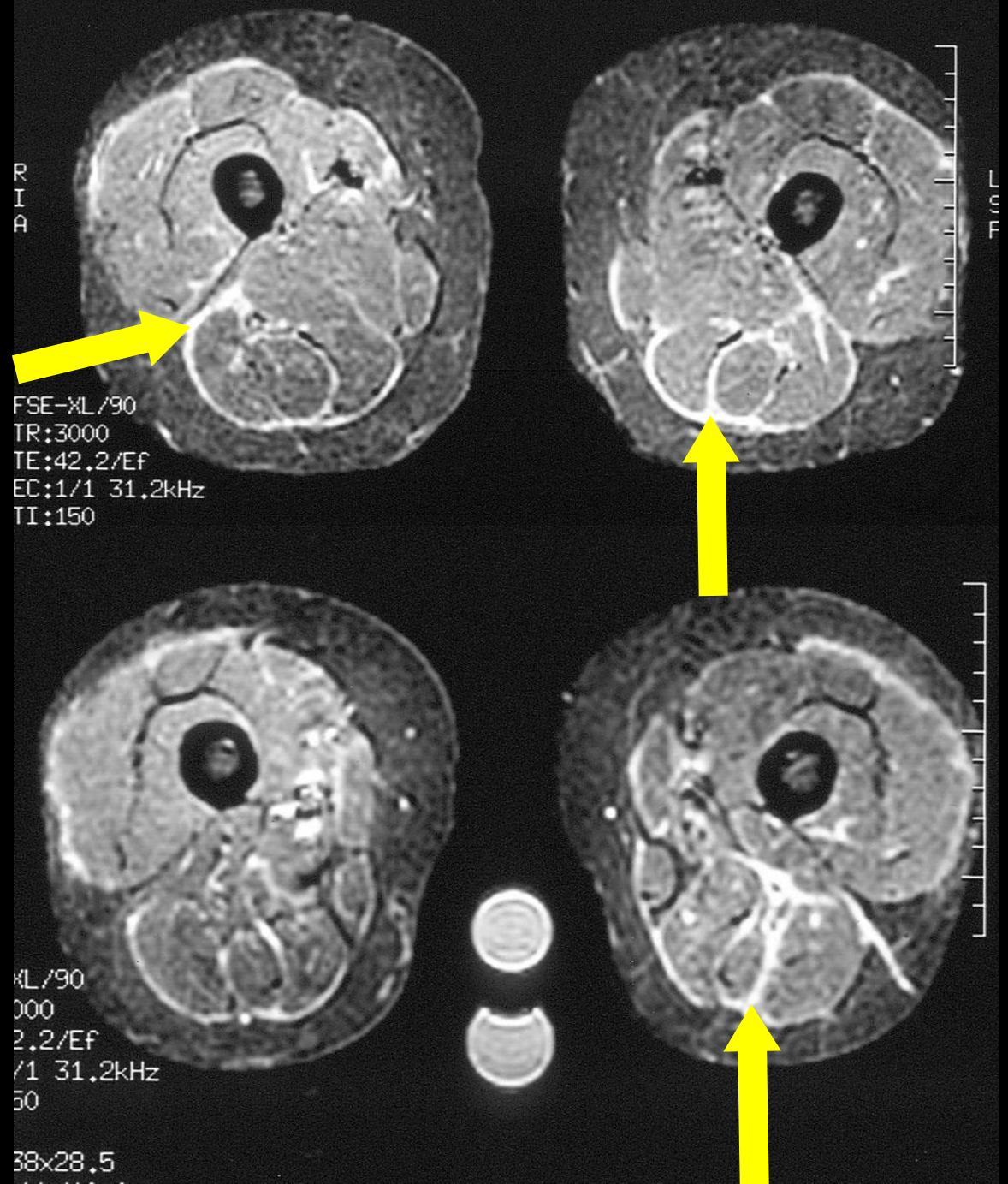
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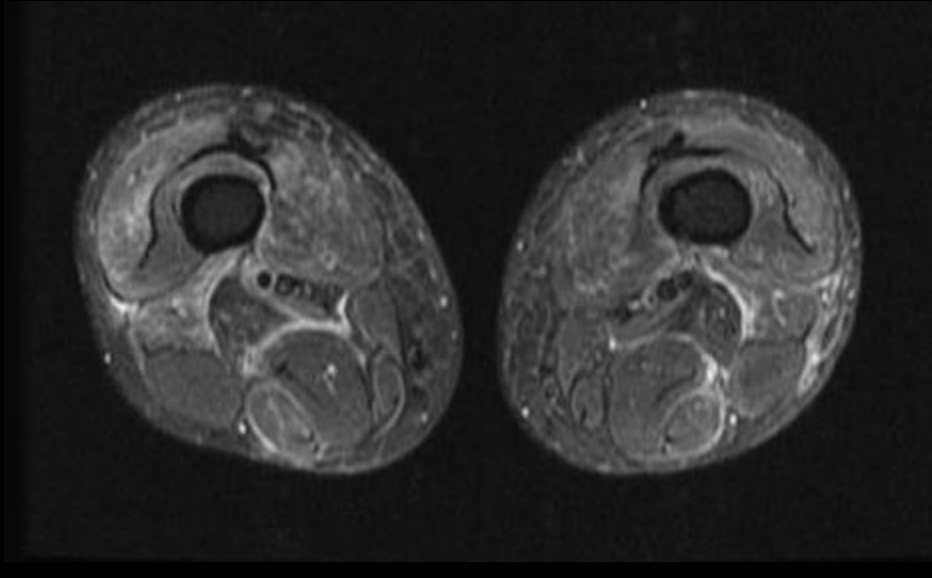
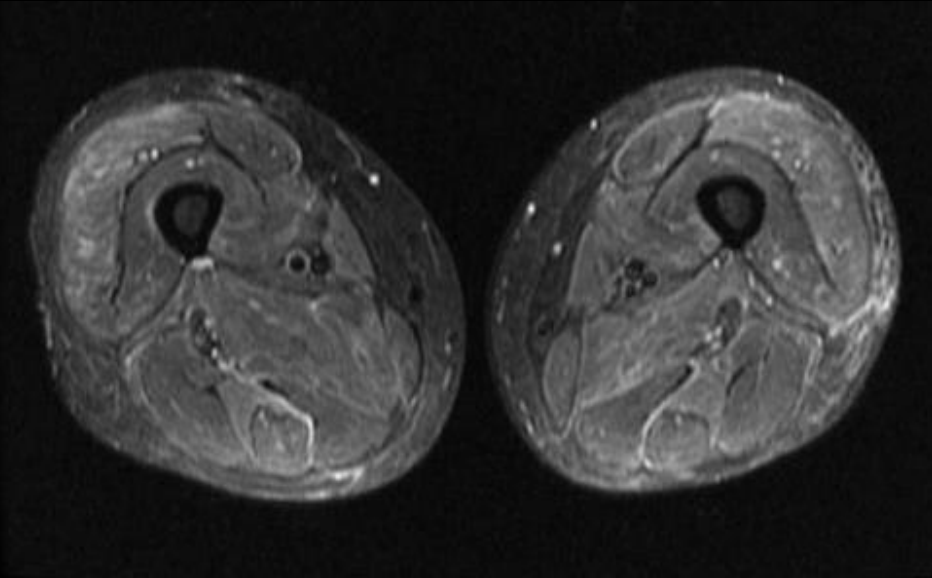
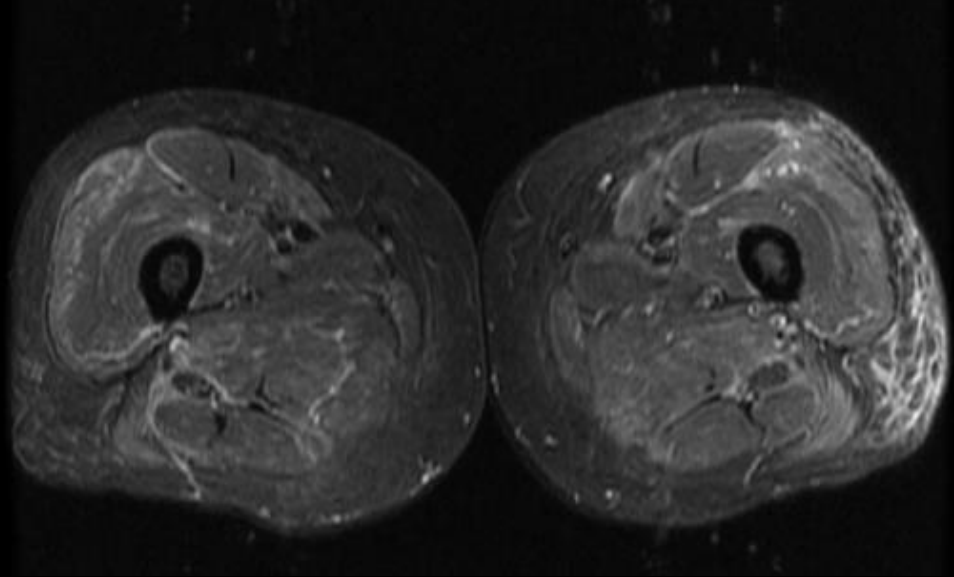
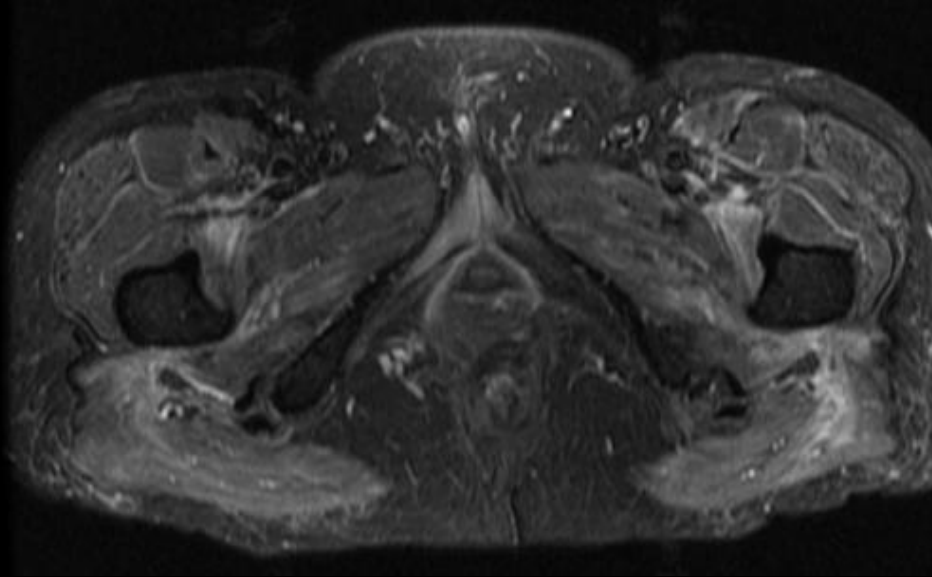
XL/90
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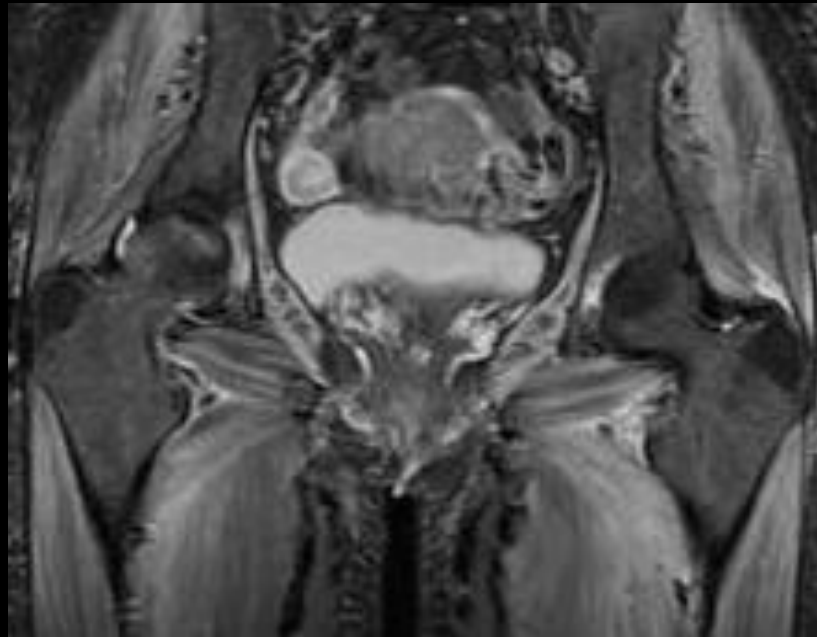
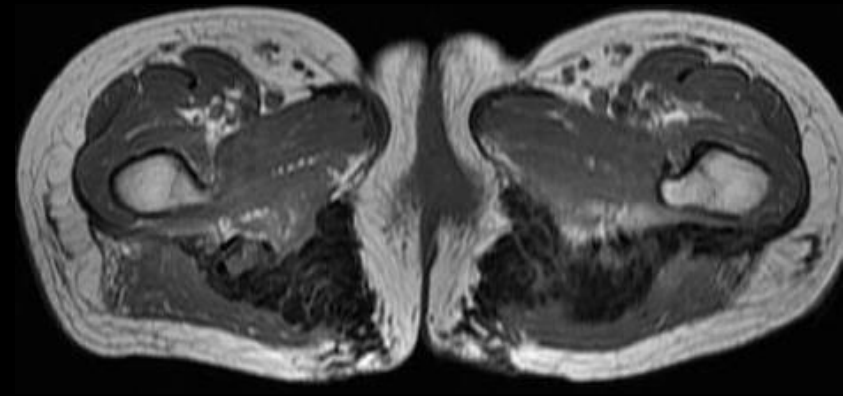
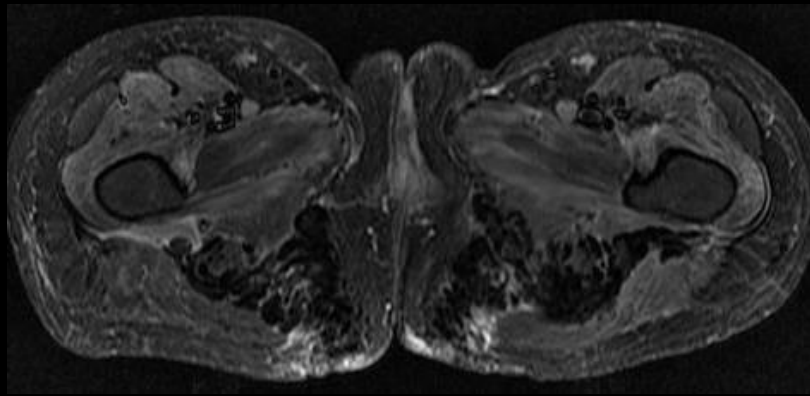




Dermatomyositis

Hx: Pelvic Pain

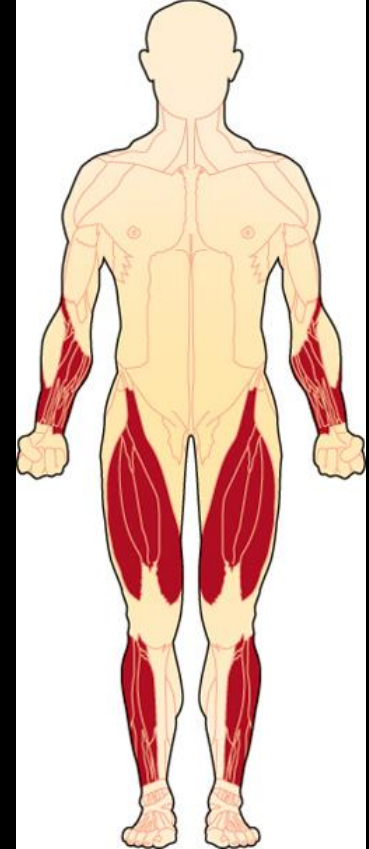


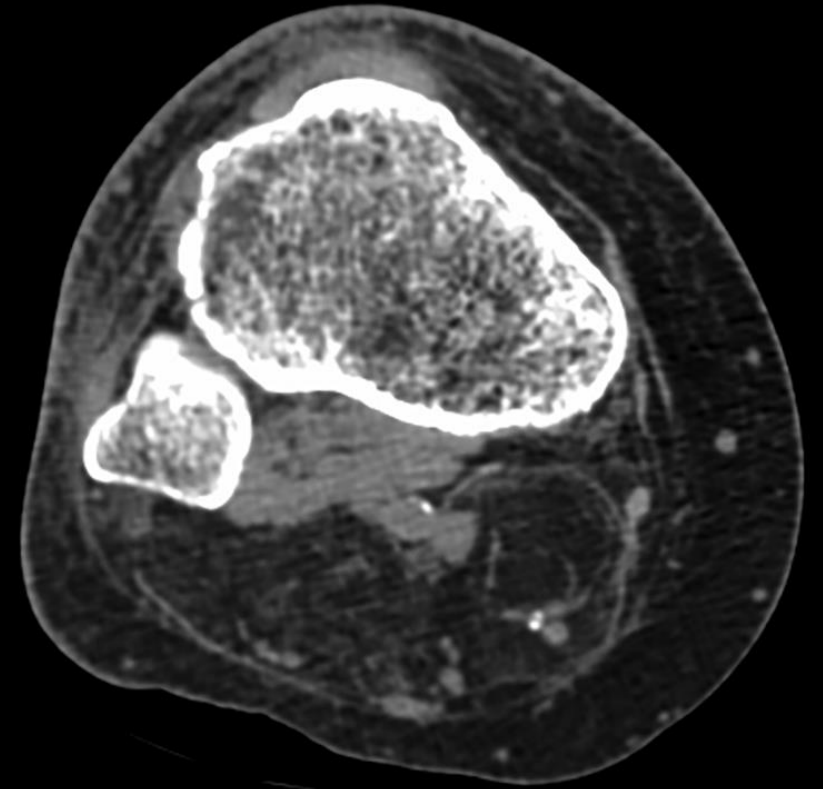
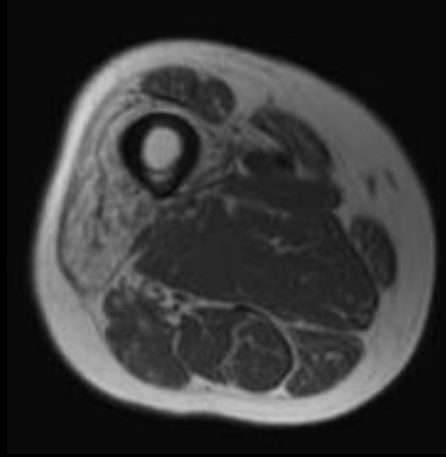
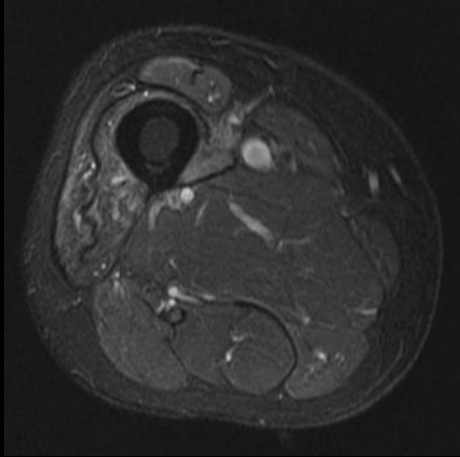
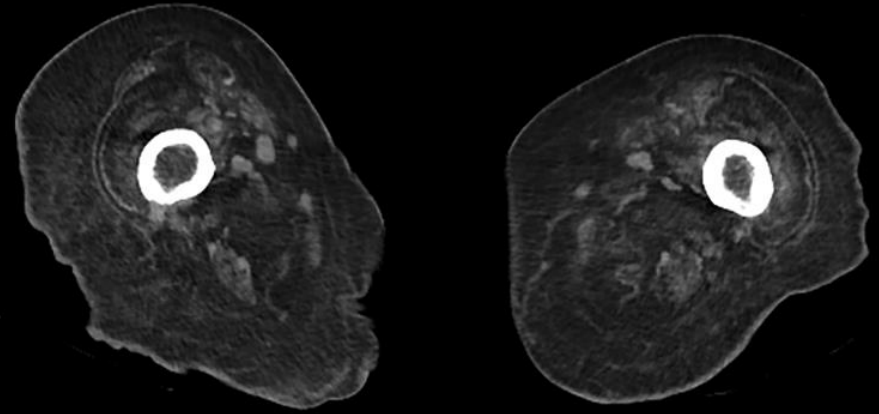
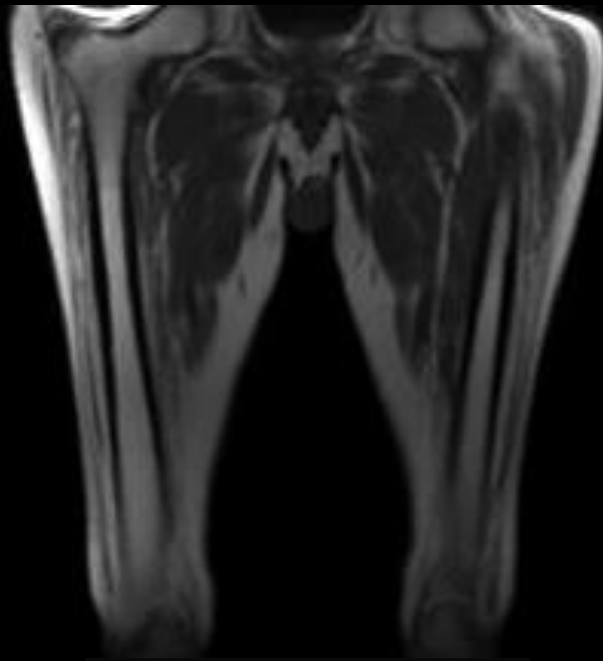
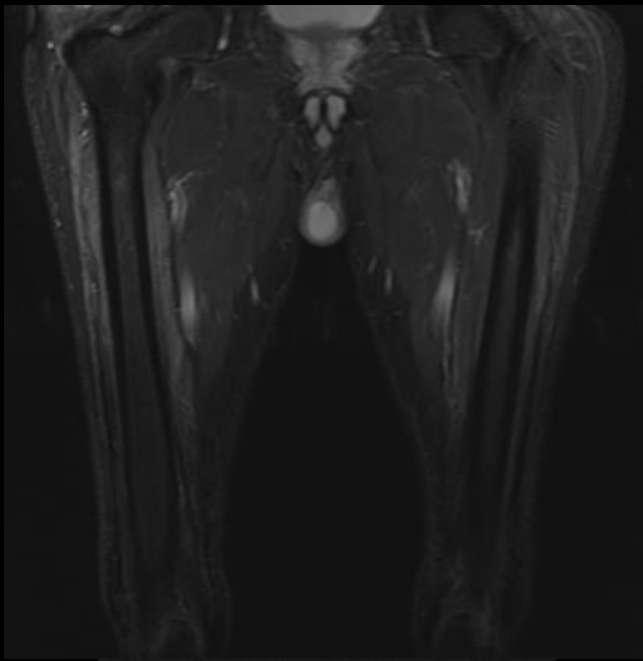


Dermatomyositis – extensive dystrophic calcification

Inclusion Body Myositis

- Elderly male
- Distal > proximal muscles
 - Medial gastrocs, FDP
- Inclusion of amyloid- β protein
- Refractory to treatment
- MRI
 - Anterior thigh compartment
 - Fatty atrophy/replacement > edema
 - Heterogeneous or focal edema and enhancement
- Fatty involvement ++ > PM/DM

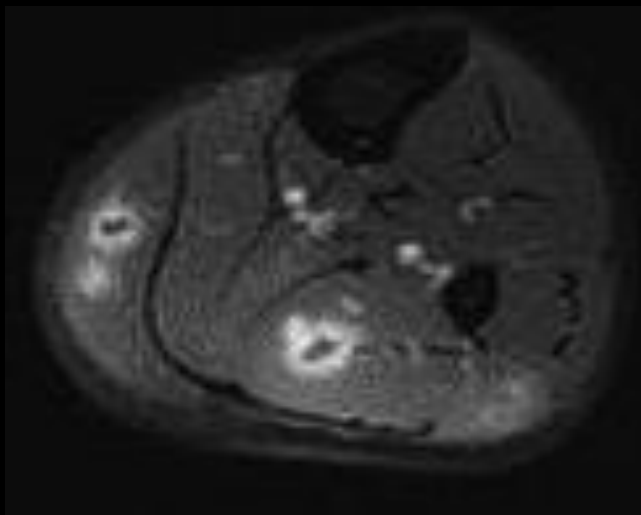
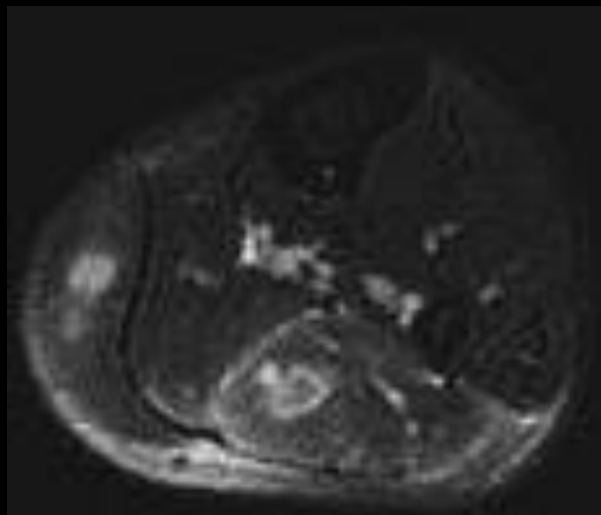




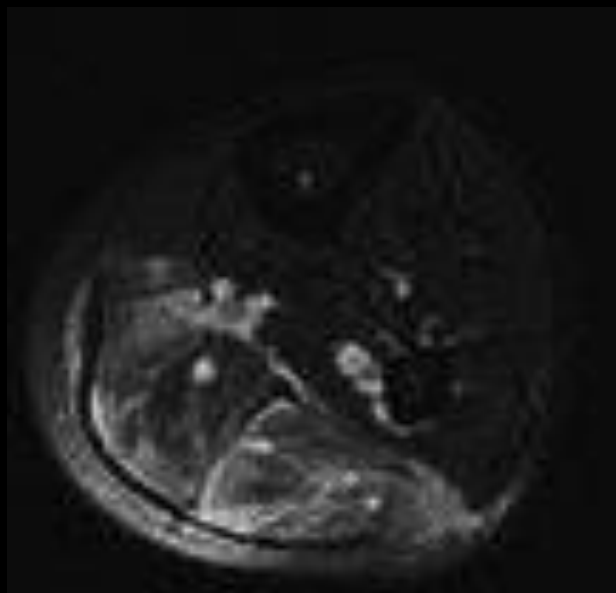
Inclusion Body Myositis – anterior thigh, fatty atrophy

Granulomatous and Vasculitic Disorders

- Granulomatous disease
 - Sarcoid
 - Crohn's
 - Behcet's
- May have more nodular appearance
 - Sarcoid: **central star-shaped low T2** signal with peripheral increased SI = "dark star" (AKA stars and stripes)
 - Behcet's: **central necrosis** with peripheral edema and enhancement



Post-Gad



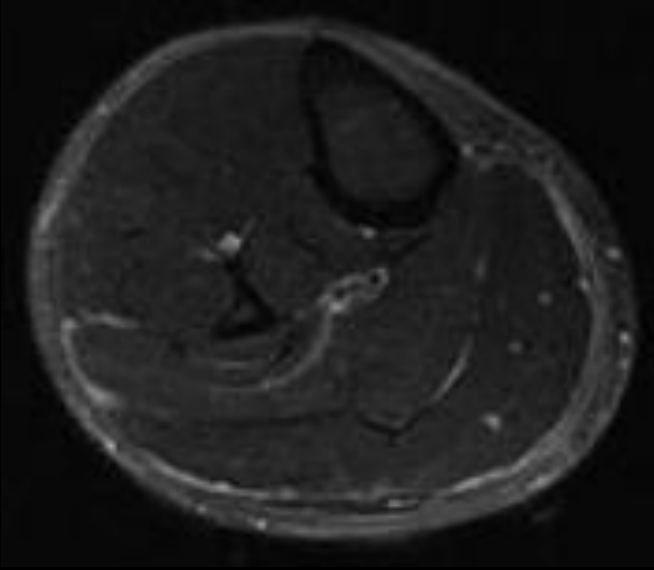
Sarcoid Myositis
– “dark star”

Eosinophilic Fasciitis (Shulman Disease)

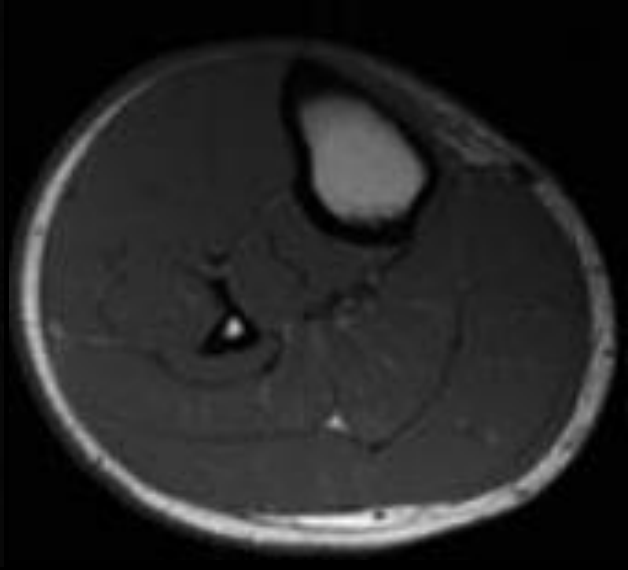
- Scleroderma like disorder
- Extremity swelling, stiffness, fatigue
 - Typically acute and rapidly progressive
 - May be associated with strenuous activity
 - 4th – 5th decade
- Peripheral eosinophilia
- Forearms and calves
- Diagnosis: Full-thickness skin to muscle biopsy
- Responsive to corticosteroid therapy

Eosinophilic Fasciitis

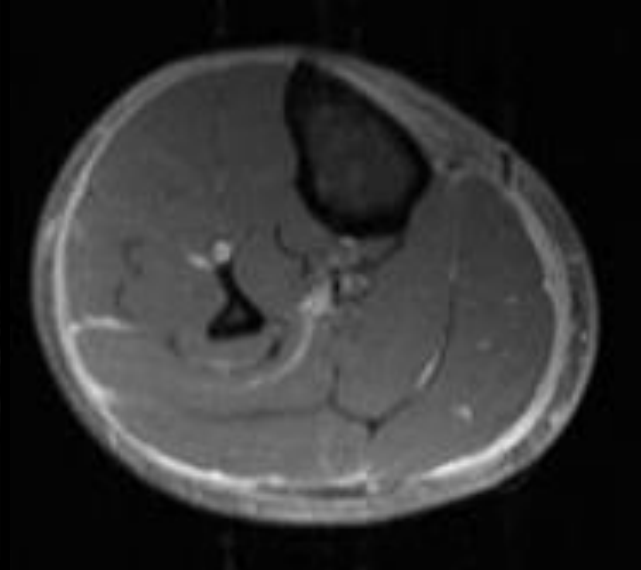
- MRI
 - Marked increased T2 signal fascia—**Thick!**
 - Marked fascial enhancement
 - +/-Perifascial muscle edema, SQ
 - **Muscle changes much less marked than fascia involvement**
 - Usually resolves with treatment



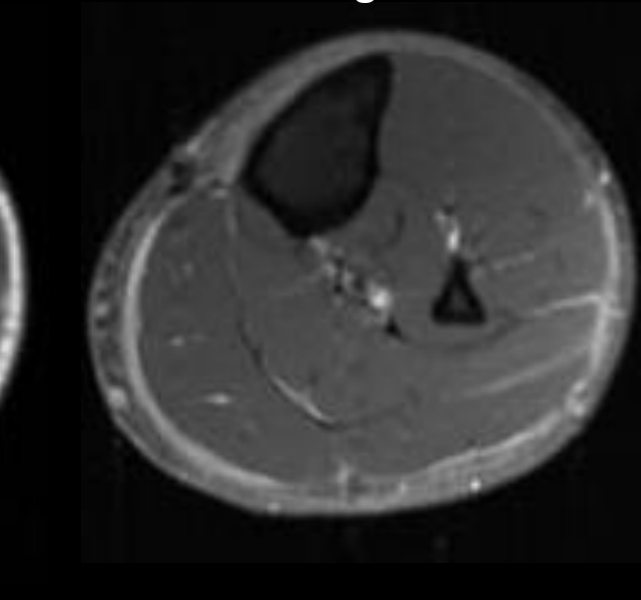
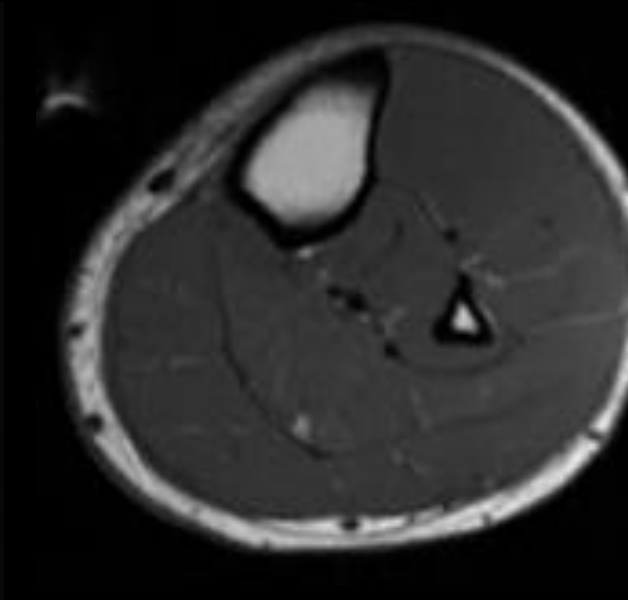
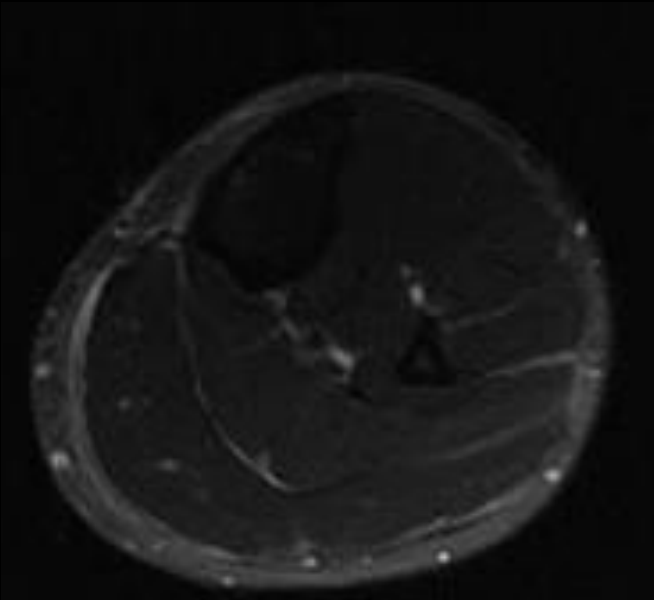
T2 fatsat



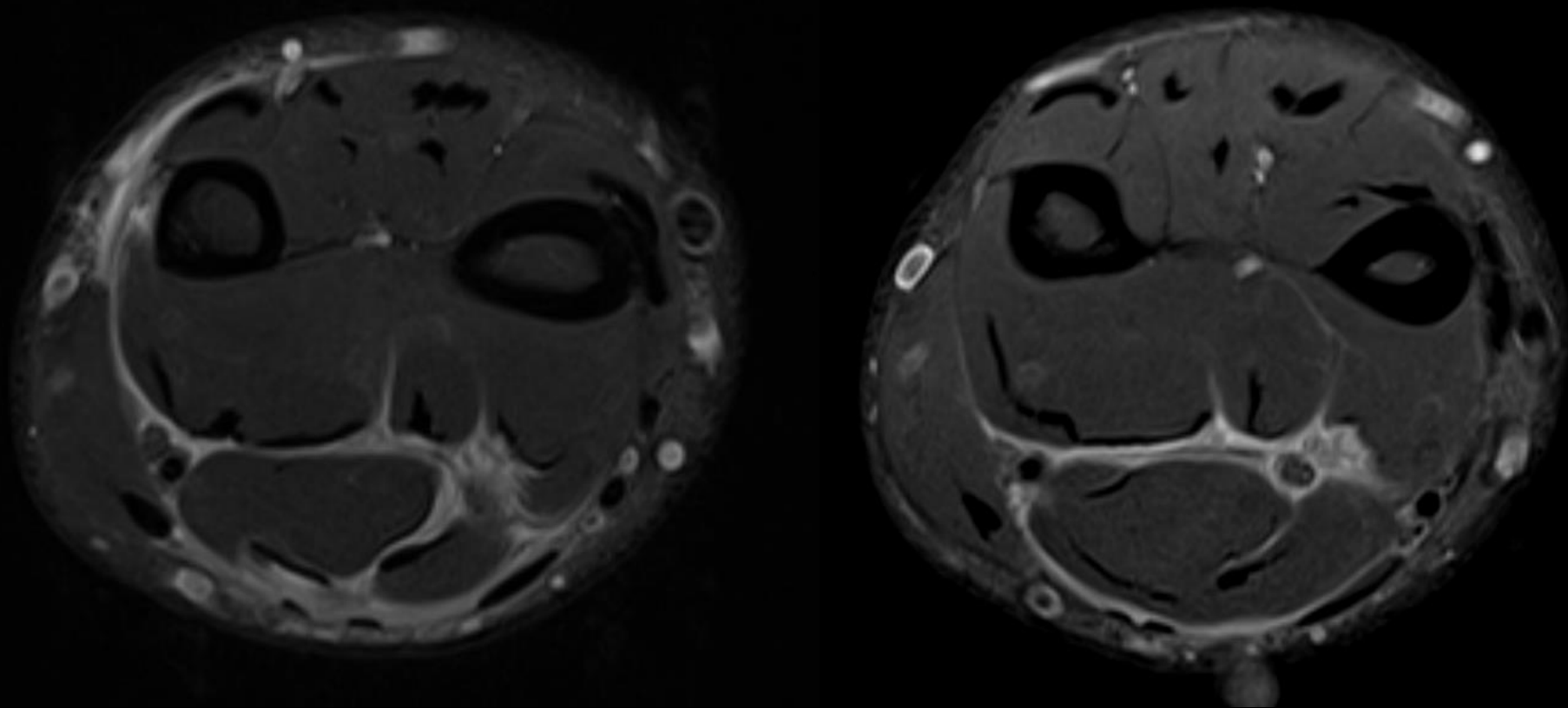
T1



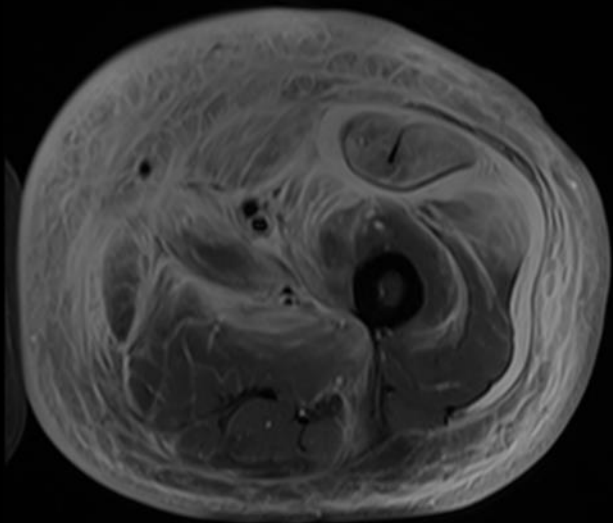
Post gad



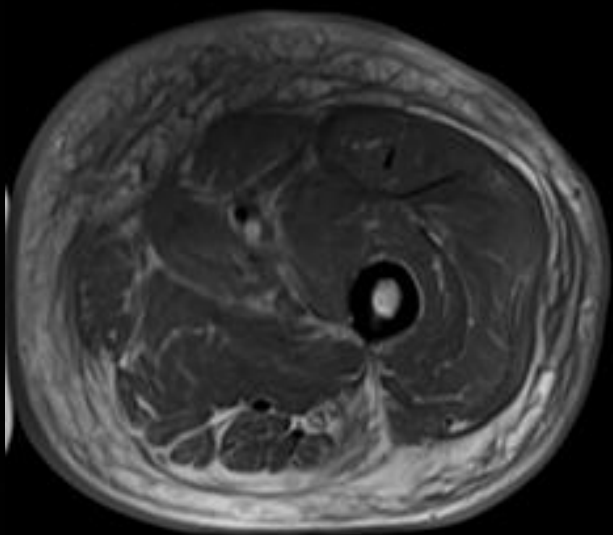
Eosinophilic Fasciitis— fascia involvement



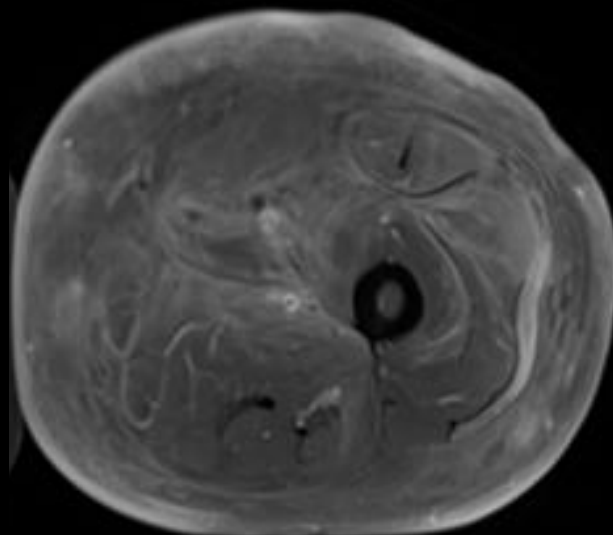
Eosinophilic Fasciitis – forearm



T2 fatsat

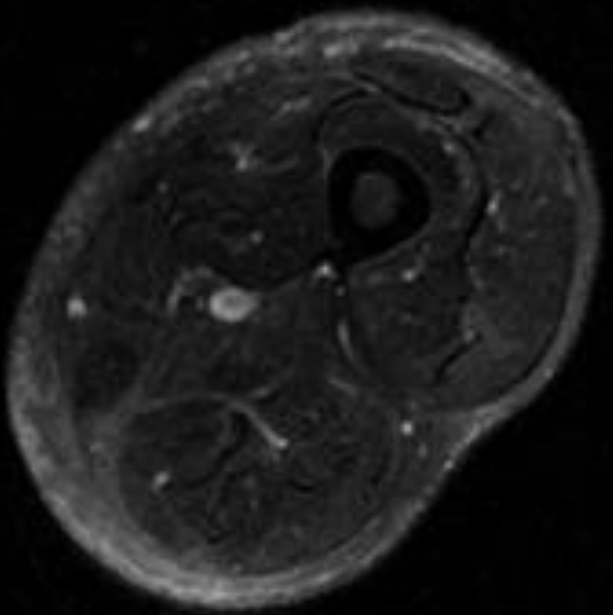


T1



Post gad

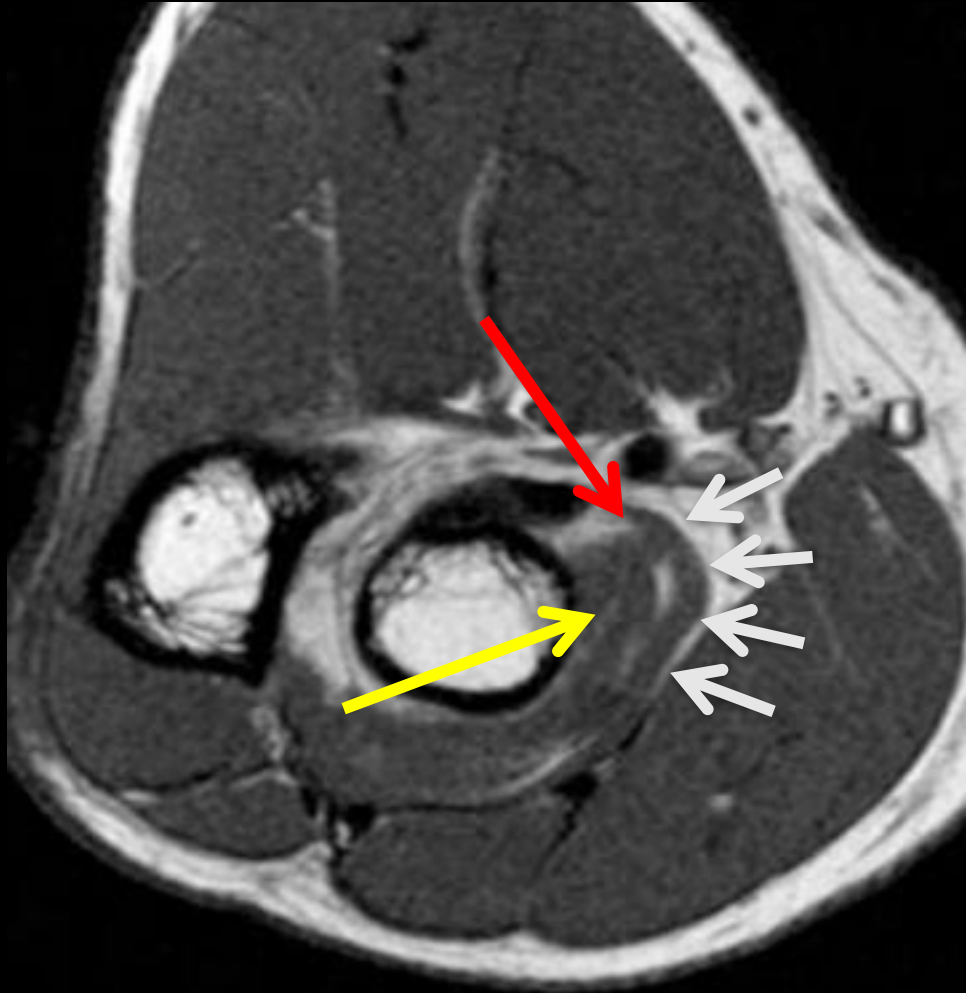
Eosinophilic Fasciitis
– thigh



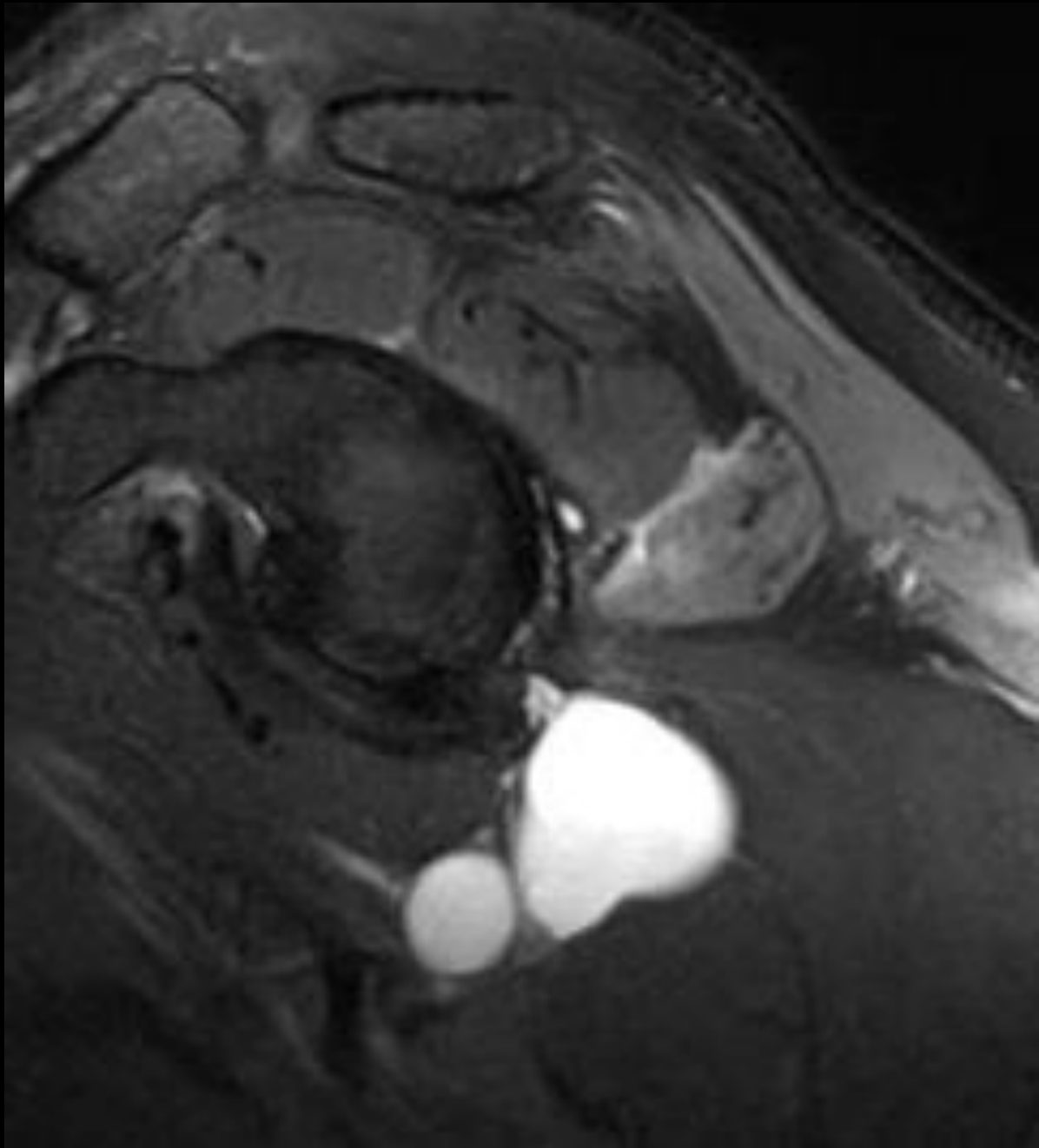
Muscle Denervation

- Causes
 - Entrapment neuropathies
 - Neuritis
 - Spinal cord injury
 - Polio
- **Shifting** of intracellular water to extracellular
- Commonly **2-4 weeks** after denervation
 - May be seen as early as 1st week
 - No collections
- **Distribution conforming to nerve innervation**

PIN (Supinator) Syndrome



- PIN of the radial nerve
- Supinator Deep Head
- Supinator Superficial Head
- Arcade of Frohse
 - AKA supinator arch
 - most superior part of the superficial supinator
 - fibrous arch over the PIN

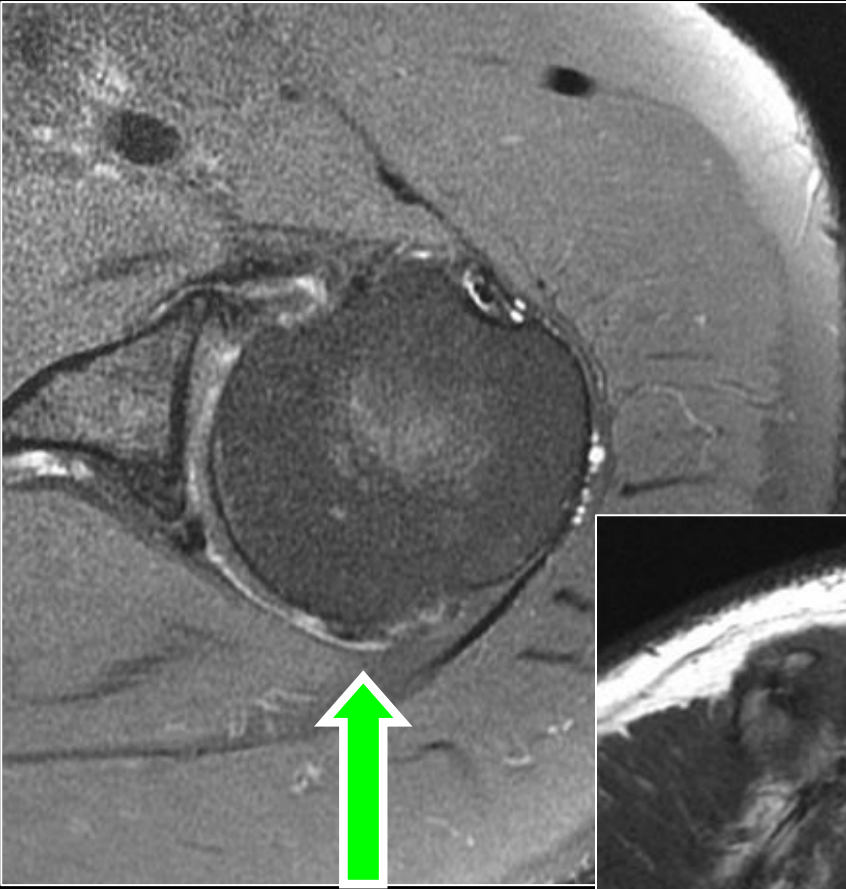


Quadrilateral Space Syndrome

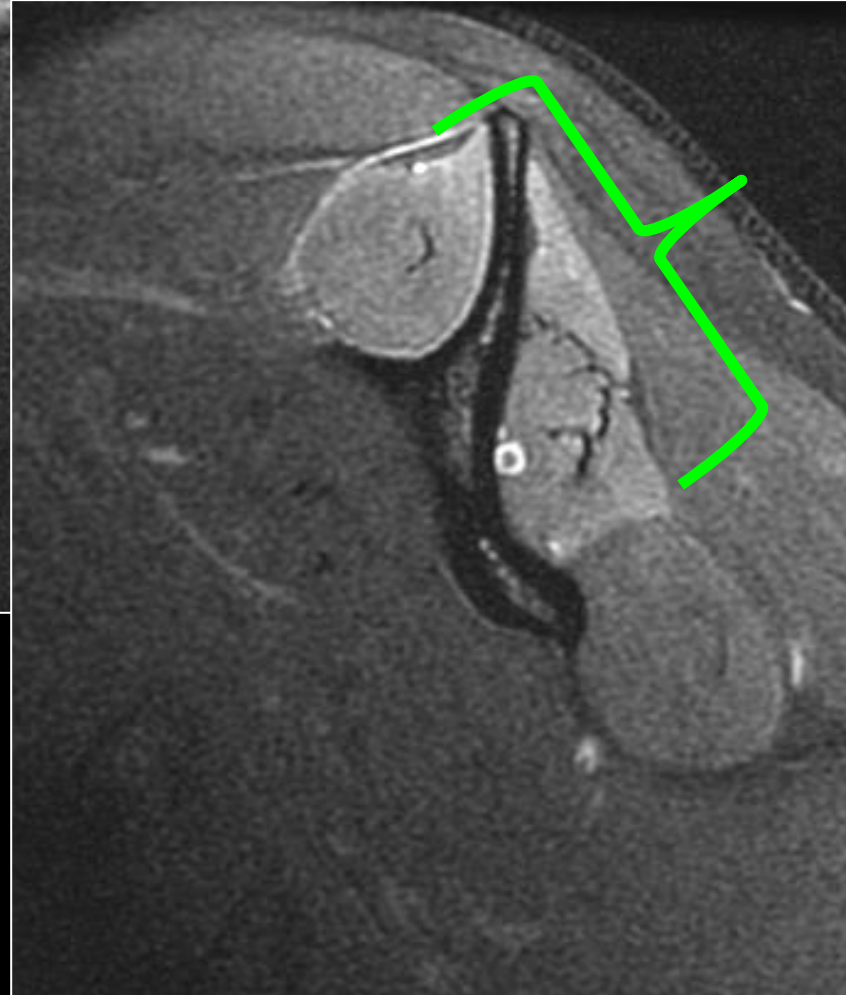
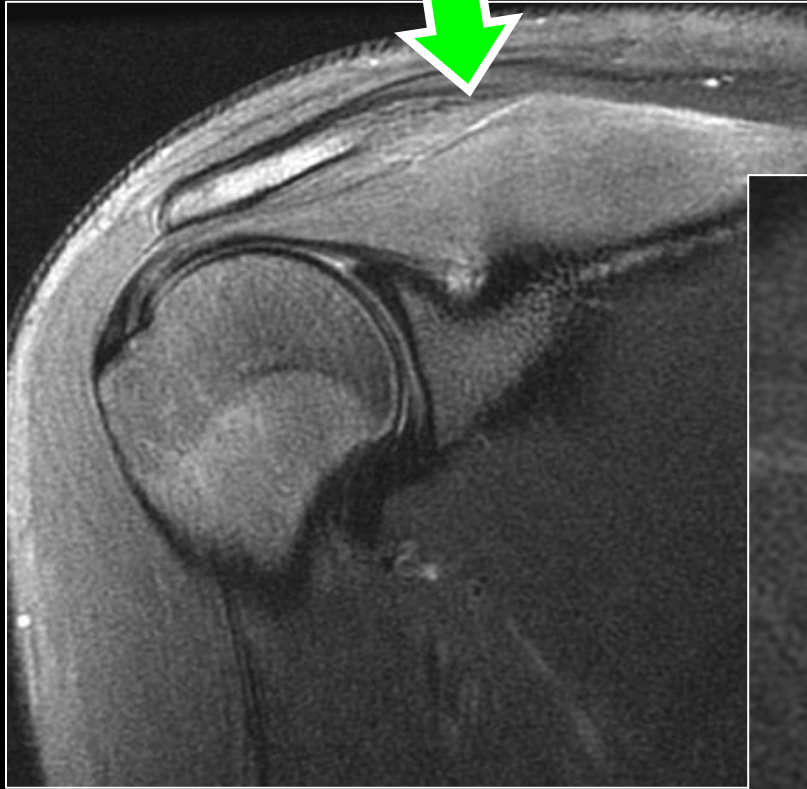
- Compression of the axillary nerve
- Innervation to the teres minor and deltoid
- 20-40 yo, M > F
- Active patients, esp. overhead athletes
- Fibrous bands in QS; paralabral cysts, fracture, masses

Isolated Teres Minor Atrophy

- 1-5% of shoulder MR scans
- Fascial sling?
- Rotator cuff tears and/or DJD
 - → humeral head decentering, irritate T.m. branch of axillary nerve
 - Chronic atrophy
- **T.m. atrophy negatively affects rTSA outcomes**



Parsonage Turner Syndrome



- → sudden onset of severe pain
- Mimics suprascapular neuropathy
- ~ 1/2 involve > 2 muscles
- 90%: SST & IST (upper trunk of brachial plexus)
- Deltoid next most common

Muscle Denervation

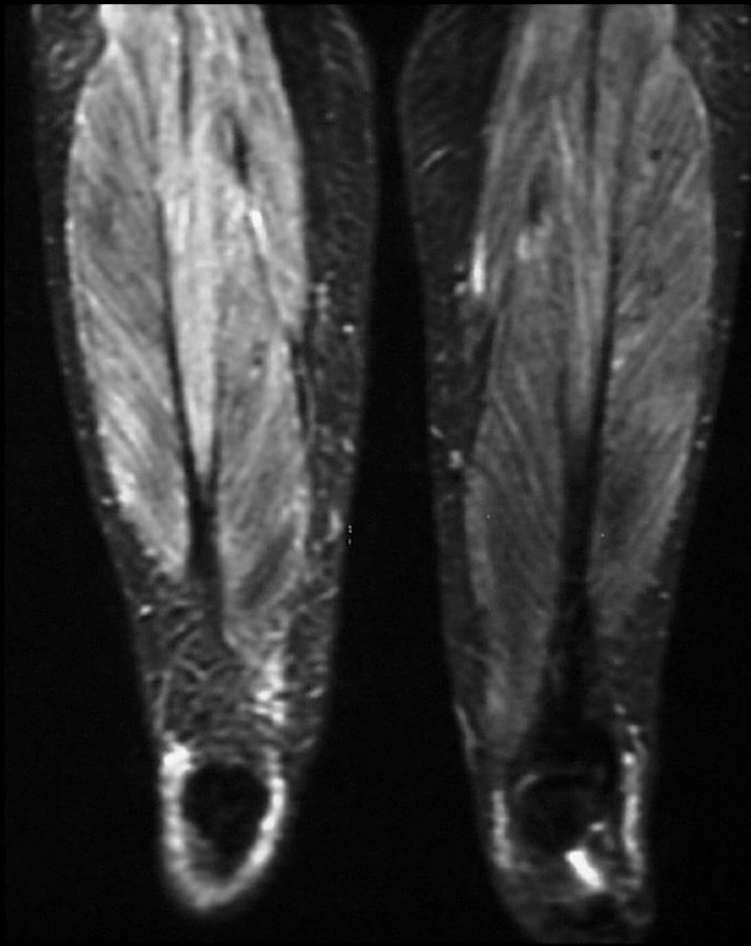
- Role of MRI
 - Assess for surgically treatable cause
 - Assess for chronic changes / fatty infiltration
- Combine with electrophysiological studies to narrow point of injury

Myonecrosis

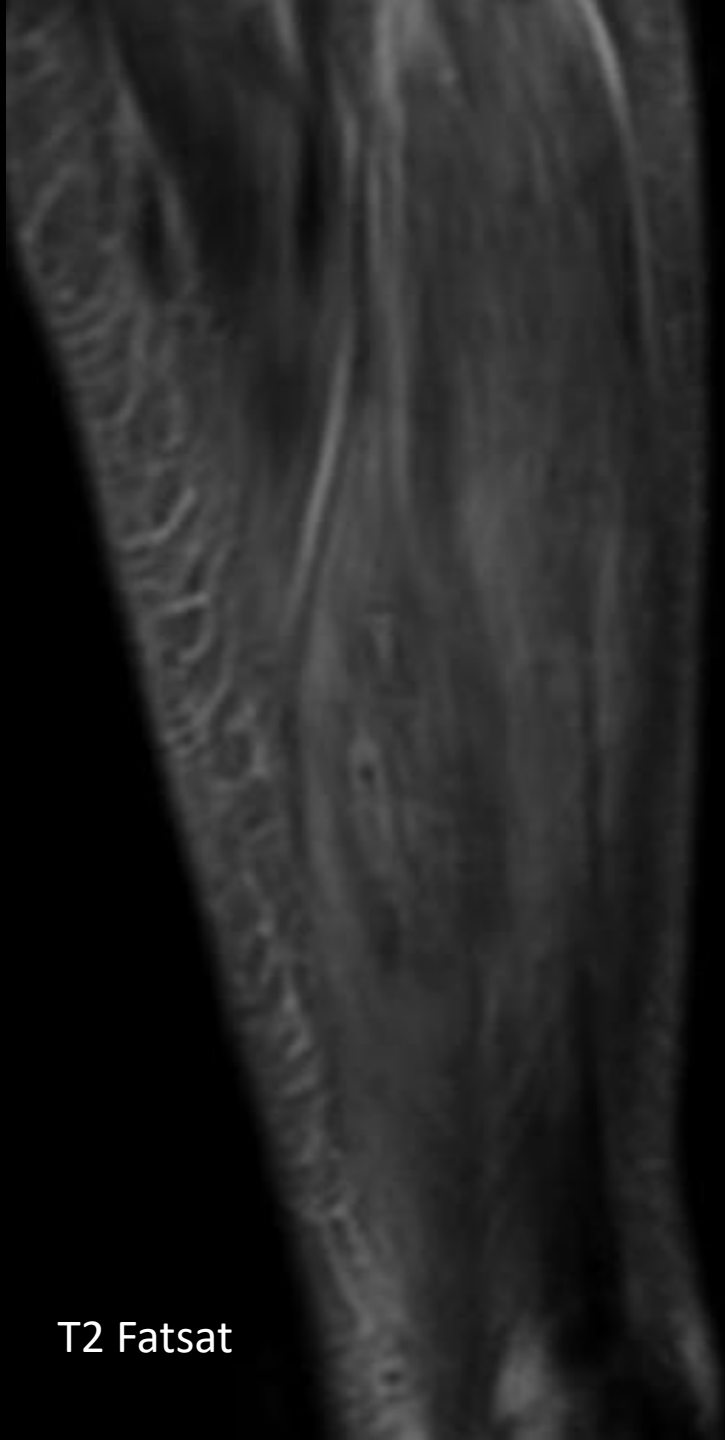
- Causes
 - Idiopathic
 - Diabetes
 - Sickle cell
 - Compartment syndrome
 - Crush injury

Diabetic Myonecrosis

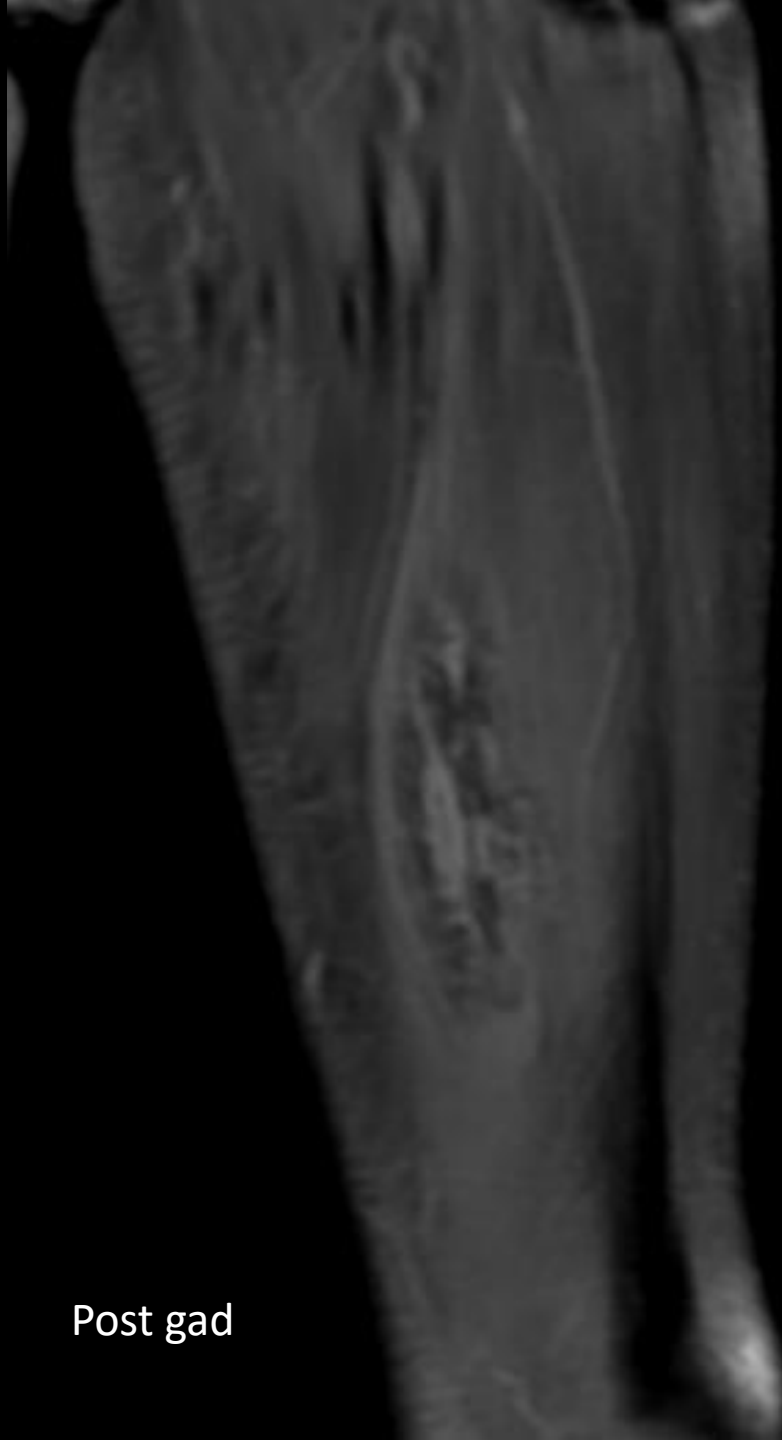
- Poorly controlled diabetes
- Clinical features
 - Pain: typically thigh muscles
 - Low grade fever Hx. -?infectious
- MRI
 - Lower extremity > upper esp. anterior compartment
 - Muscle edema
 - Maintained architecture on T1
 - Fascia: mild displacement, edema
 - Peripheral / serpentine enhancement



Diabetic Myonecrosis – Muscle edema



T2 Fatsat



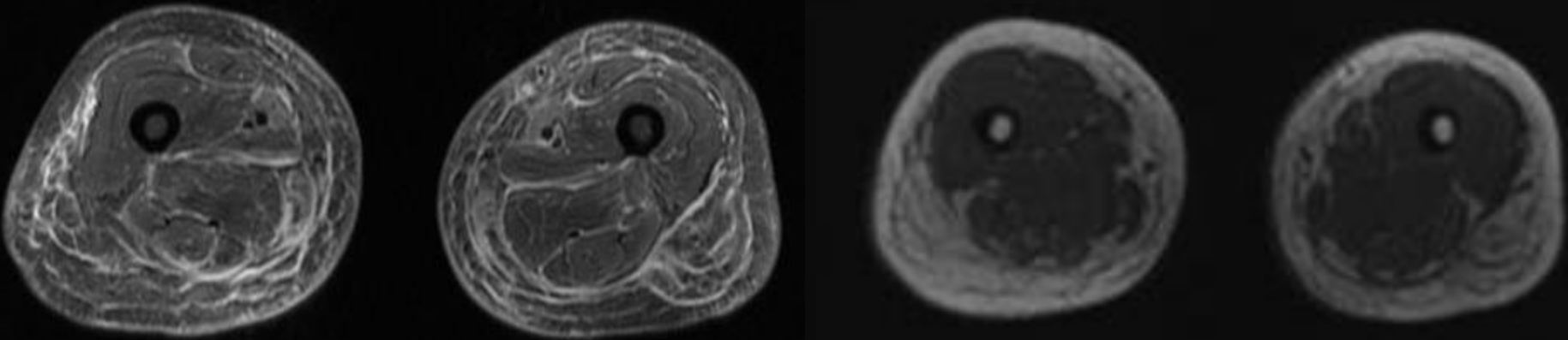
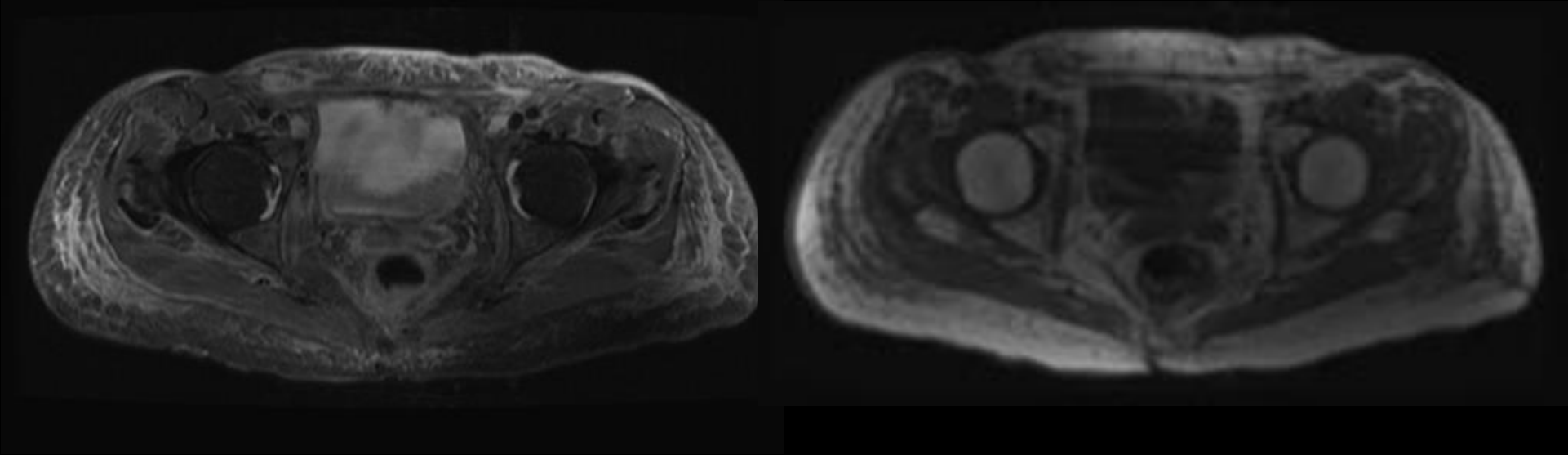
Post gad

Graft Versus Host Disease

- Allogenic stem cell transplantation
 - Has been describe in abdom organs (liver, sm. bowel)
- Focal necrosis with massive lymphocyte infiltration
- > 2-3 months post transplant
- Skin/subcutaneous induration and plaques
 - Lichenoid type
 - Sclerodermatous type
- May lead to joint contractures

Graft Versus Host Disease

- MRI
 - Thighs > calves > pelvis > arms
 - Skin thickening
 - Subcutaneous septal thickening and edema
 - Fascial thickening and edema
 - Patchy or diffuse muscle edema
 - Less common than subcutaneous/fascial change



Graft vs Host –
Skin thickening & Subcutaneous septal thickening and edema

Role of MRI in Non-Traumatic Muscle Pathologies

- Etiology:
 - Distribution
 - ? one compartment, bilateral
 - Proximal vs distal
 - ? Nerve distribution
 - Subcutaneous tissues / fascia
 - History is key
 - Diabetes, CTD, radiation, exertional
- Guide biopsy
- Monitor treatment

Conclusion

- Most injuries at predictable locations
- Imaging
 - Atypical features
 - Assessment of severity
 - ?Prognostic information
- Non-traumatic
 - Generally non-specific
 - History, distribution
 - Guide biopsy