Lisfranc Injuries

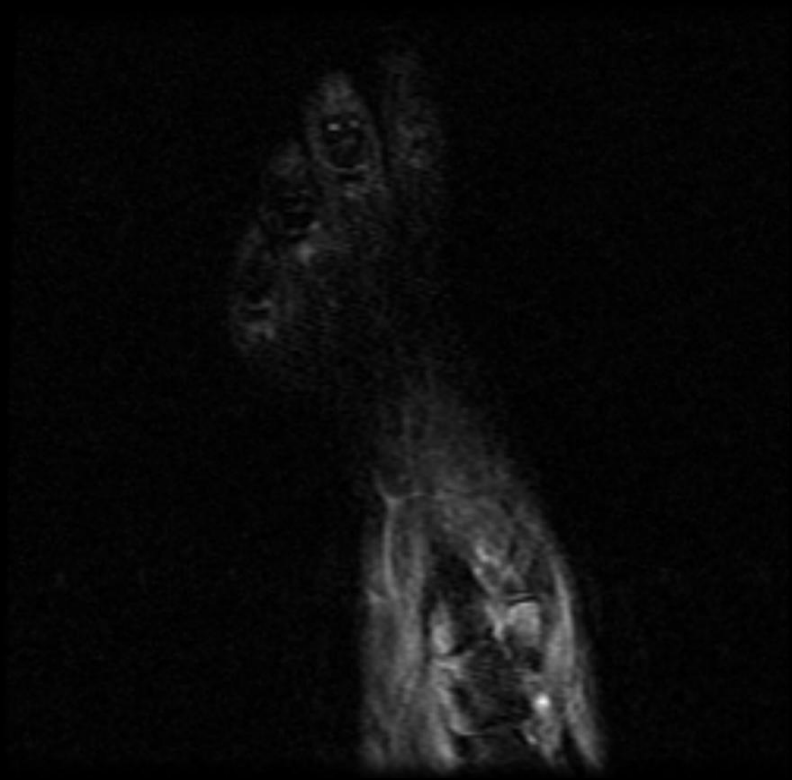
Omar Qureshi

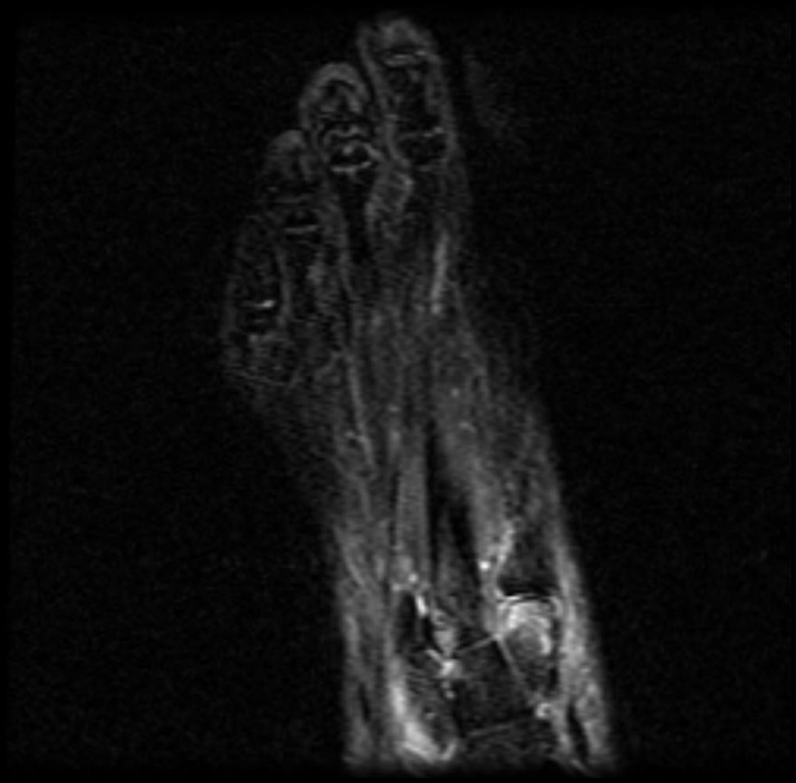
6.25.2015

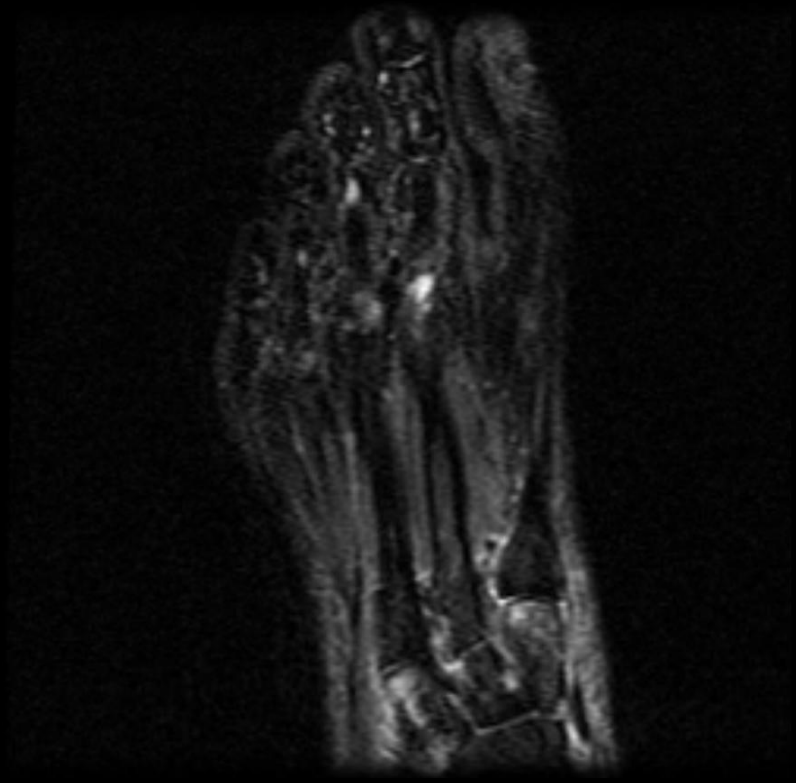
37 year old female

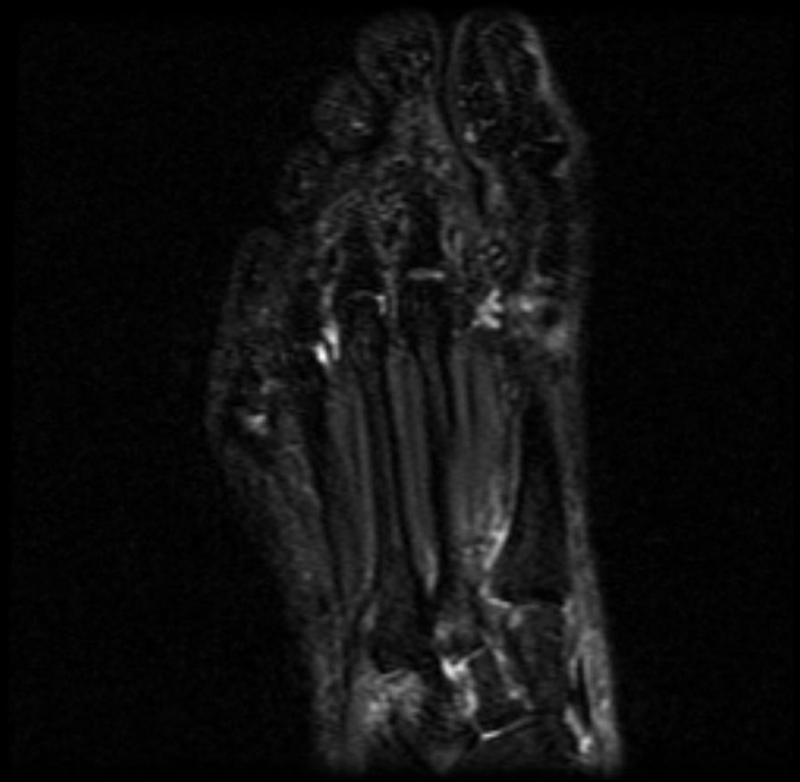
Rule out stress fracture

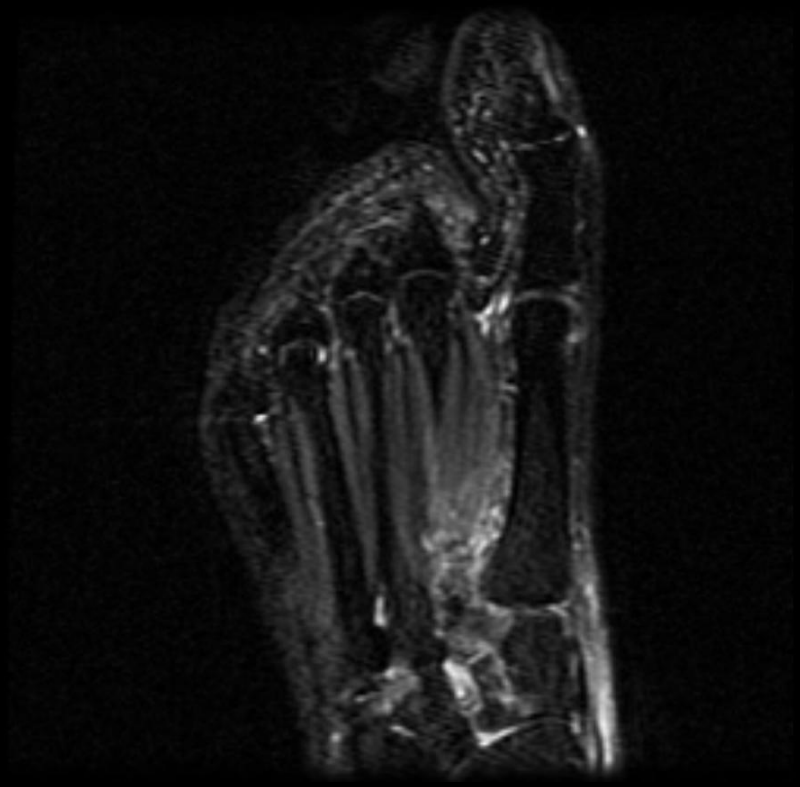

R
WTF

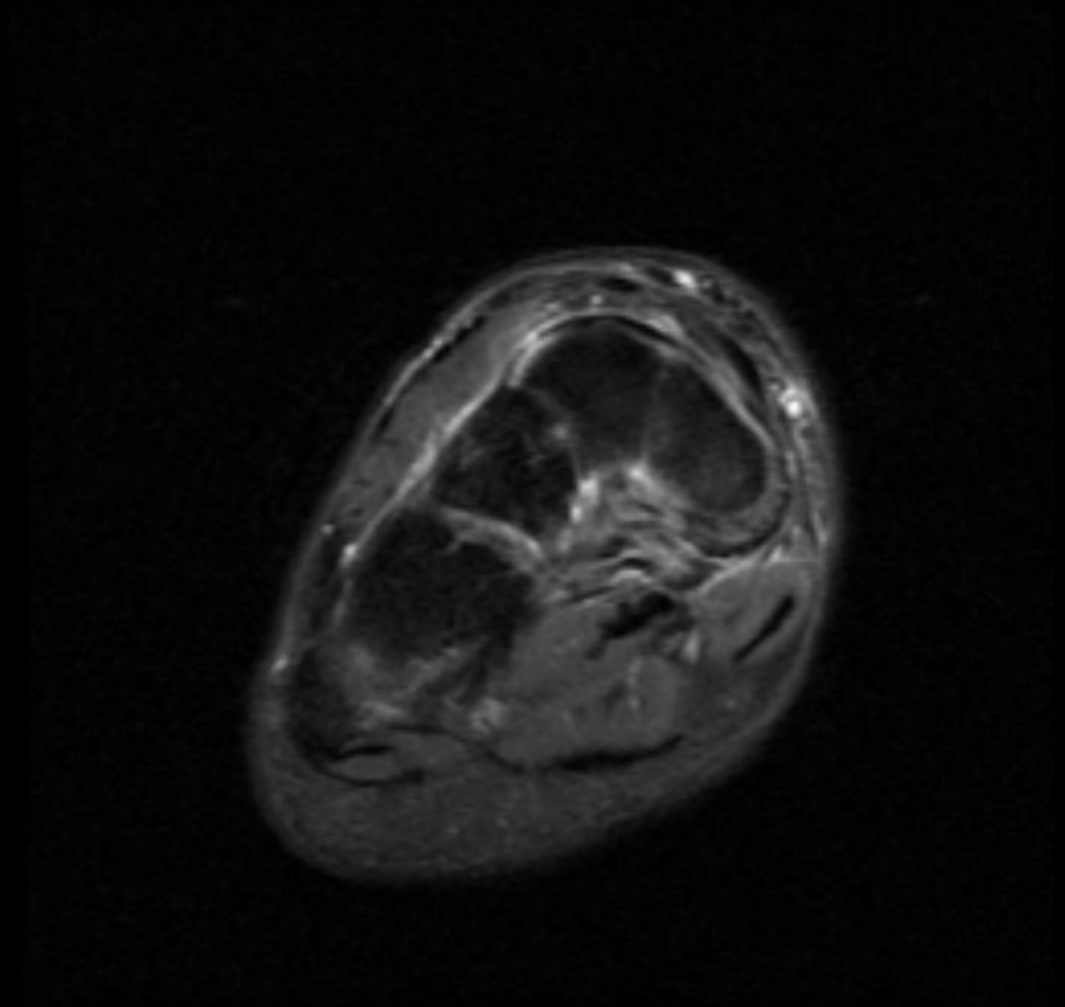


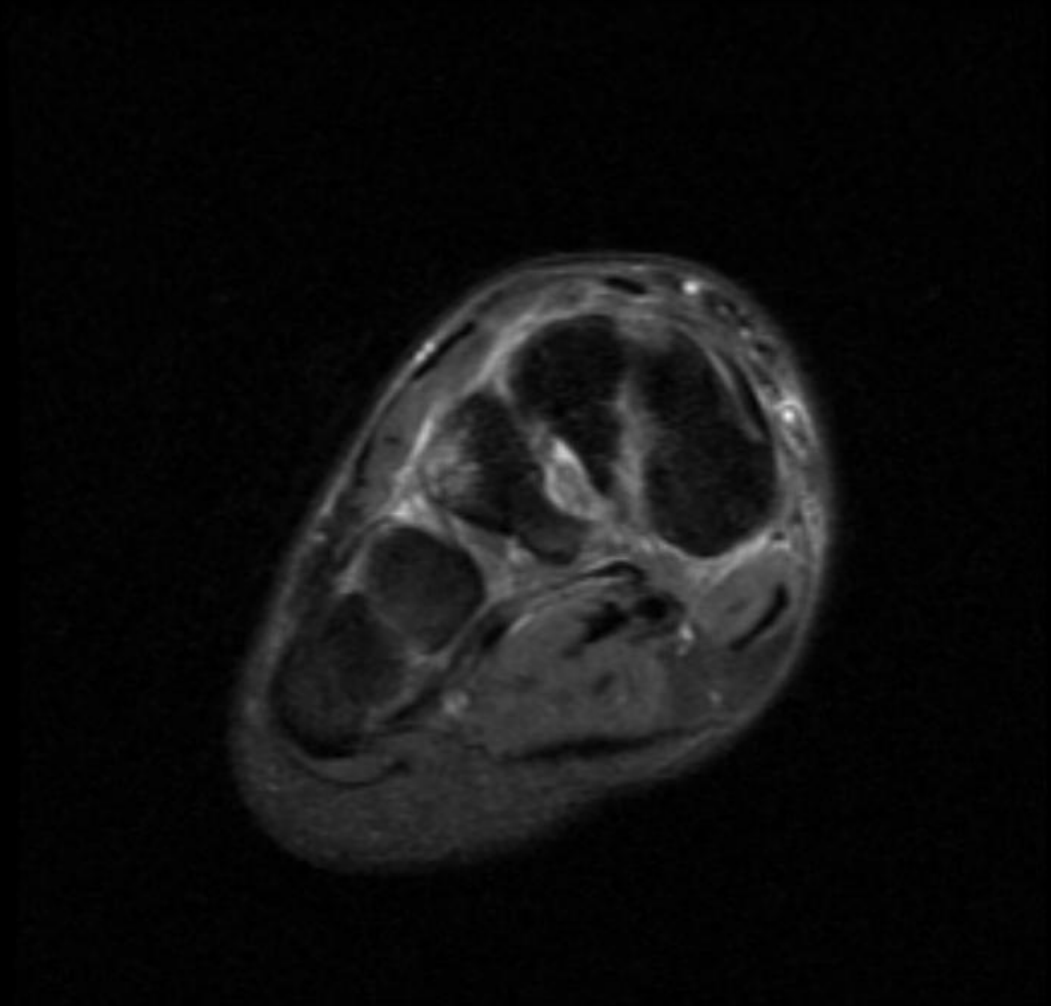


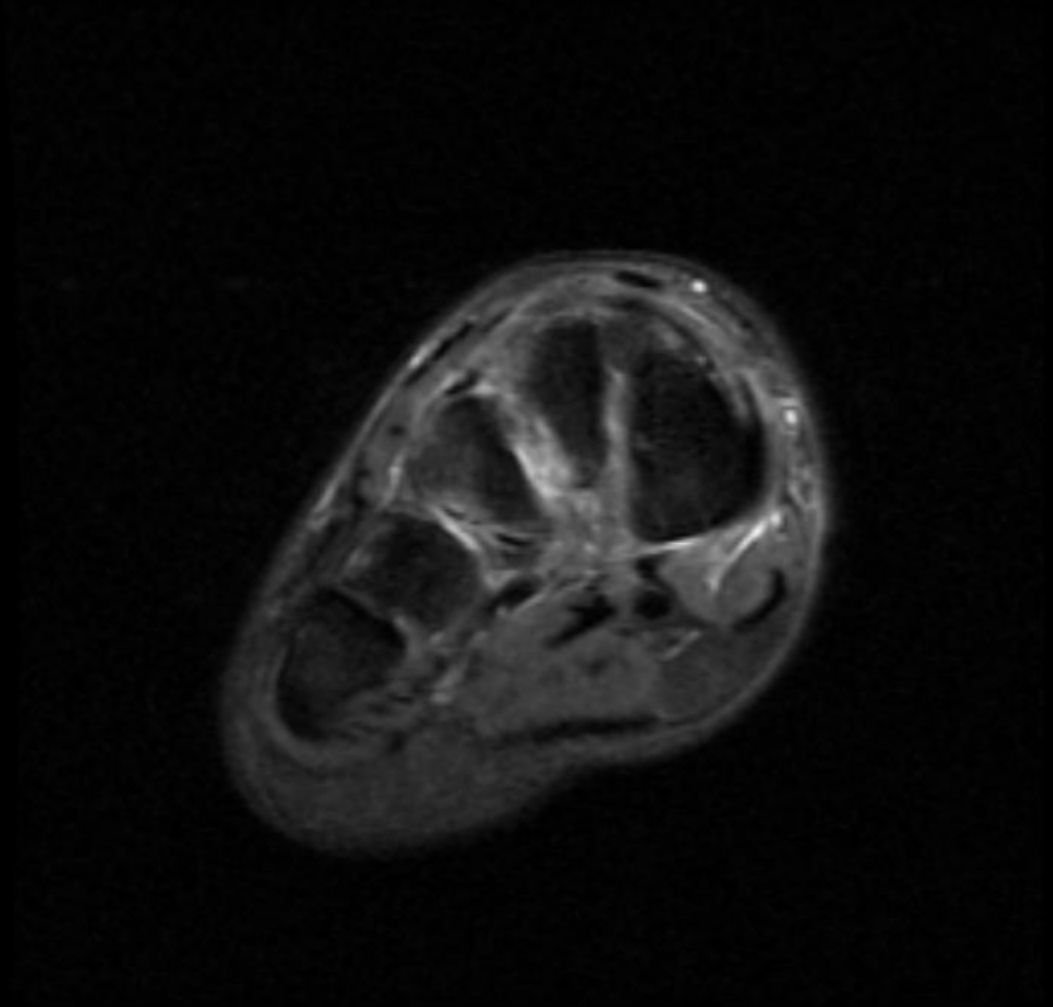


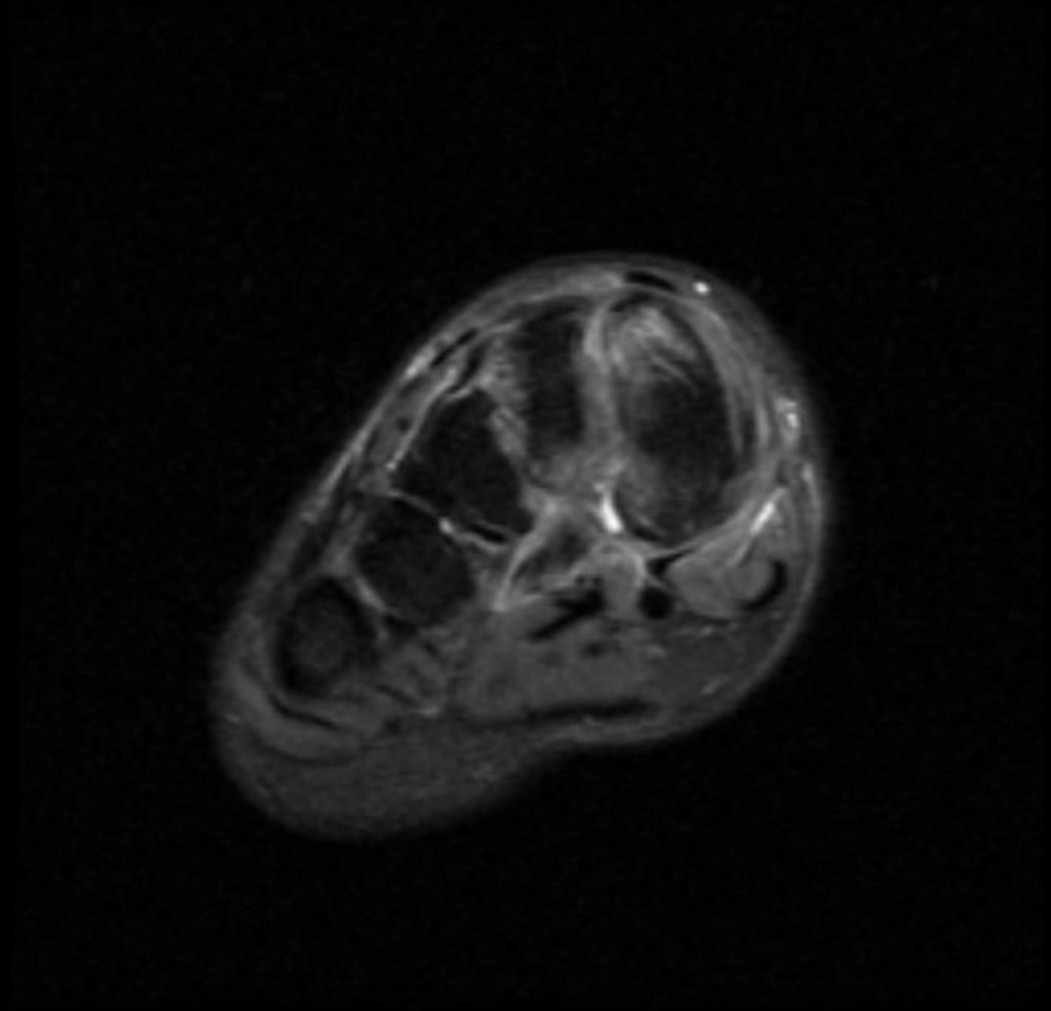


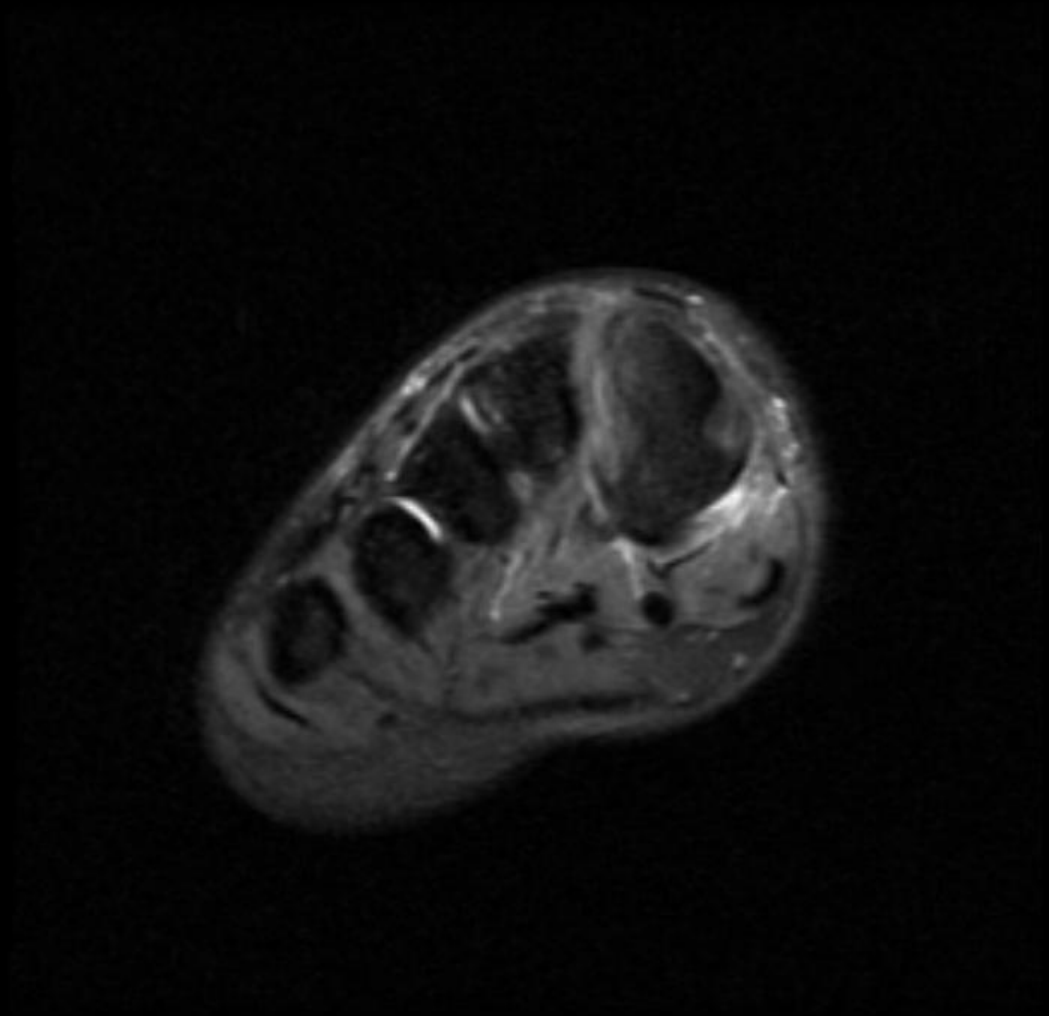


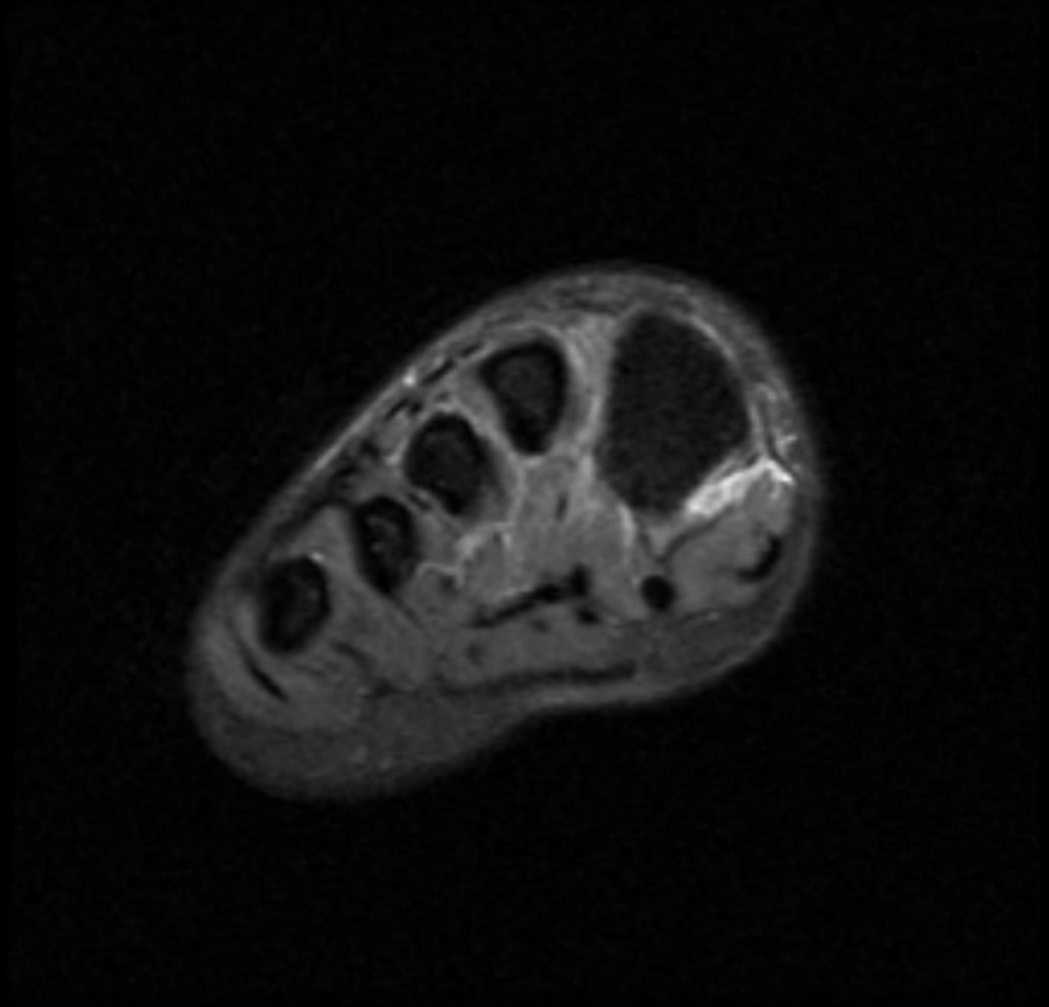












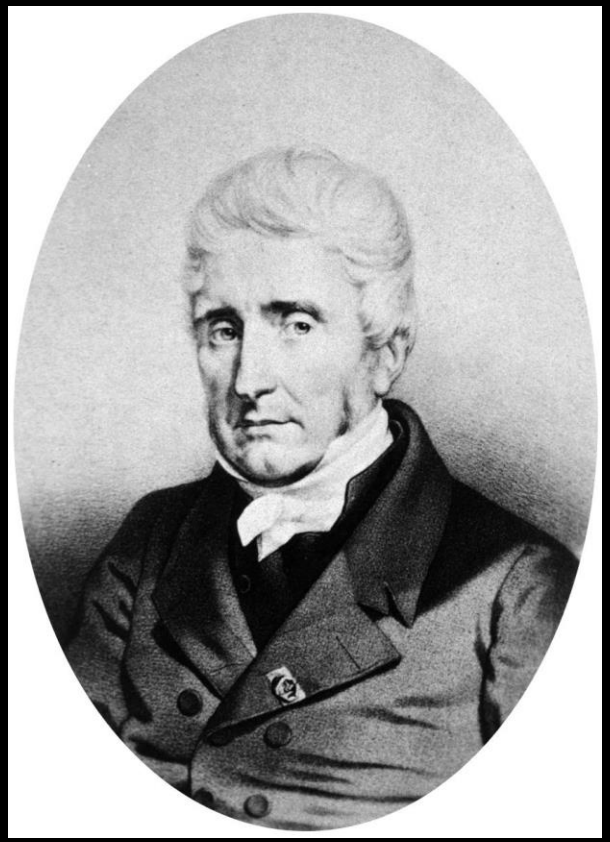
Lisfranc Fractures/Injuries

- Prevalence
  - 0.2% of all fx
  - 1/55000
  - 2 to 3 times more common in males
- Poor long-term prognosis
  - Inadequate or inappropriate Rx
  - Delayed or initially missed dx
  - Chronic pain, instability, arthritis, deformity

Litigious Joint ?

- ~ 20% missed initially (Goossens and De Stoop)
- Gupta (2008): “one of the most common reasons for malpractice lawsuits against radiologists and emergency medicine physicians”
- Calder and Saxby (2003)
  - Over 50% of patients with Lisfranc had pursued legal claims by 2 years after initial injury
  - Many patients with poor outcomes

Jacques Lisfranc de Saint Martin



- French surgeon and gynecologist
- 1787–1847
- Removal of rectal carcinoma
- Female lithotomy
- Amputation of cervix uteri

Wikipedia

Napolean's Surgeon

- Studied medicine in Lyon and Paris
- Assistant to Guillaume Dupuytren*
- War of Sixth Coalition, 1815
- Stirrup injuries and amputations

Lisfranc Joint Complex

- Complex polyarticular system
  - Tarsometatarsal
  - Intertarsal
  - Intermetatarsal
- Capsules
- Ligaments
- Tendons and expansion
- Bones

Anatomy

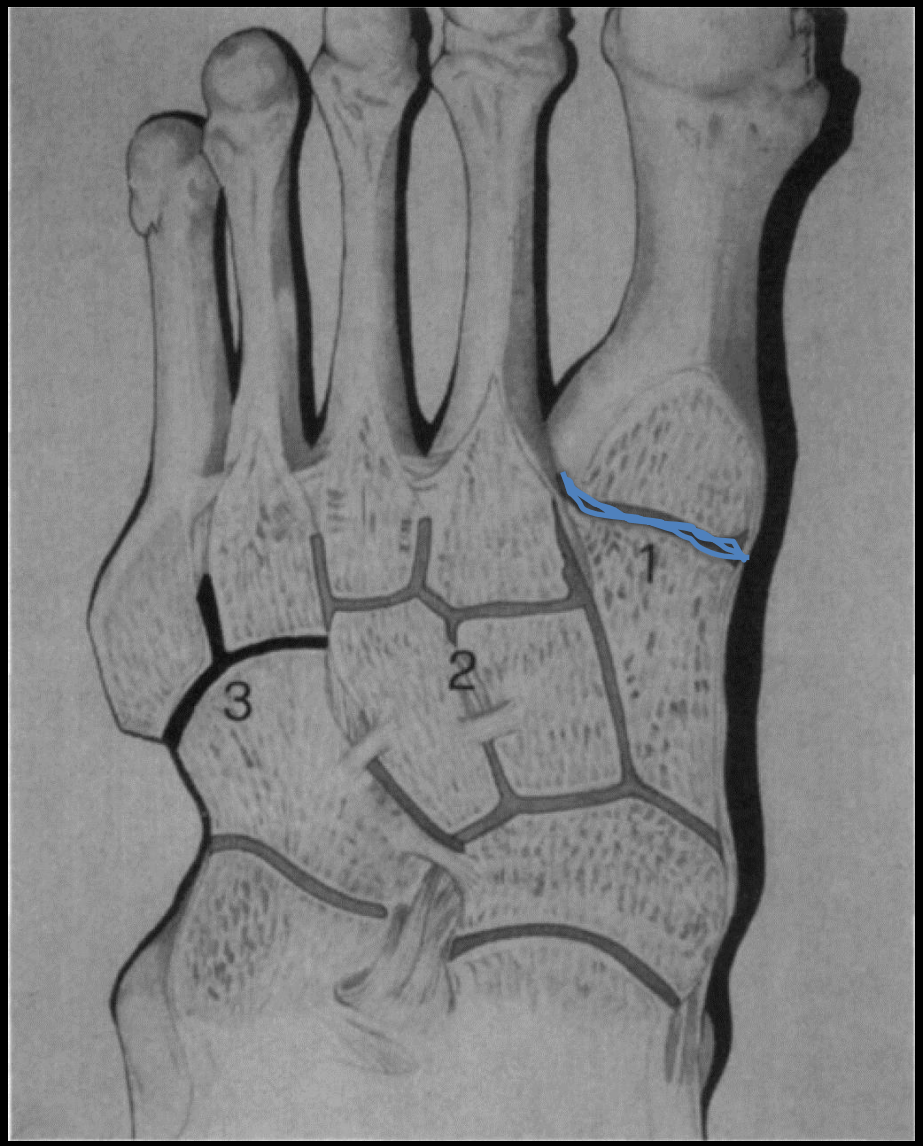
Lisfranc Joint Ligamentous Complex: MRI With Anatomic Correlation in Cadavers

Miguel Castro[1], Lina Melão[1 2], Clarissa Canella[2], Marcio Weber[2], Pedro Negrão[3], Debra Trudell[2] and Donald Resnick[2]

- TMT = tarsometatarsal
- C1 = medial cuneiform
- C2 = intermediate cuneiform
- C3 = lateral cuneiform
- Cu = cuboid
- M1, M2, M3, M4, M5 = corresponding metatarsals
- p = plantar
- d = dorsal

Capsules

- 3 capsules → 3 articular compartments
  - Medial
    - C1-M1
  - Central
    - C2-M2, C3-M3, C1-C2, C2-C3, M2-M3, C3-M2, C3-M4
    - Communicates with cuneonavicular joint
  - Lateral
    - Cu-M4/M5, M4-M5

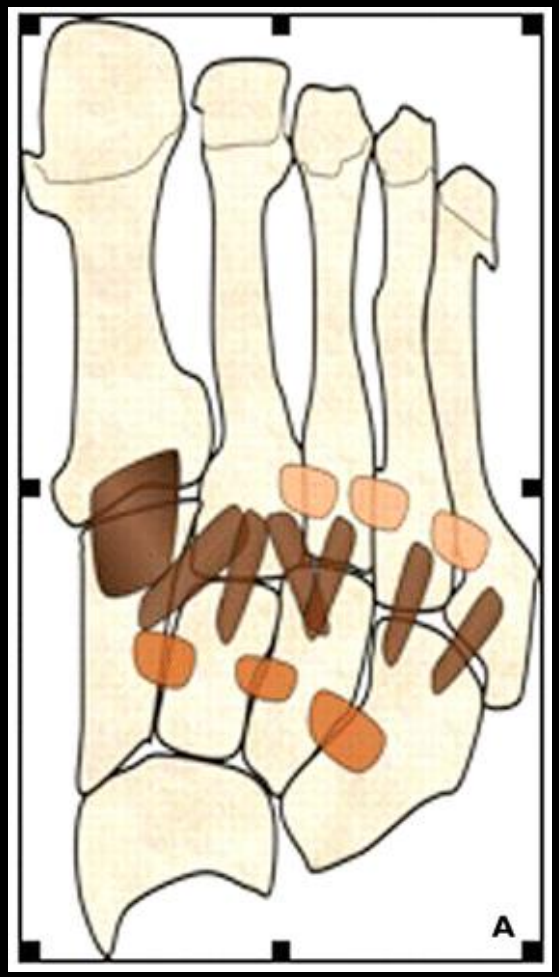


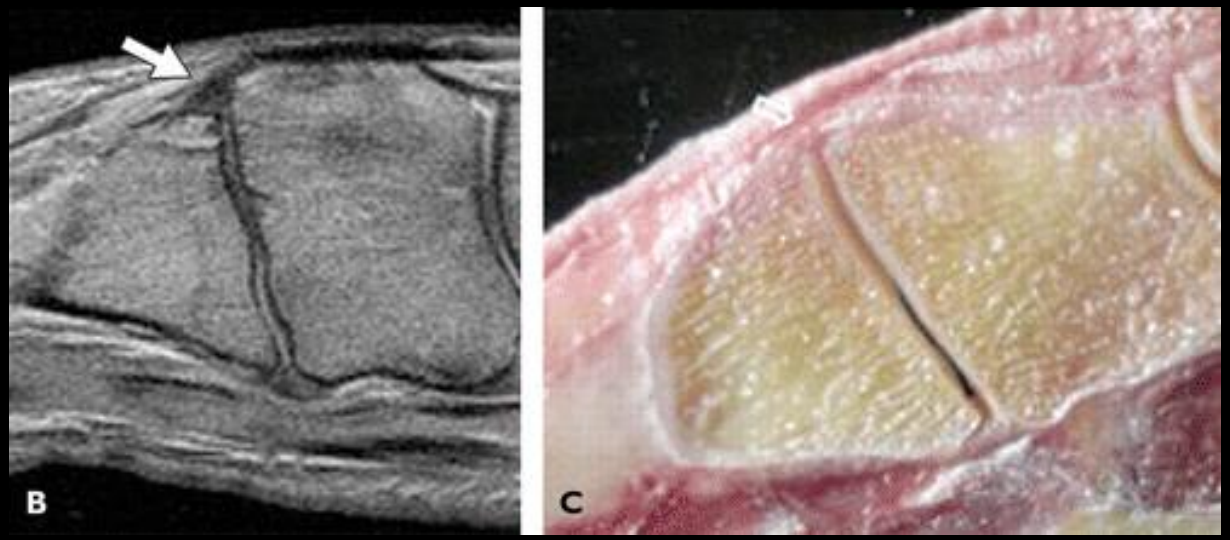
de Palma et al

Ligaments

- Dorsal TMT
- Interosseous TMT
  - Thicker and more prominent; stronger (?)
  - Signal: low (50%); intermediate (50%)
  - Homogenous (60%); striated (40%)
- Plantar TMT
- Intermetatarsal
- Intertarsal

Dorsal Ligaments



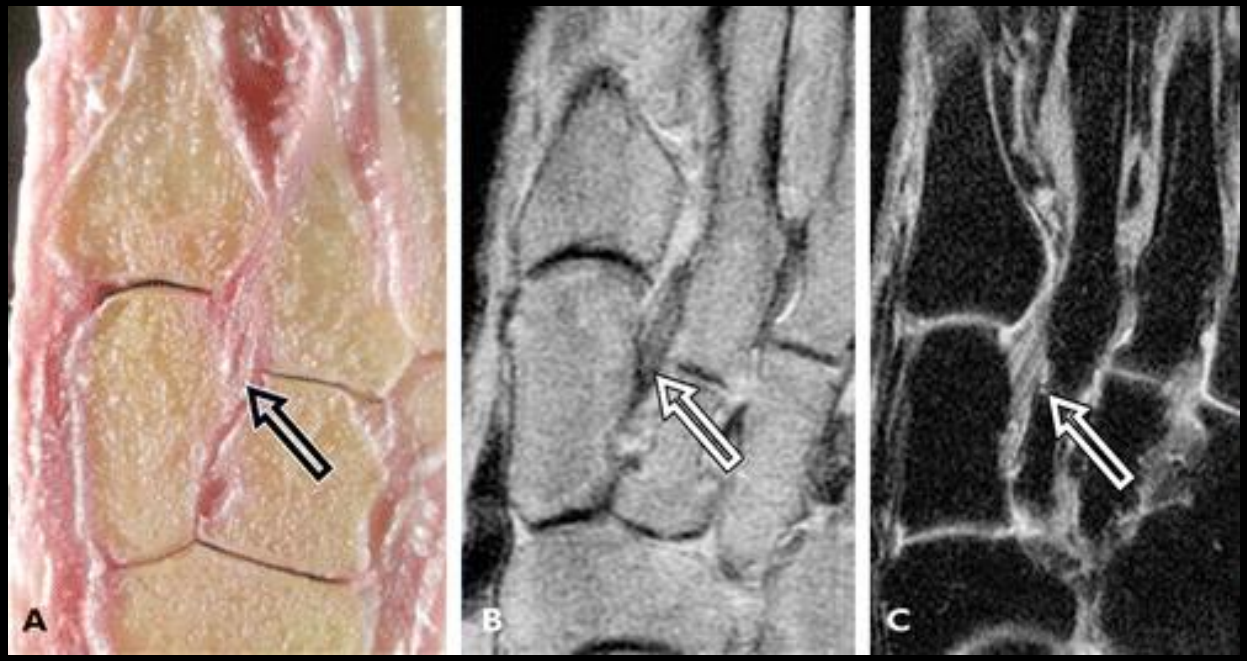


- Short and flat
- Ribbon-shaped
- Weakest

Castro et al

Lisfranc Ligament (C1-M2)

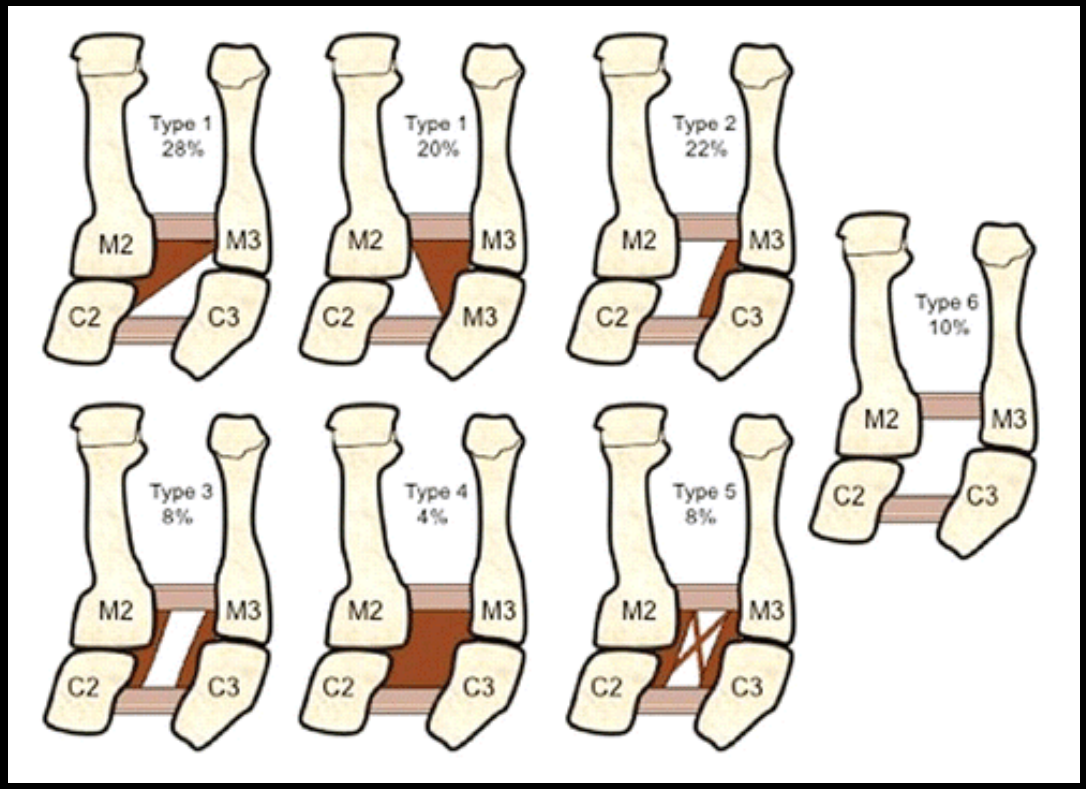
- Aka medial or 1st interosseous (cuneometatarsal) ligament; some literature dC1-M2*
- Lateral surface of C1 – inferomedial M2
- Largest; 8-10mm long and 5-6mm thick
- May have superior and inferior bundles



Castro et al

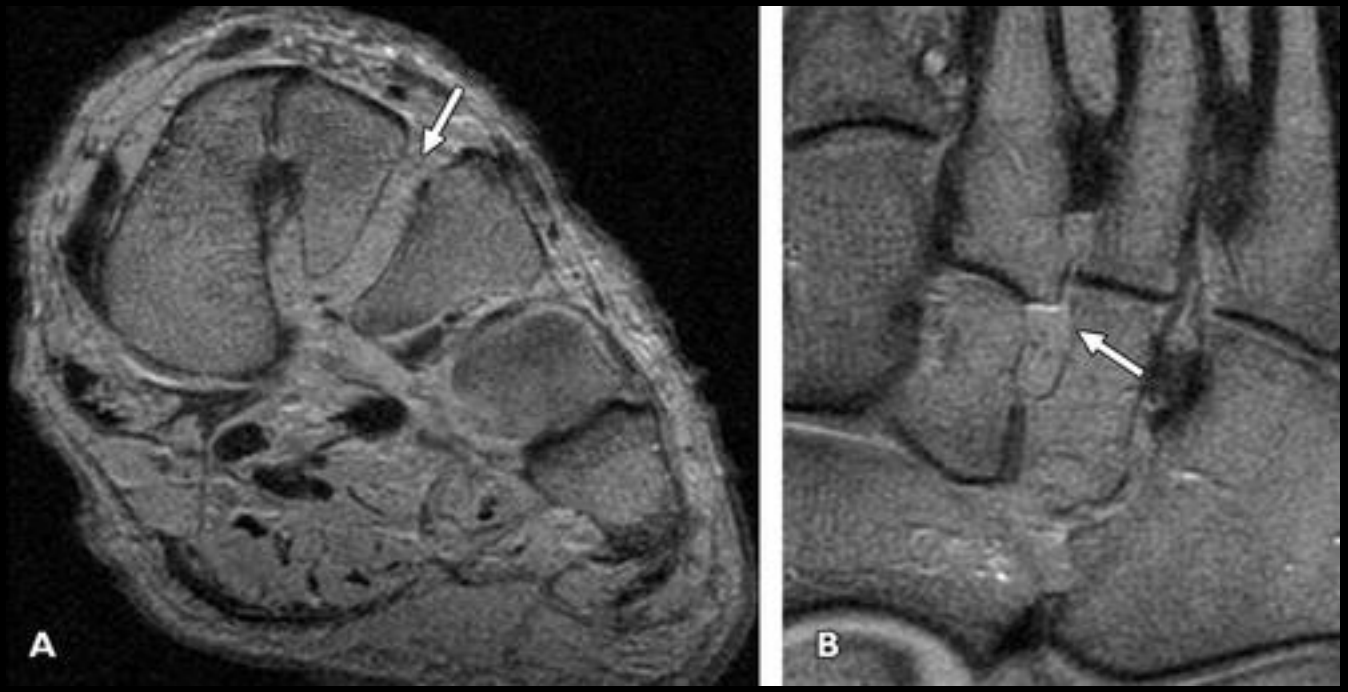
2nd Interosseous Cuneometatrsal Ligament

- Aka central, middle, intermediate interosseous ligament
- Between C2-C3 and M2-M3
- MRI – if present, always visible on coronal sequences
- Configuration best on axial and transverse oblique



Castro et al

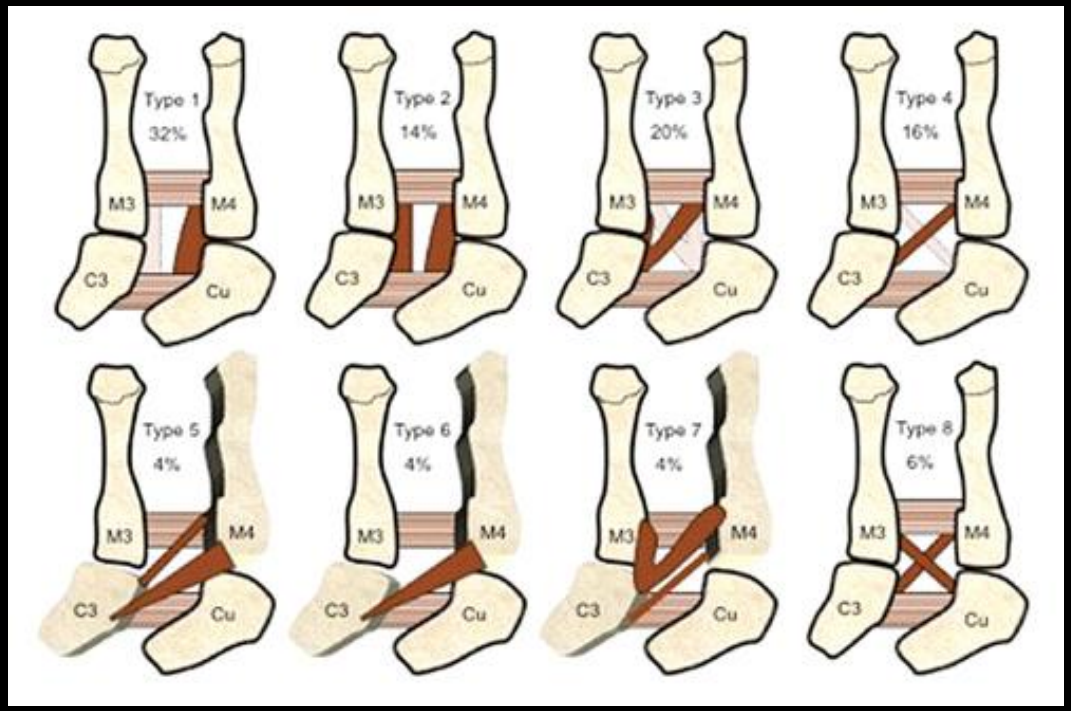
Absent 2nd Interosseous Cuneometatarsal Ligament



Castro et al

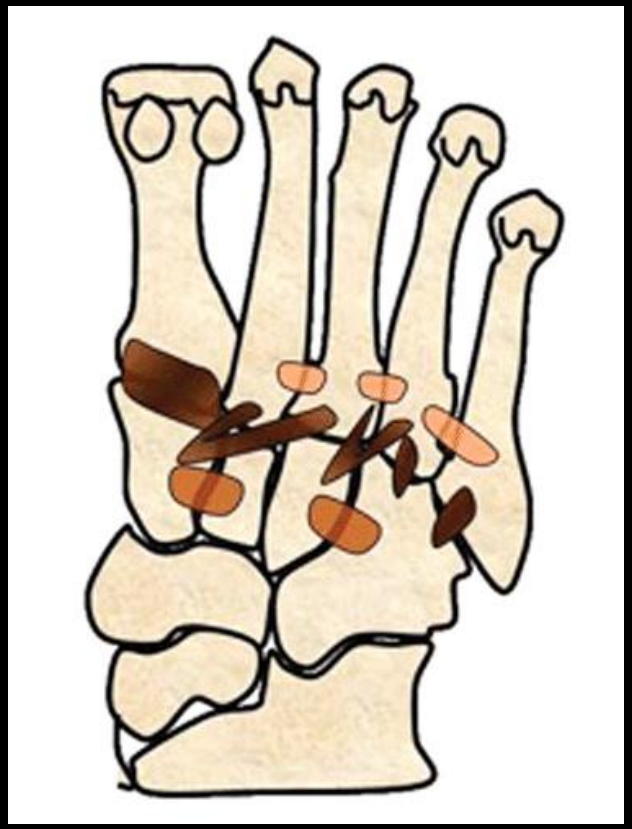
3rd Interosseous Ligament

- Aka lateral



Castro et al

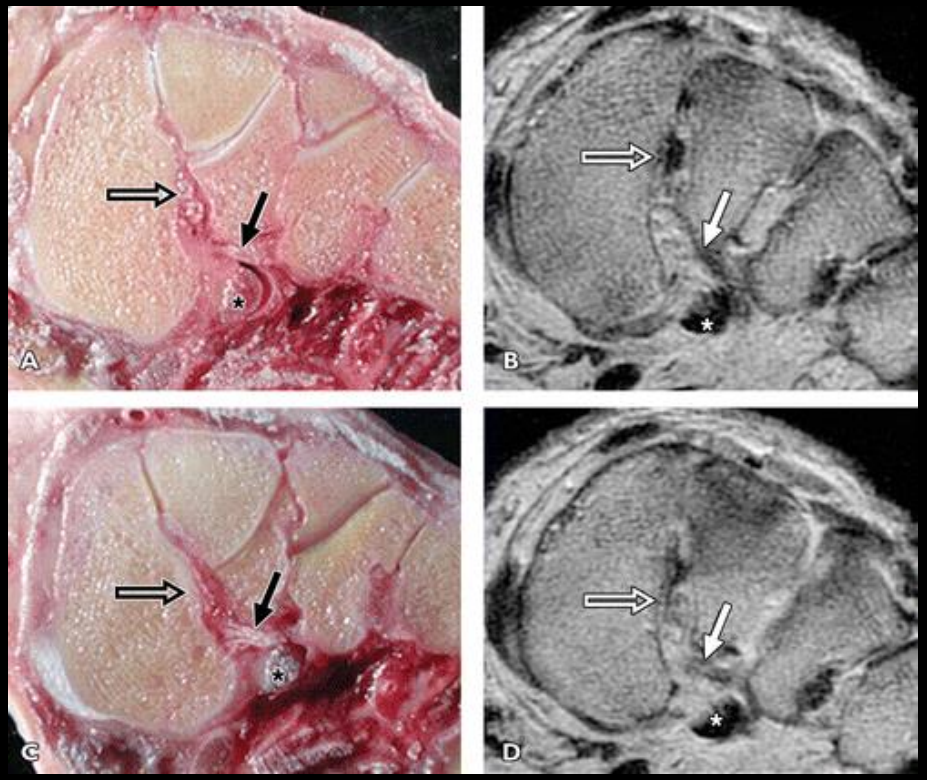
Plantar Ligaments

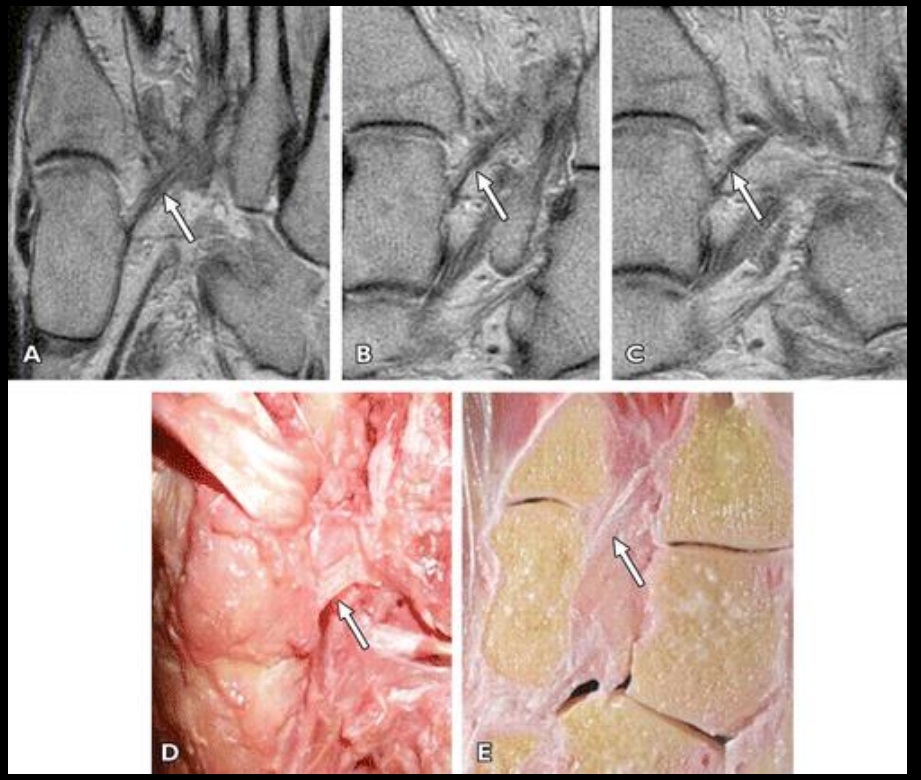


- 2nd plantar ligament (pC1-M2M3) aka plantar Lisfranc ligament
- Arises inferolateral C1
- Proximal and deep to peroneus longus tendon
- Oblique course, laterally and distally
- Splits
  - Deep (superior) component M2
  - Superficial component M3

Castro et al

Plantar Lisfranc Ligament





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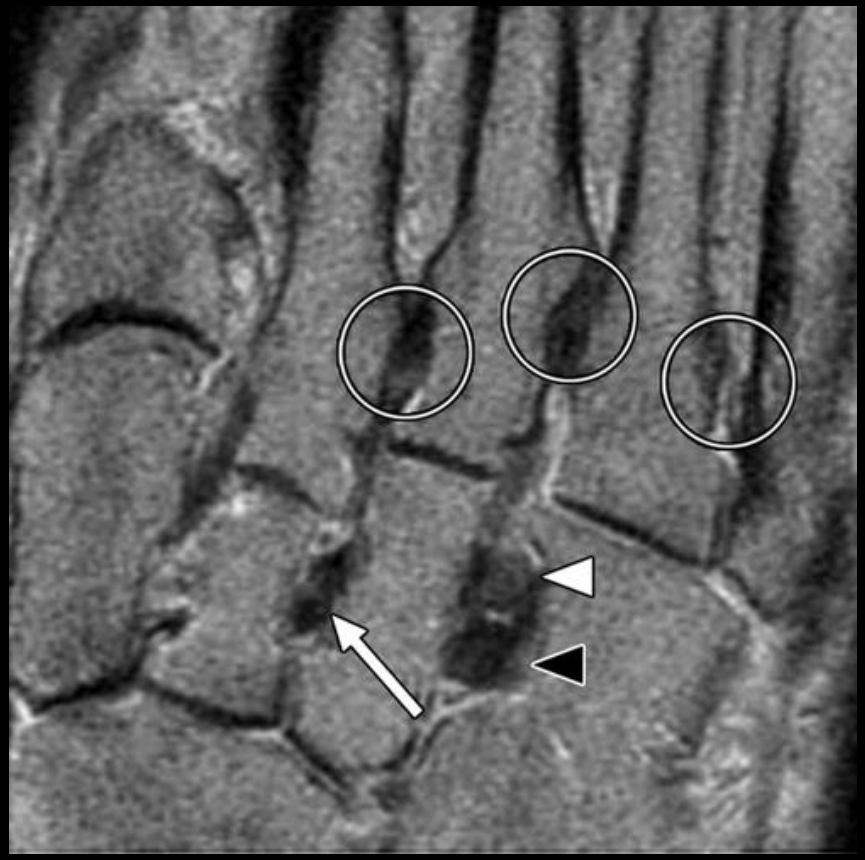
Tarsal and metatarsal interosseous ligaments



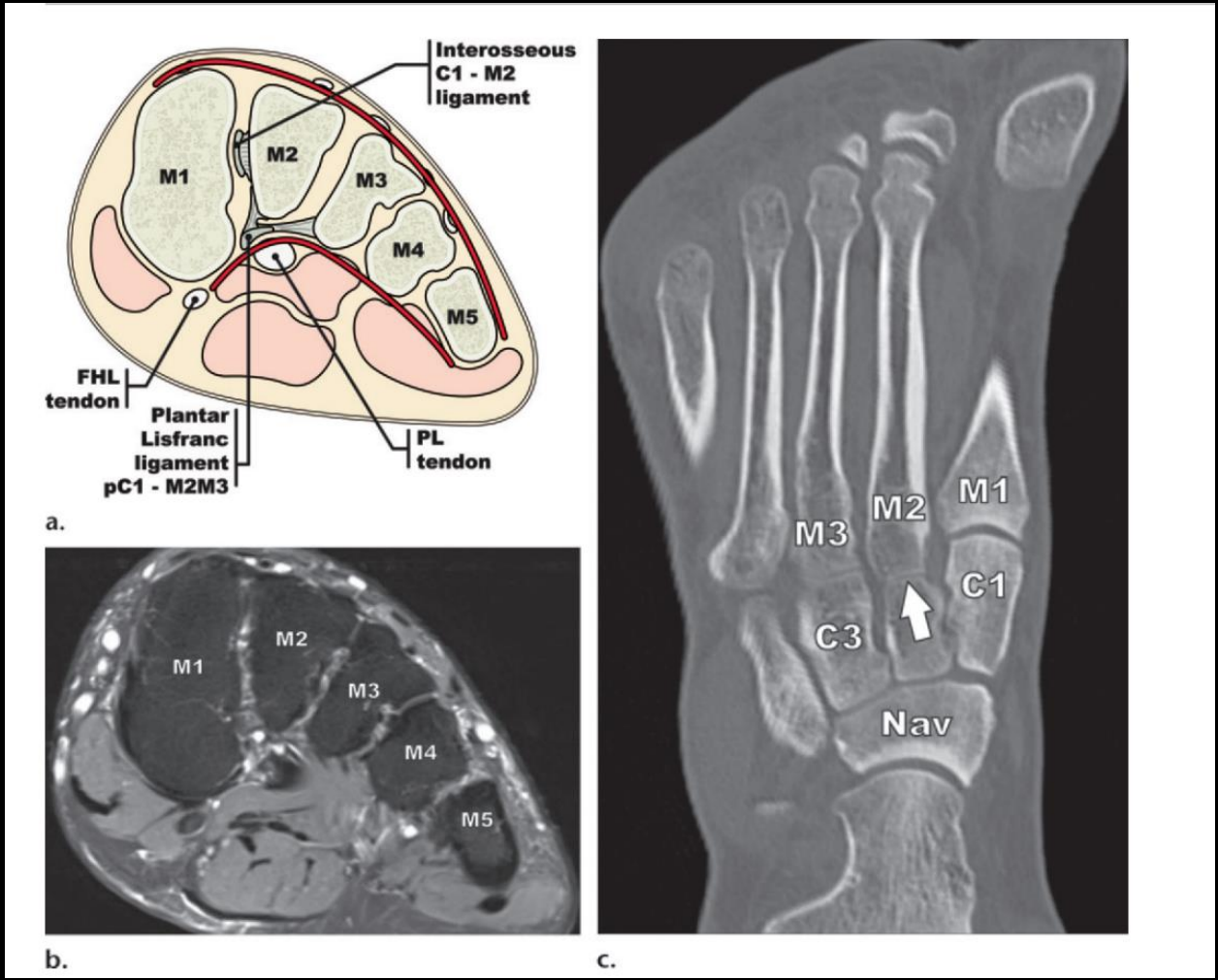
*No M1-M2

Castro et al

Secondary Stabilizers

- Tendinous insertions
  - Peroneus longus
  - Tibialis anterior
  - Tibialis posterior
- Intrinsic muscles
- Plantar ligaments
- Plantar fascia

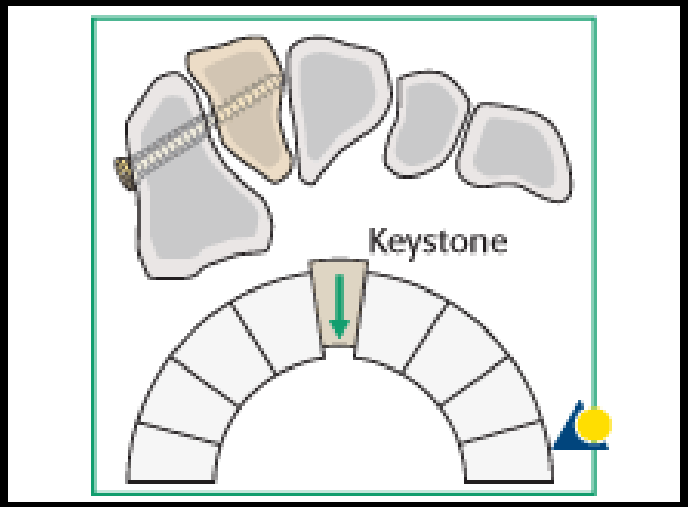
Normal Osseous Anatomy

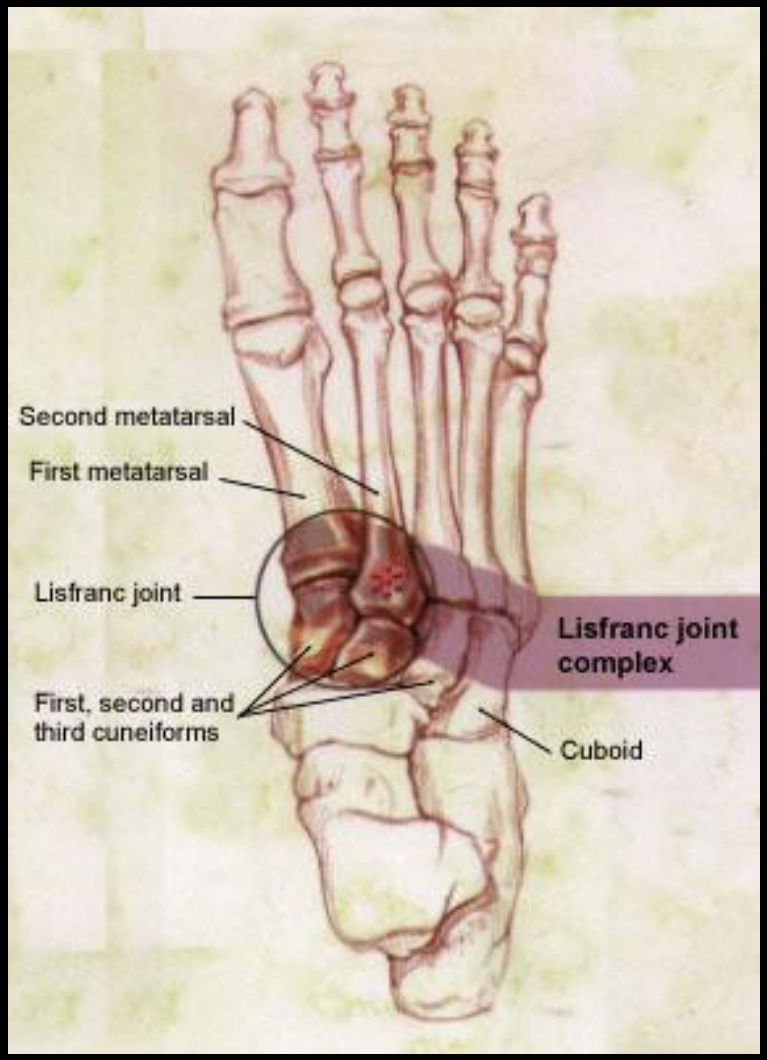


Siddiqui et al

Keystone Concept

- 2nd metatarsal wedged into cuneiforms
- Weak link, prone to injury
- Shallow recess

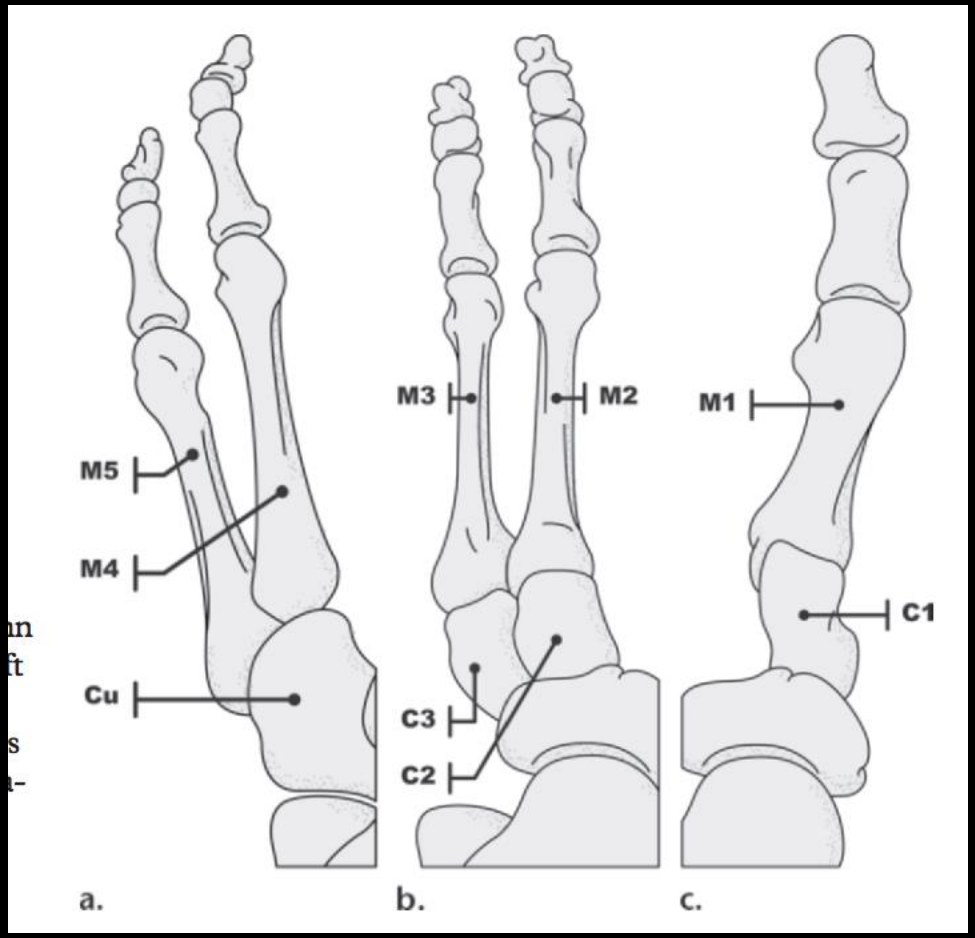




Aofoundation.org

Burroughs et al

Normal 3-Column Anatomy



- Medial – rigid
- Middle – most rigid
- Lateral - mobile

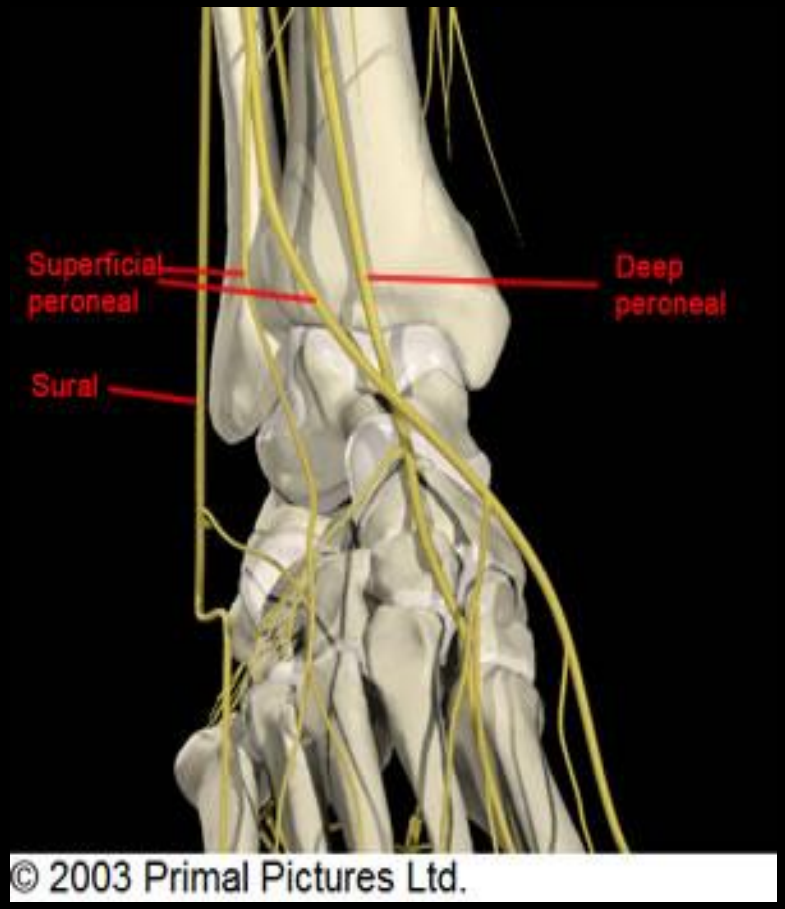
Siddiqui et al

Neurovascular Considerations

- Medial branch of the deep peroneal nerve (M1-M2)
- Perforating branch of dorsalis pedis artery (M1-M2)
- Compartment syndromes
- Arthropathy

Deep Peroneal Nerve

- Divides at midfoot
- Sensory medial branch
  - First interspace
- Sensorimotor lateral branch
  - EHB
  - EDB
- Acute injury → muscle edema
- Chronic injury → muscle atrophy
- Deep to the EHB myotendinous junction



Injury Mechanisms

High Impact vs Low Impact

High Impact (67%)

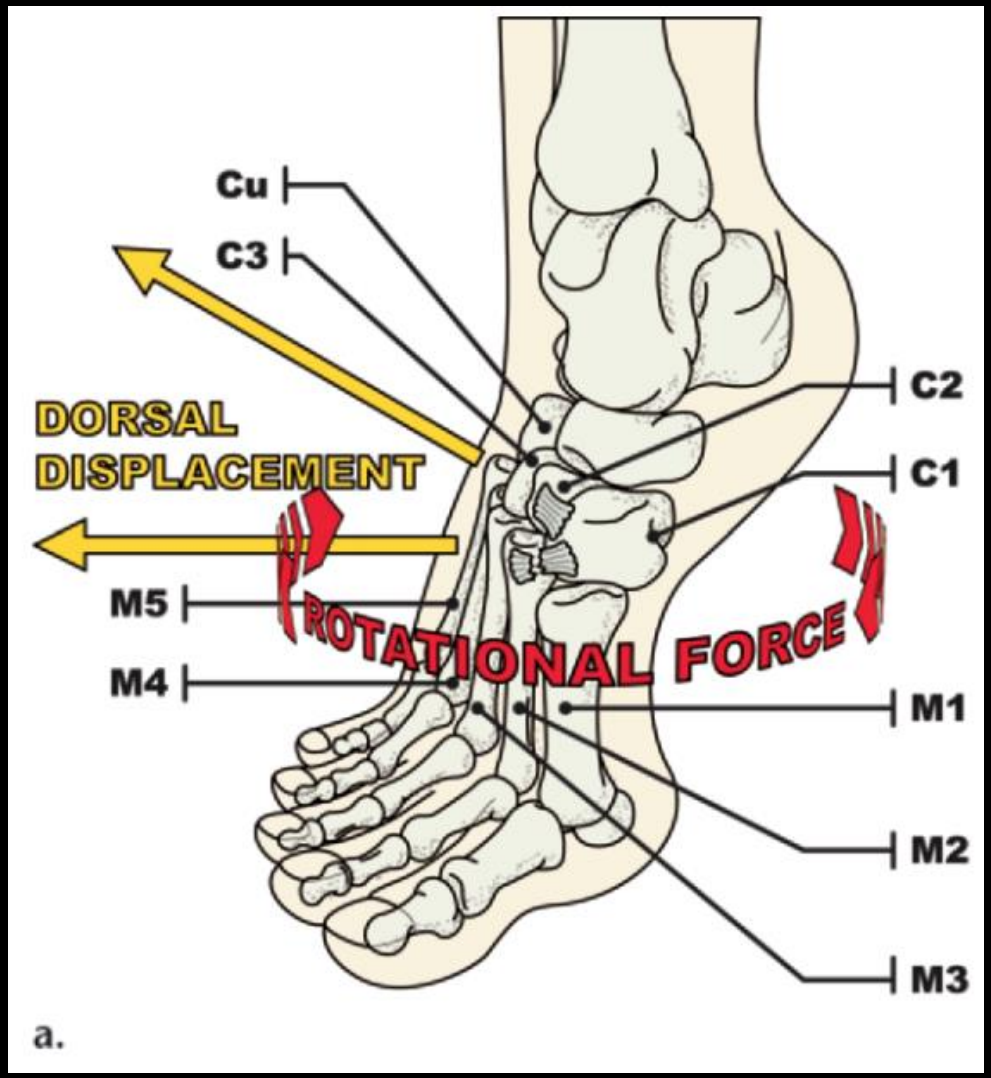
- Direct forces
- MVAs
  - Floorboard impact
- Falls from height
- Industrial accidents
- Crush type mechanism
- Plantar or dorsal displacement of metatarsals

Low Impact Midfoot Sprains (33%)

- Indirect forces
- Sports-related
- Dorsal displacement of metatarsals
- Forefoot abduction
- Forced plantarflexion
- Transverse vs longitudinal instability (Kaar)

Forefoot Abduction

- Fixed hindfoot
- Weight of body rotates around TMT joint
- Ligament failure
- Lateral displacement of lesser metatarsals
- Horse stirrup
- Sailborders
- Planted cleated foot with sudden rotational change



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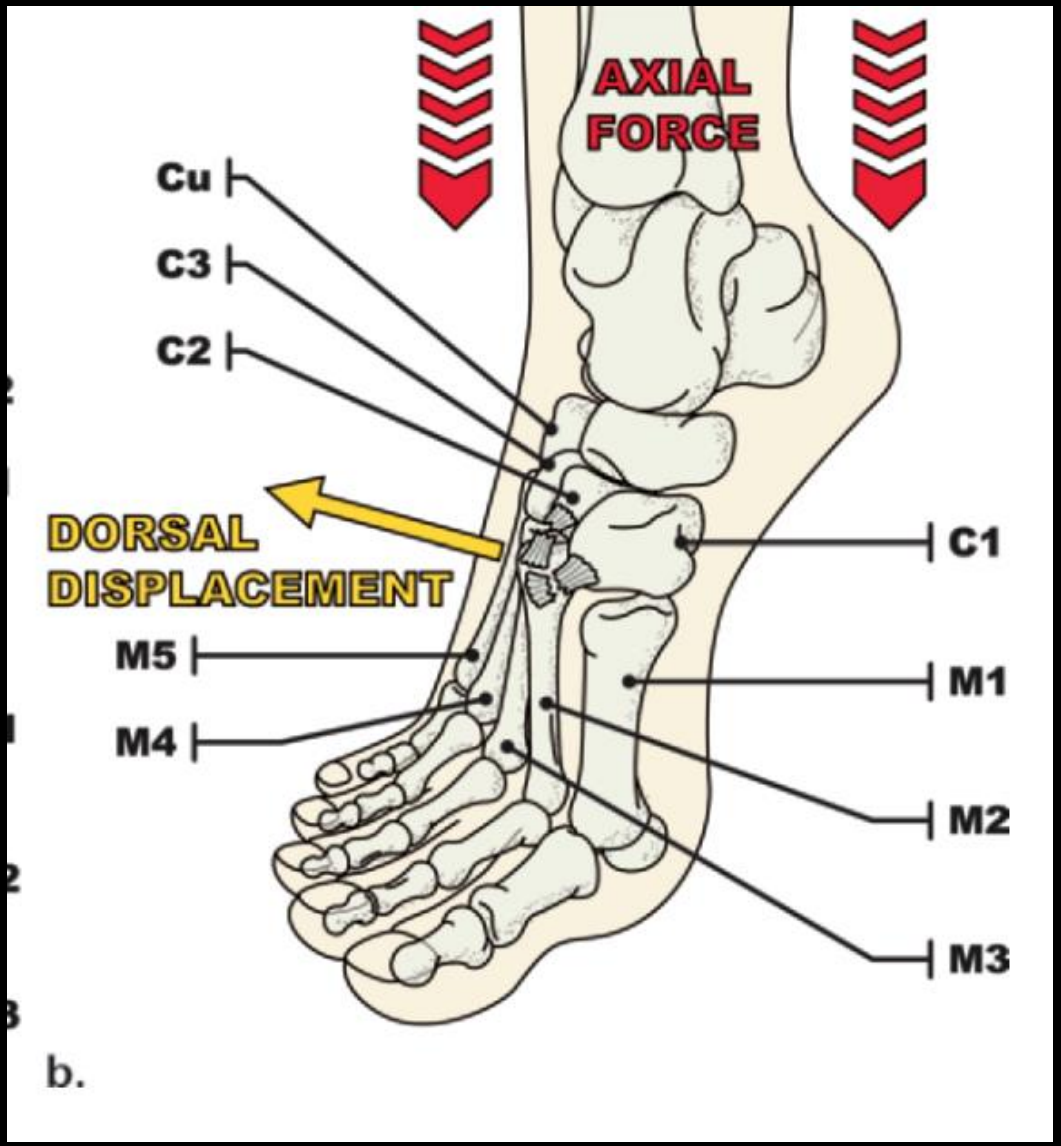
Nutcracker Fracture

Forced external rotation

Wikiradiography.net

Forced Plantarflexion

- Forefoot rigidly planted in plantar-flexed position (toes extended)
- Axial force applied through metatarsals in a longitudinal axis
- Compressive force through TMT joint
- Football players
  - Falling body applied to heel of plantar-flexed player whose knee is on ground
- Ballerinas, dancers, gymnasts
- Misstep/fall from curb or stairs
- “Bunk bed” fx



Siddiqui et al

Traditional Diagnosis

- Imaging
  - Fx base of M1, M2
  - Step-off at C2-M2 “positive gap sign”
  - Tarsal fractures
- Clinical
  - Focal pain
  - Midfoot/forefoot edema
  - Plantar arch ecchymosis
  - Inability to bear weight

21 year old male status post injury

AP
Foot AP

Tudor Hughes MD

Classification Systems

- Quenü and Küss (high grade)
- Myerson (high grade)
- Nunley-Vertullo (low grade)

Qüenu and Küss

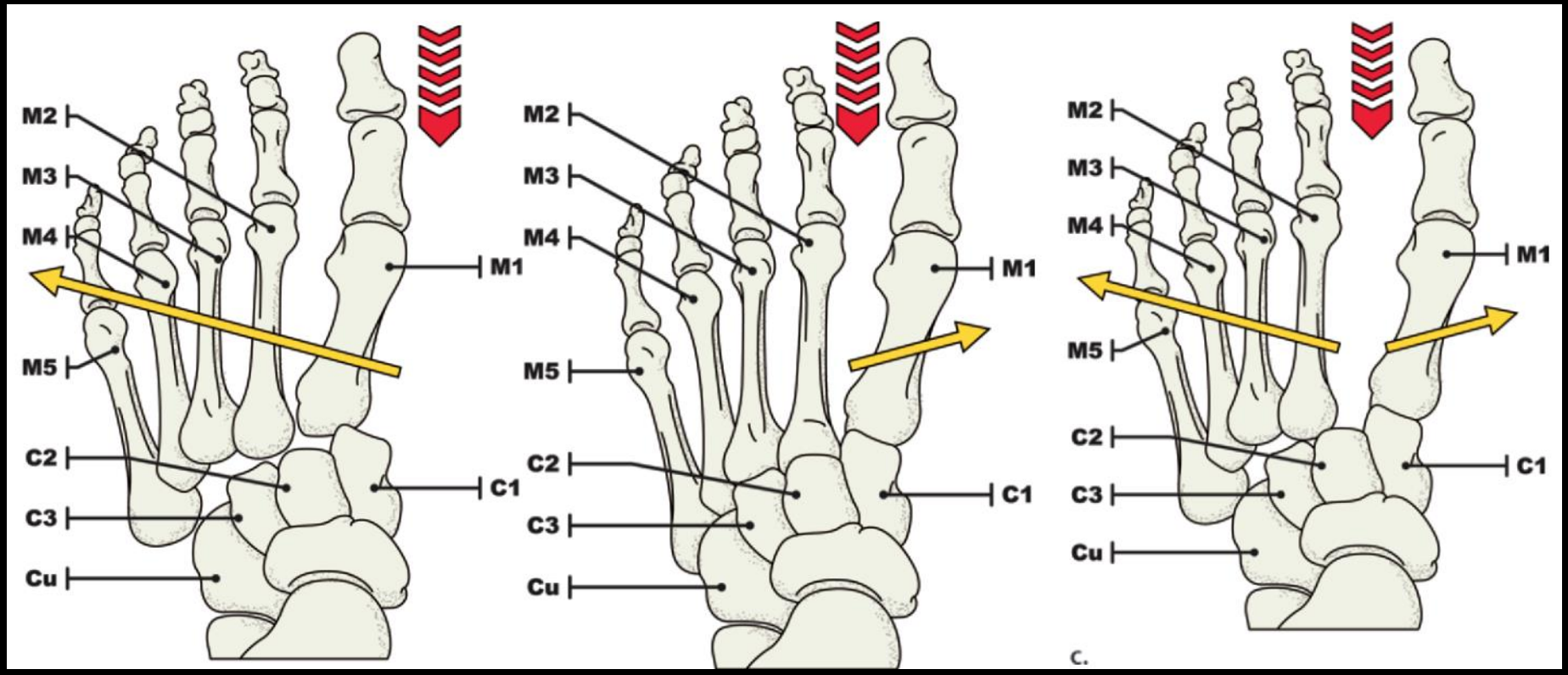
- 1909

Table 1: Quenü and Küss Classification of High-Grade Lisfranc Fracture-Displacements

Injury Type	Incongruity	Direction of Displacement
Homolateral	Complete	All five metatarsal bases are displaced in the same direction
Isolated	Partial	Displacement of one or two of the metatarsal bases
Divergent	Complete	M1 is displaced medially and M2–M5 are displaced laterally

Note.—M = metatarsal.

Fracture-Dislocations



Homolateral Isolated Divergent

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Homolateral

Isolated

Slipped with abduction force while wearing flip-flops

Brady Huang MD

Divergent

13 year old female, status post trauma

Tara Robbins MD

Myerson

- Most common current system
- Not always useful for directing treatment or outcomes

Table 2: Myerson Classification of High-Grade Lisfranc Fracture-Displacements

Injury Type	Subtype	Incongruity	Direction of Displacement
A (homolateral complete)	…	Complete	M1–M5 are displaced together in any direction
B (homolateral incomplete)	1	Partial	Only M1 is medially displaced
	2	Partial	Only M2–M5 are laterally displaced
C (divergent)	1	Partial	M1 and only some of the lesser metatarsals are displaced in opposite directions
	2	Complete	M1 is displaced in the opposite direction of the lesser metatarsals, which move as a unit

Note.—M = metatarsal.

Myerson B2 (Homolateral Incomplete)

Tara Robbins MD

Nunley-Vertullo

Table 3: Nunley-Vertullo Classification of Low-Grade Midfoot Sprains

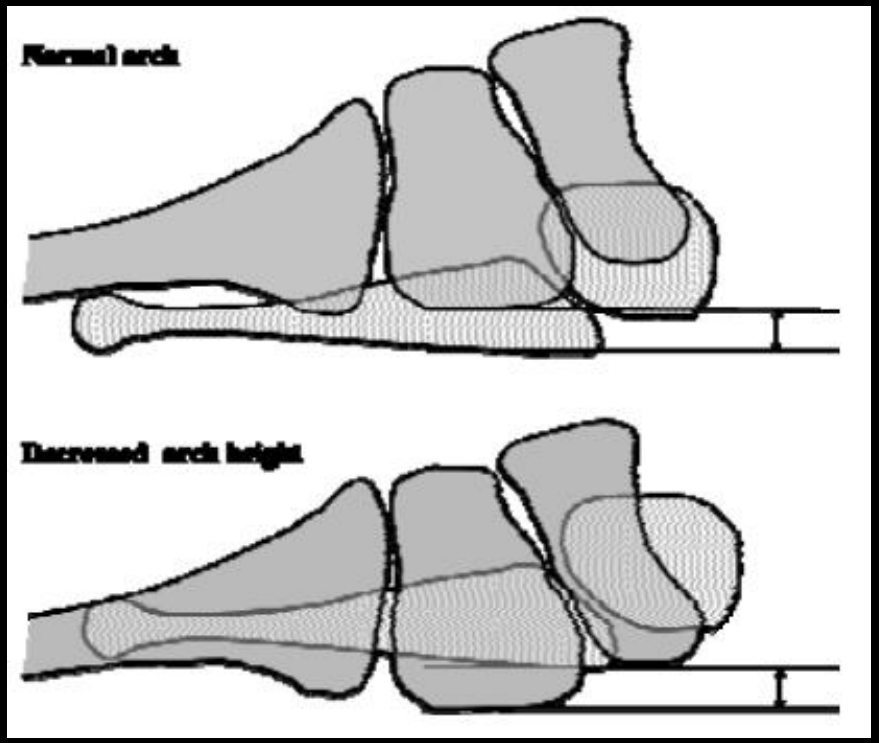
Stage	Clinical Findings	Findings at Weight-bearing Radiography and Bone Scintigraphy
I	Low-grade Lisfranc ligament complex sprain	Normal Increased radiotracer uptake
II	Lisfranc ligament insufficiency or disruption; intact plantar ligament	Anteroposterior: 2–5-mm M1-M2 diastasis Lateral: no loss of arch height
III	Interosseous and plantar Lisfranc ligaments disrupted	Anteroposterior: >5-mm M1-M2 diastasis Lateral: decreased distance between the plantar surfaces of C1 and M5 (loss of arch height)

Note.—C = cuneiform, M = metatarsal.

Force →

Dorsal capsule → Interosseous Lisfranc ligament → Plantar Lisfranc ligament

Loss of Arch Height



Hawkes et al

C1-M5 relationship

Siddiqui et al

IF SURGERY IS BRILLIANT

WHEN IT OPERATES,

IT IS MUCH, MUCH MORE

WHEN

WITHOUT BLOODSHED

WITHOUT MUTILATION,

IT GETS

HEALING THE SICK

Aggressive Surgeon

- Never described fracture-dislocation
- Quick amputation time
- “So obsessive a scalpel-wielder that he lamented the passing of the Napoleonic age when the grenadiers had provided him with so many splendid opportunities for amputations”

Medical Revolution in France by David Vess

Wikipedia

Imaging Characteristics

- Radiography
- Bone Scintigraphy
- Ultrasonography
- Computed Tomography
- MR Imaging

Normal Alignment of Tarsal-Metatarsal Joints

Metatarsal	AP Projection	Oblique Projection
1st		Lateral border of 1st metatarsal is aligned with lateral border of 1st (medial) cuneiform ←
2nd		Medial border of 2nd metatarsal is aligned with medial border of 2nd (intermediate) cuneiform ←
3rd	Medial and lateral borders of the 3rd (lateral) cuneiform should align with medial and lateral borders of 3rd metatarsal →	
4th	Medial border of 4th metatarsal aligned with medial border of cuboid →	
5th	Lateral margin of the 5th metatarsal can project lateral to cuboid by up to 3mm on oblique →	
On lateral view	Line drawn along long axis of talus should intersect long axis of 5th metatarsal	

X-rays

- Initial workup
- Small chip fx from base of M2 or C1
  - *Fleck sign*
  - Pathognomonic for high impact injury (90%)
- Cuboid compression fx
- Weightbearing; bilateral feet
  - Limited secondary to pain
- C2-M2 malalignment

Stress Views

- Under anesthesia

- > 2 mm diastasis at M1-M2
  - Abnormal
  - Instability

56 year old male status post fall

Ric Bhullar

Os Intermetatarseum

- Dorsal foot pain
- Parasthesias in 1st web space
- Compression of medial branch of deep peroneal nerve
- < 2% radiographs
- Bilateral

Scienceopen.com

48 year old male slip and fall

- Medial midfoot pain
- No numbness
- Non weightbearing

Brady Huang MD

Brady Huang MD

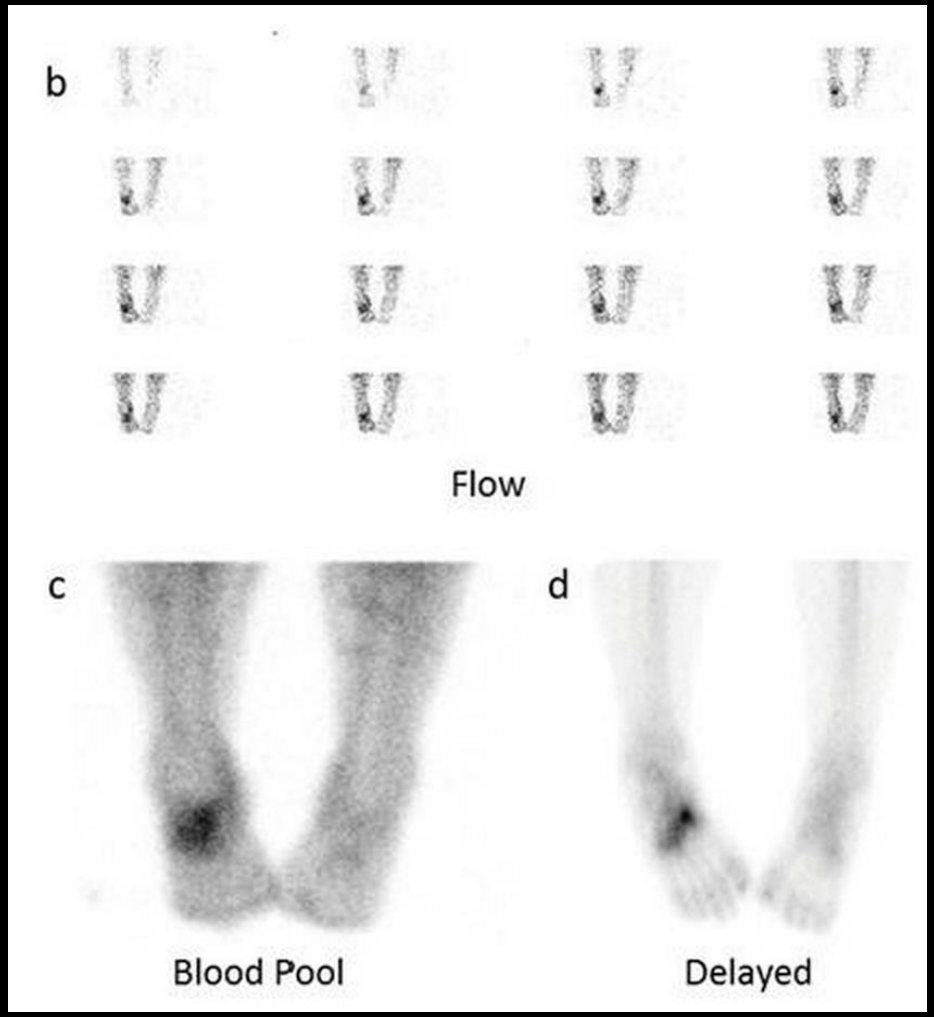
Weightbearing

Mini Pathria MD

Bone Scan

- Low grade injuries
- Nunley and Vertullo (2002): 100% sensitivity for low grade stage I sprains
- Nonspecific
- Supplanted by CT/MR
- Unexplained pain
- Unsuspected (polytrauma)

63 year old with right foot pain



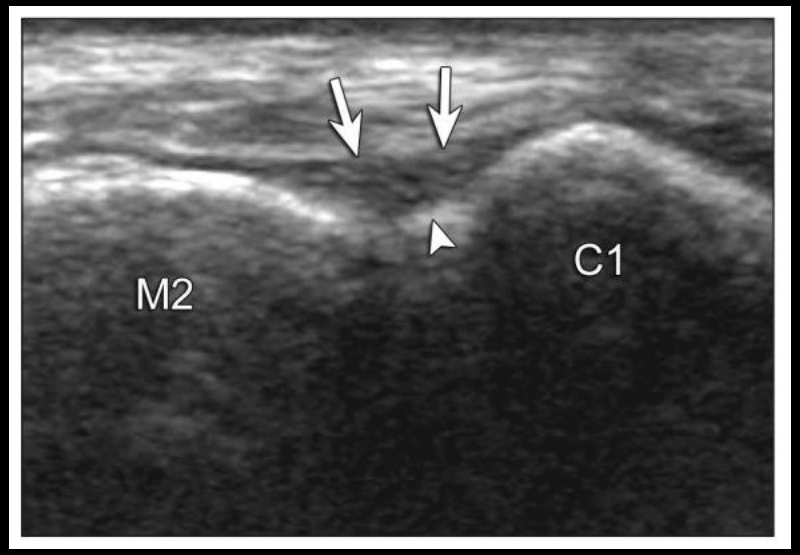
Elgazzar et al

Ultrasound

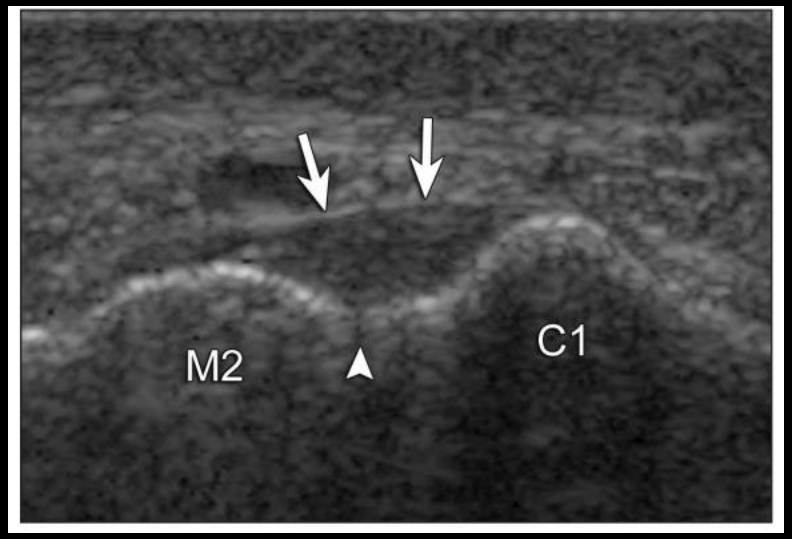
- Assess dC1-M2
  - 2nd ary sign for Lisfranc ligament tear
- Woodward (2007)
  - Non-visualization of dC1-M2
  - C1-M2 > 2.5mm
  - Dynamic widening of C1-M2 with weight-bearing

Footandankleultrasound.com

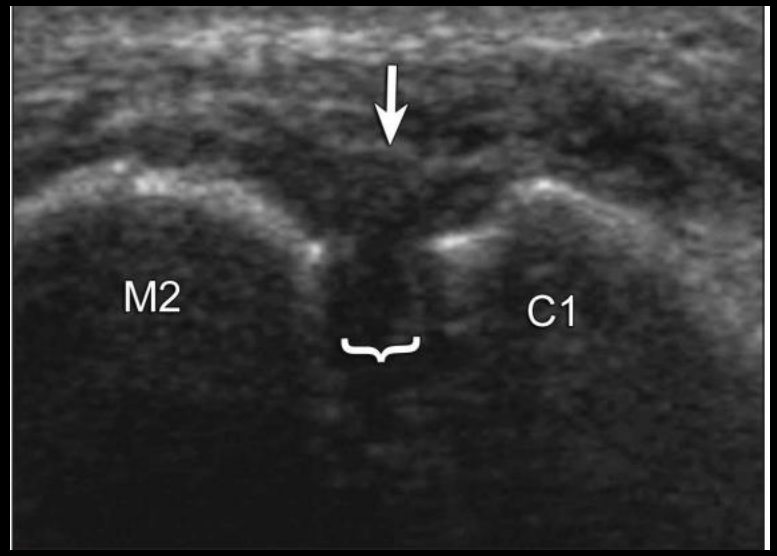
Normal



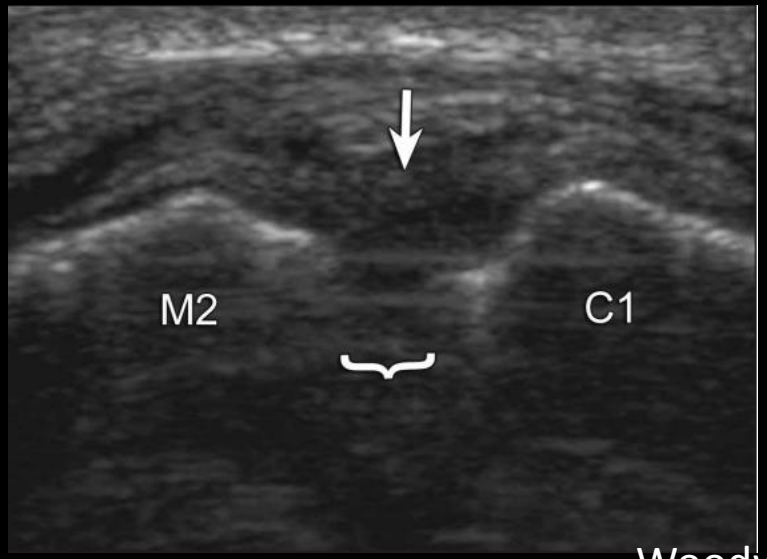
Sprain



Tear



Tear on WB



Woodward et al.

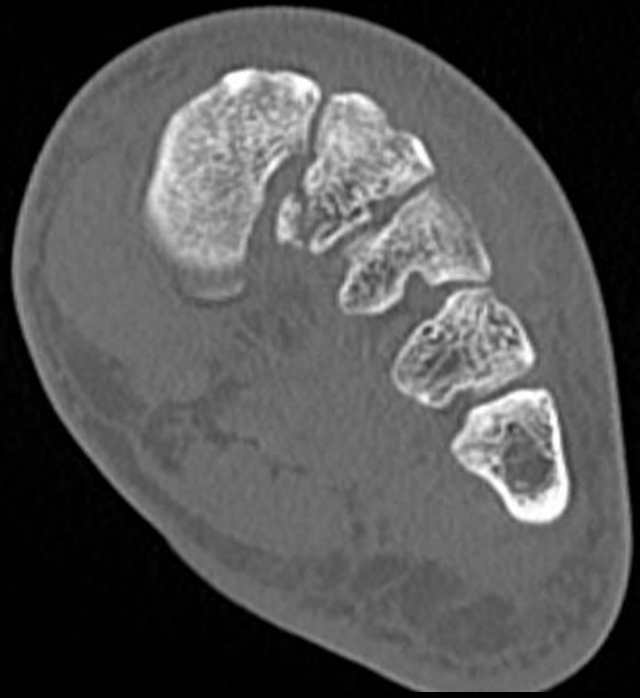
CT Imaging

- High velocity trauma
- Radiographically occult fx
- Priedler (1999): 50% more metatarsal and 100% more tarsal fx vs radiographs
- Limited use in low-impact injuries

29 year old with injury

Brady Huang MD

Brady Huang MD



Brady Huang MD

MR Imaging

- Low-grade midfoot sprains
- Soft tissue and ligamentous injuries
  - *Frank ligament disruption*
  - *Ligament elongation*
  - *Periligamentous edema*
- Small FOV midfoot/forefoot

MRI-Based Grading Scheme

- None exists
- Nunley-Vertullo
  - Low grade
    - Isolated to dorsal capsule
    - Elongation of interosseous Lisfranc ligament
  - High grade
    - Complete interosseous or plantar Lisfranc ligament disruption
    - Fluid tracking lateral margin M1

Fluid tracking along lateral margin of M1

MacMahon et al

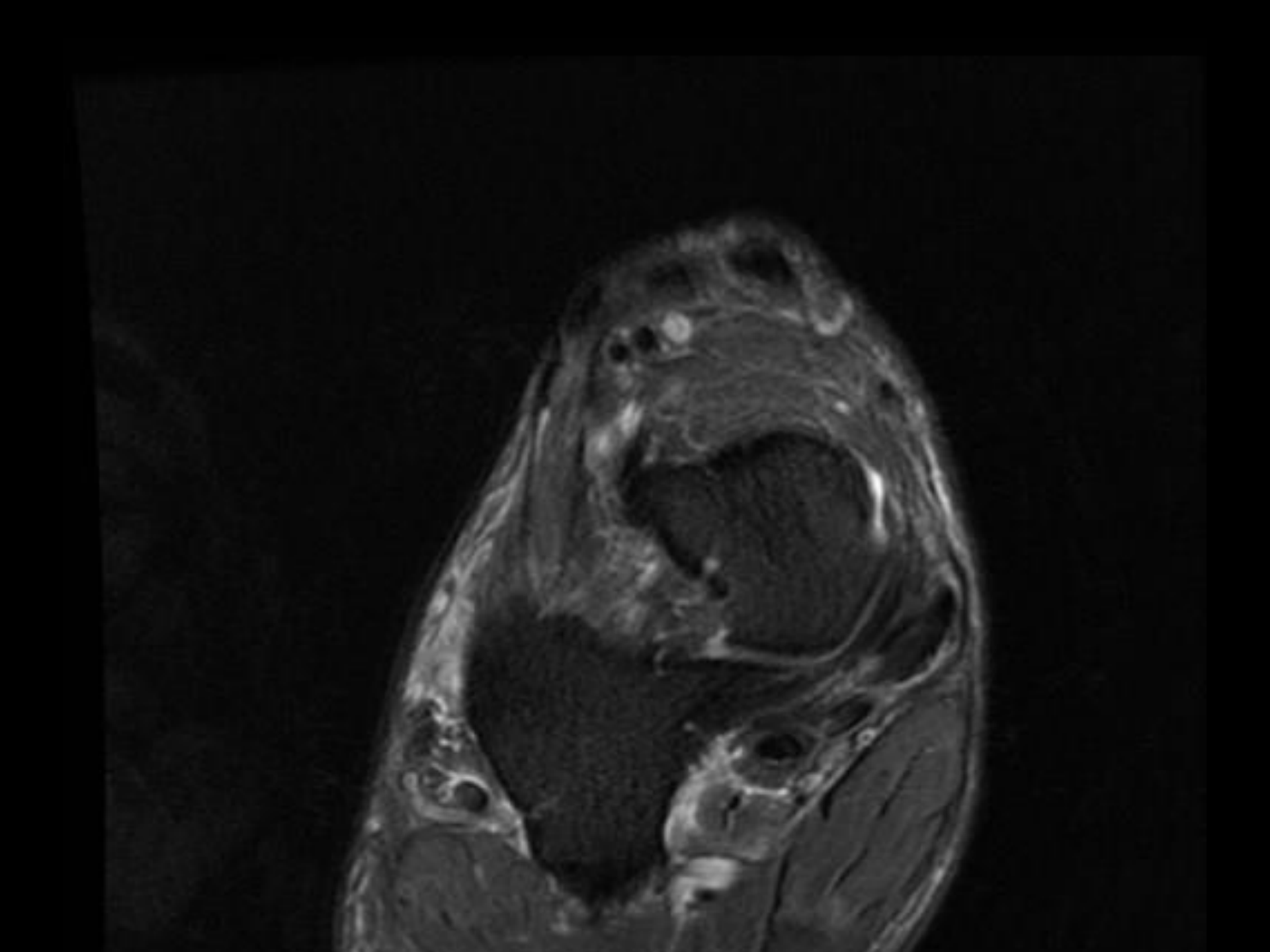
MacMahon (2008)

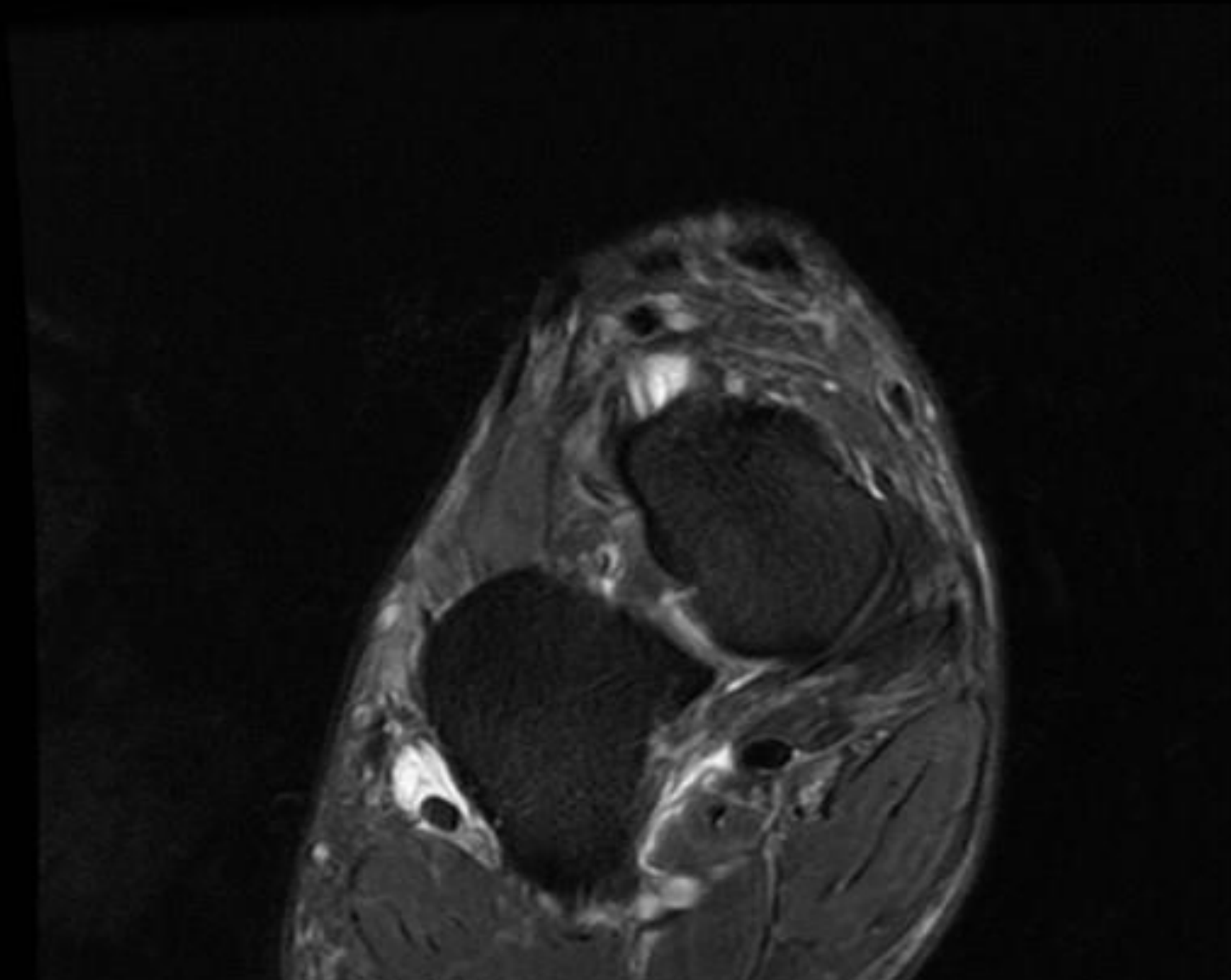
- Grade 1
  - Periligamentous edema
- Grade 2
  - Abnormal signal in ligament
- Grade 3
  - Complete disruption of ligament

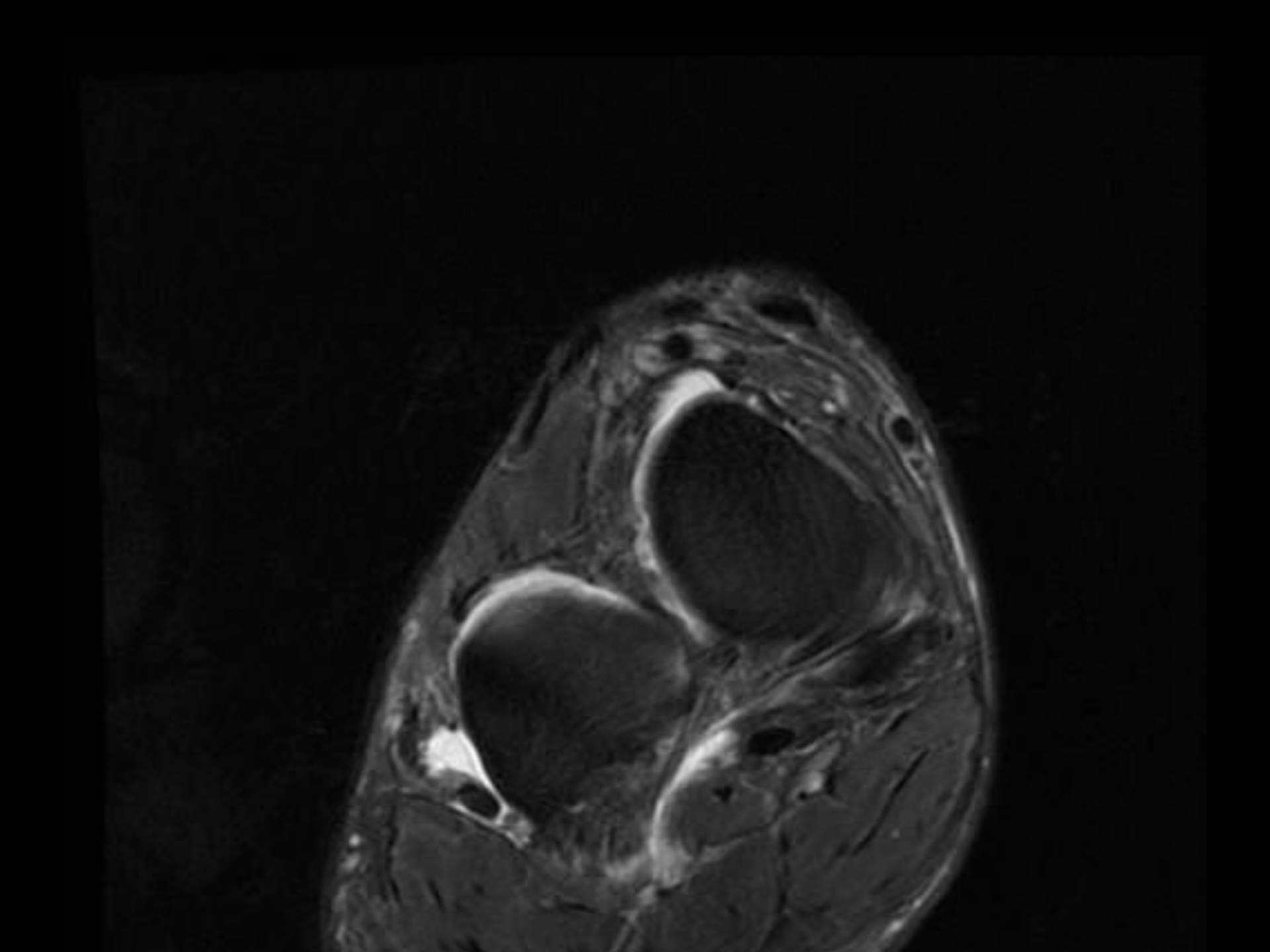
26 year old with skateboard injury

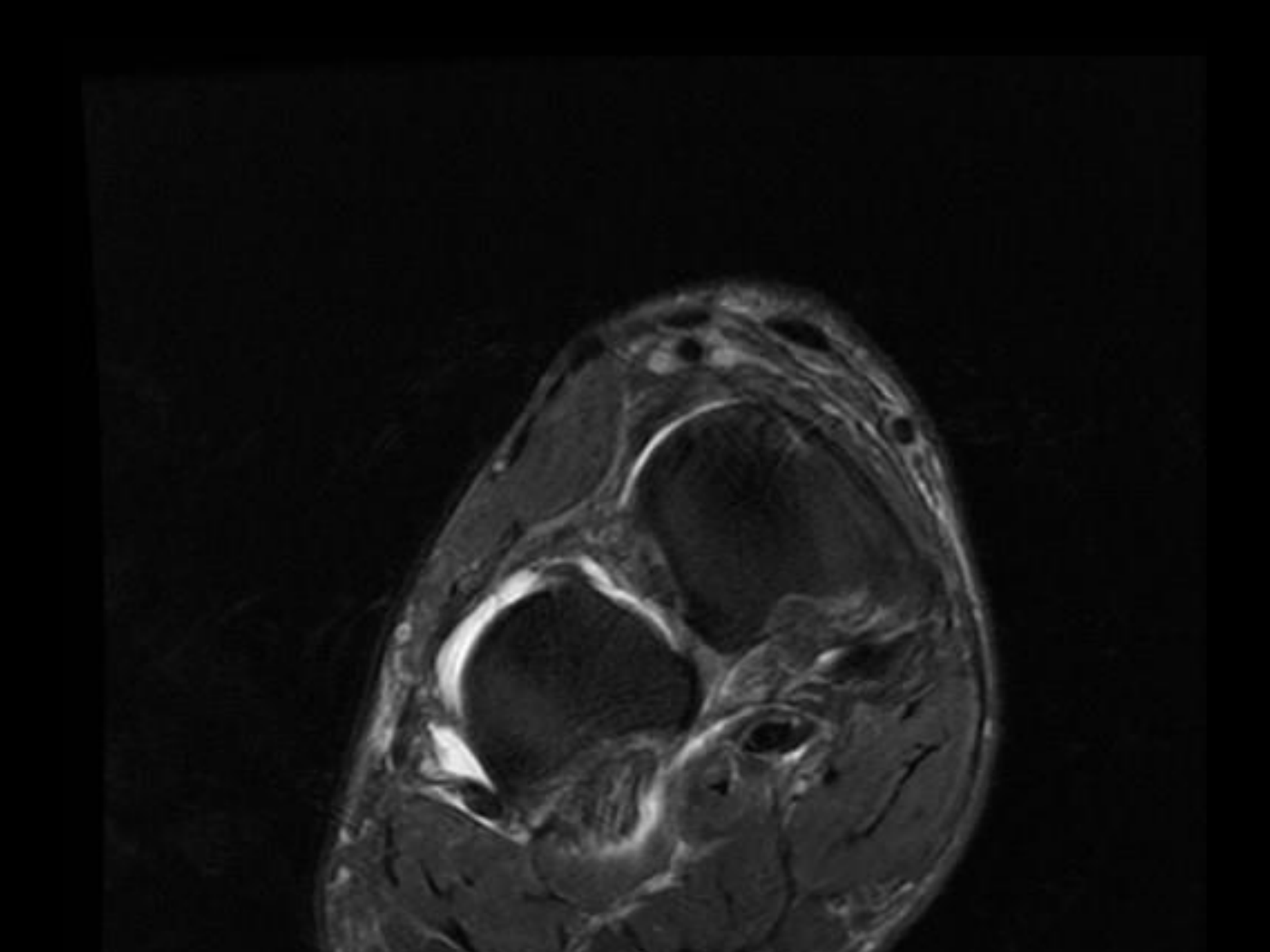
1st webspace swelling and pain

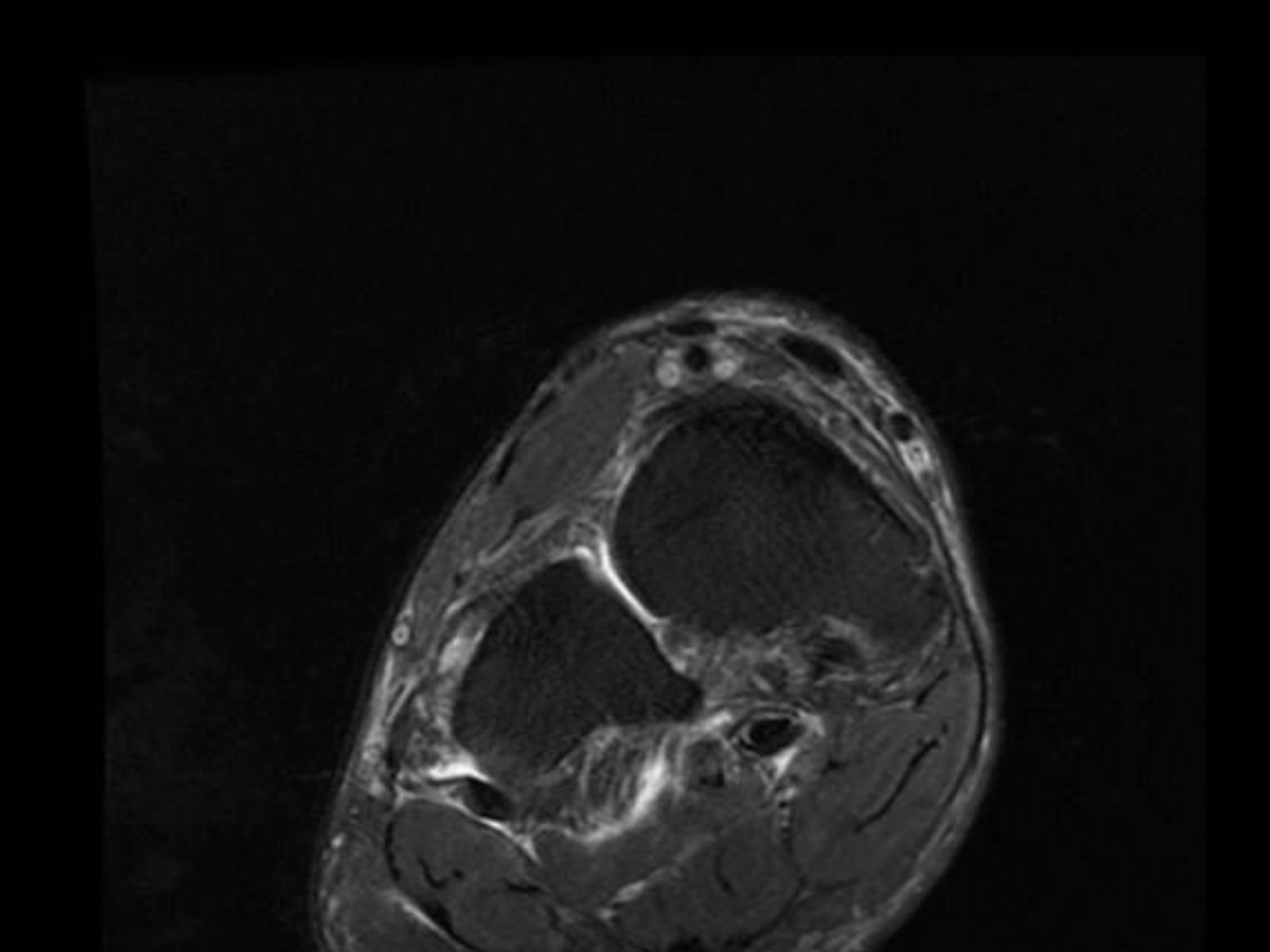
Connie Montgomery MD

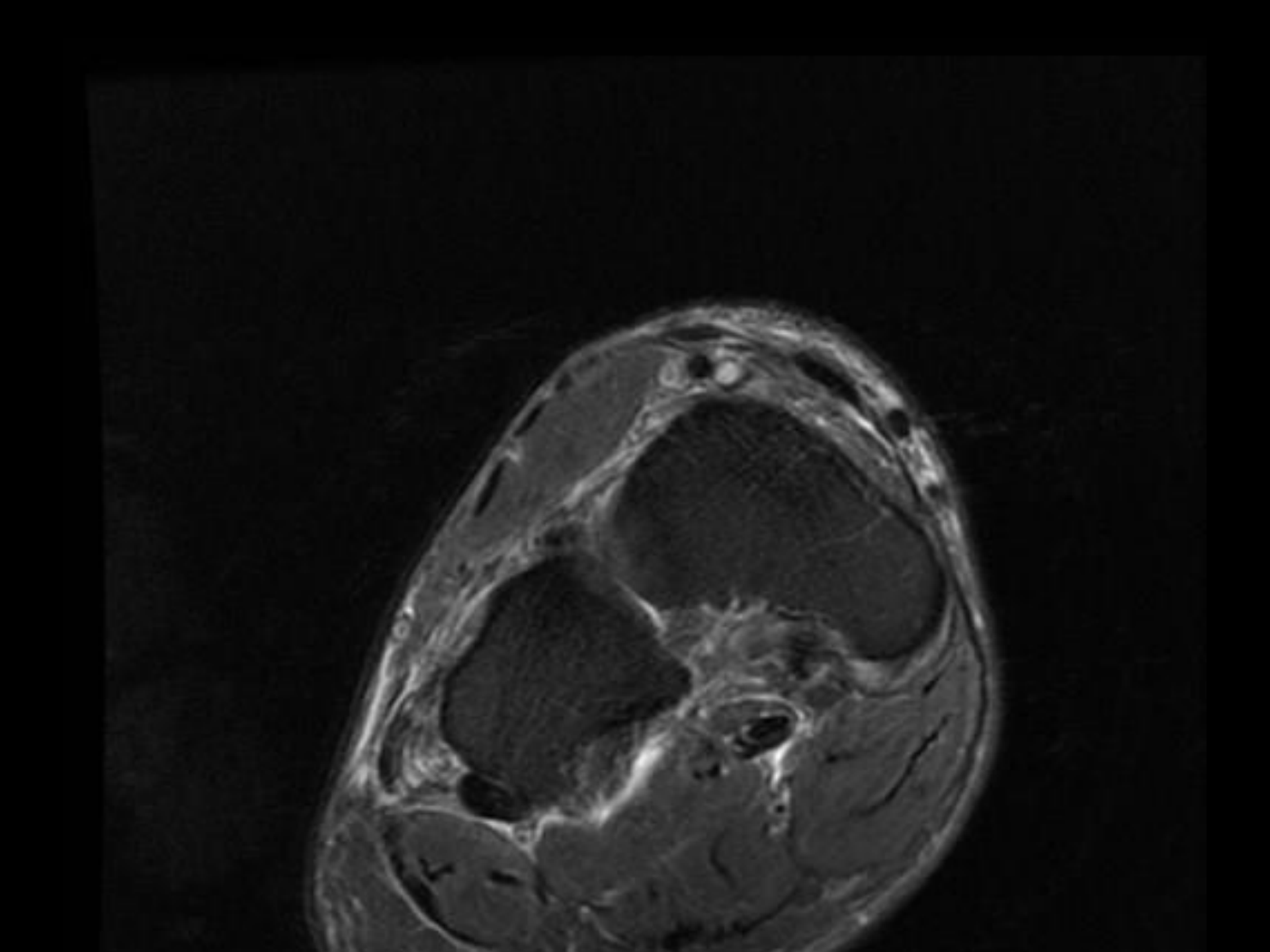


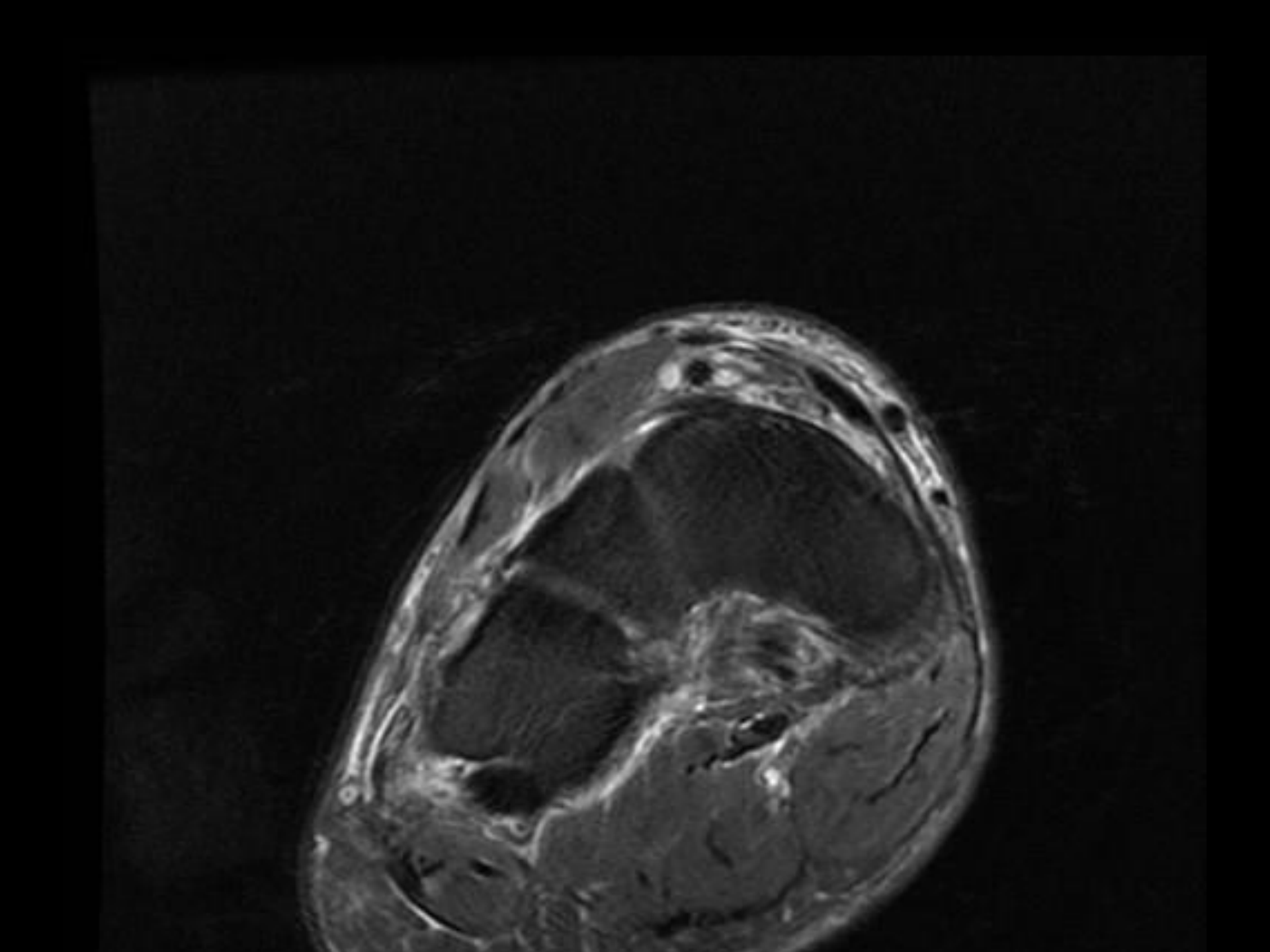


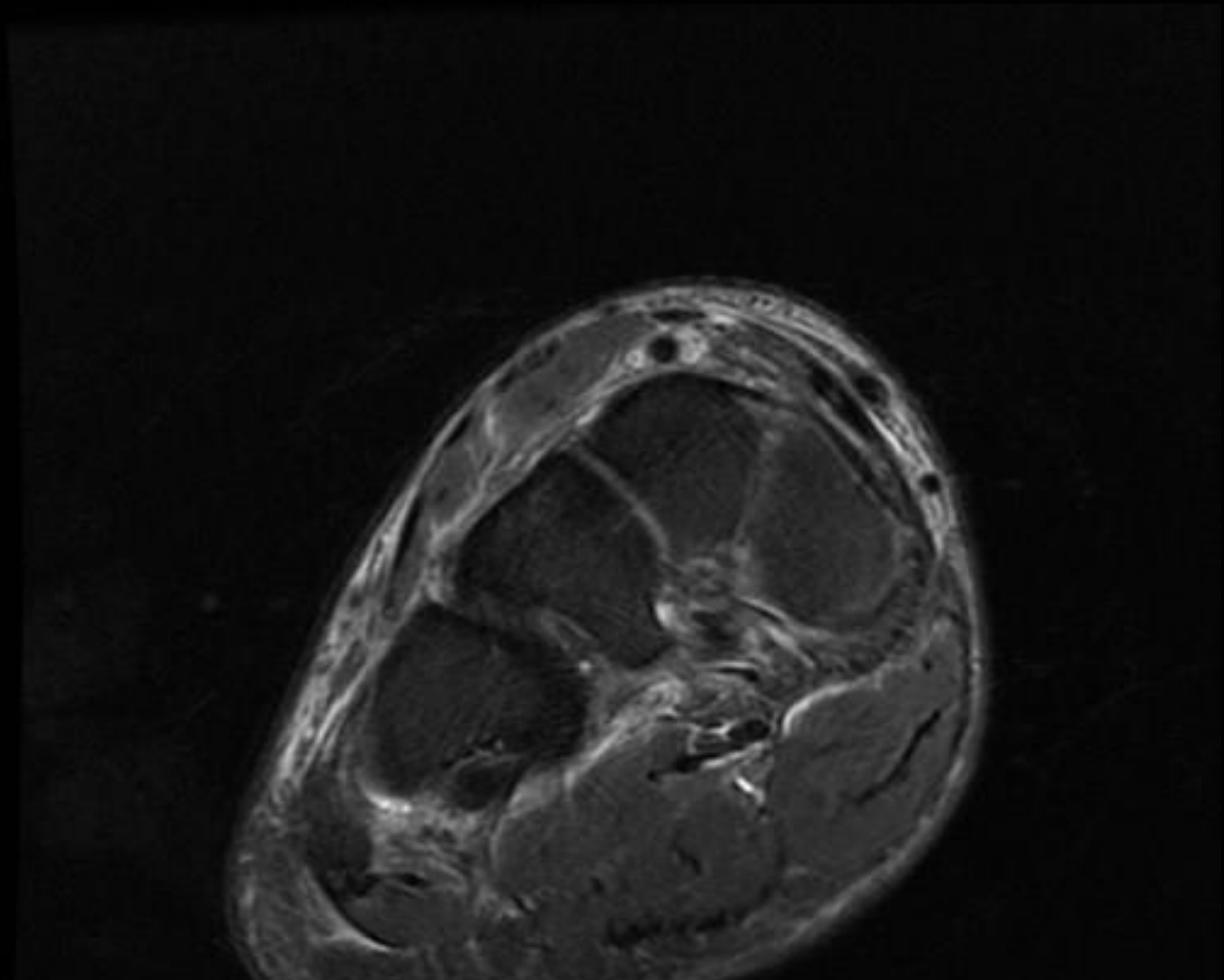


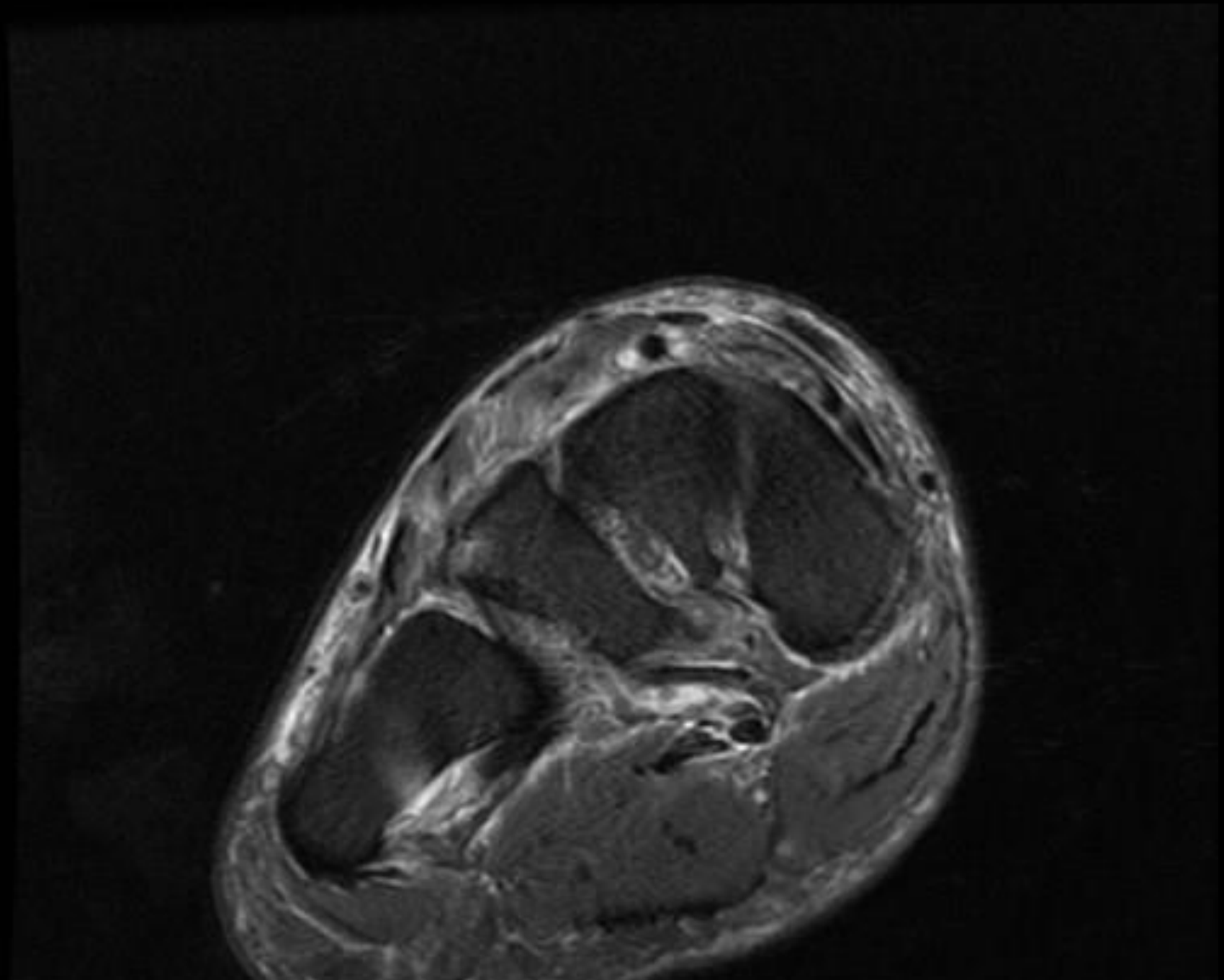


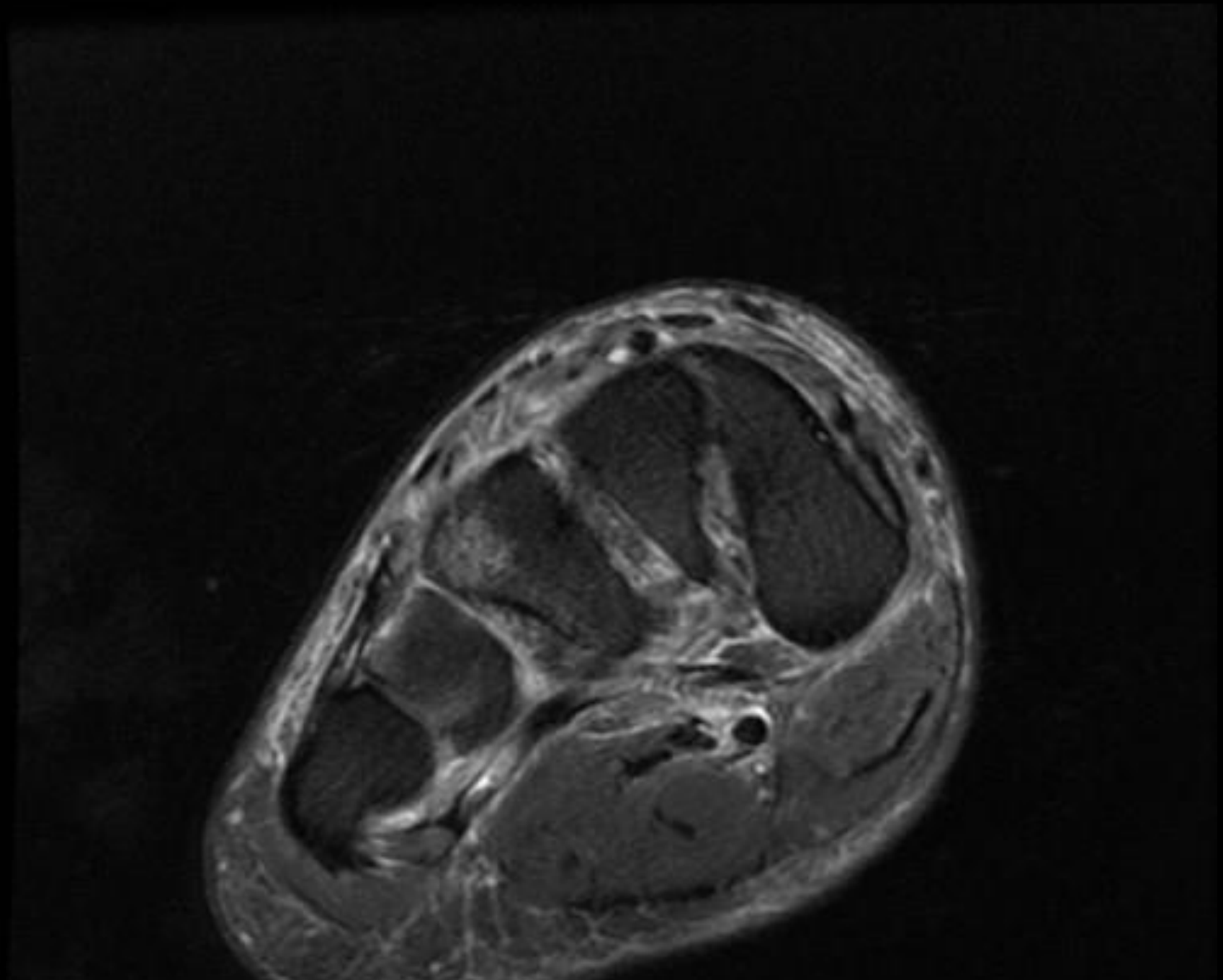


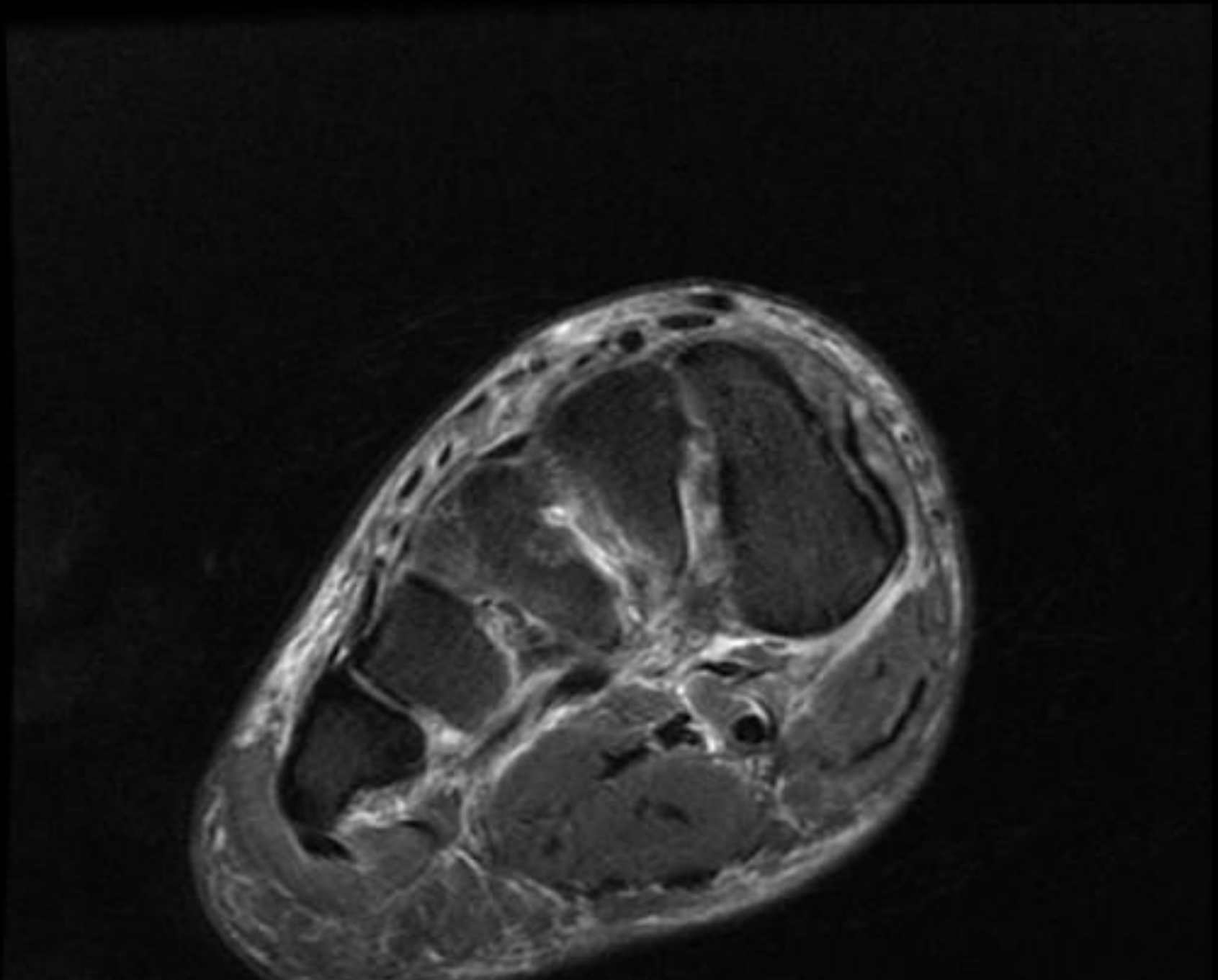


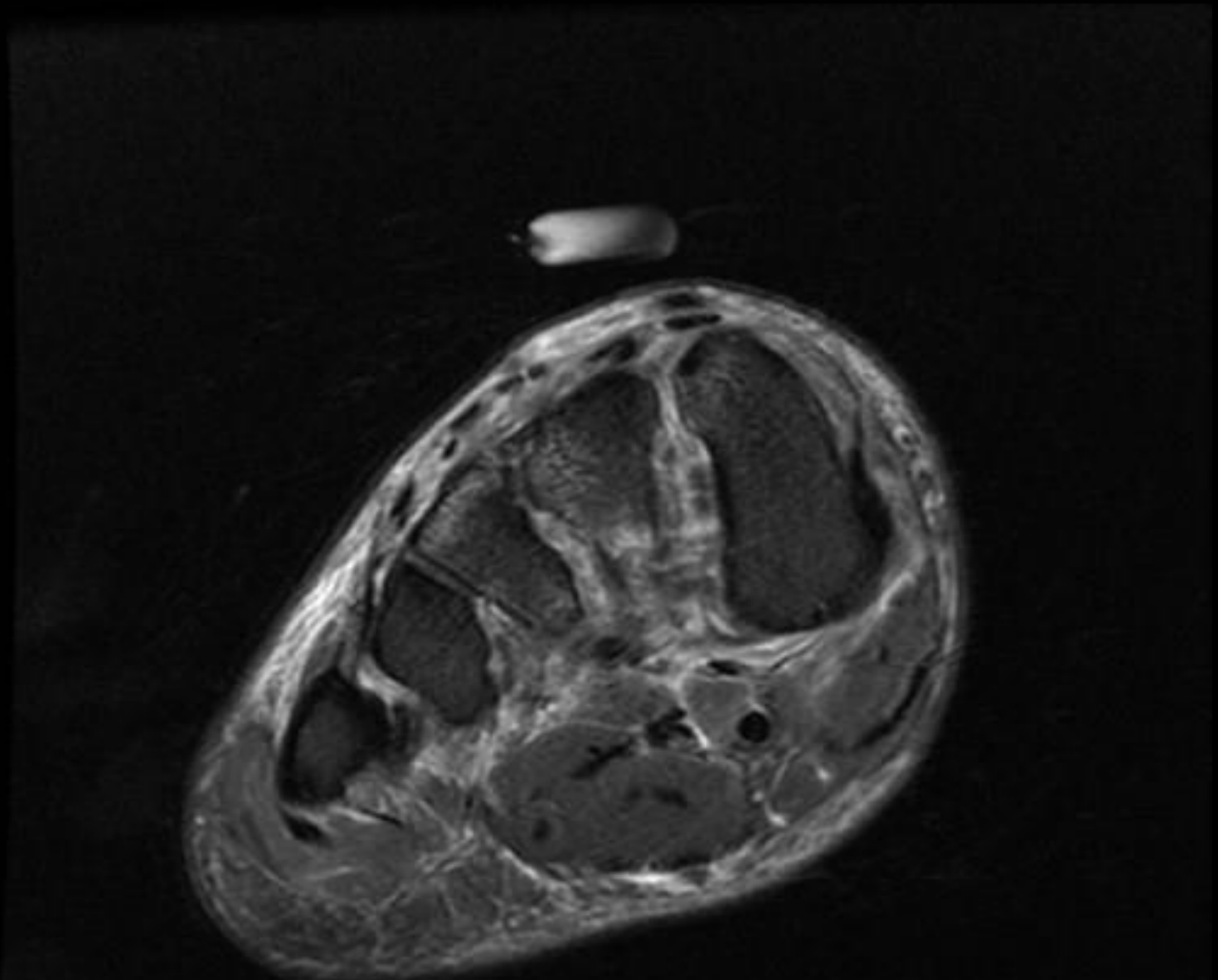


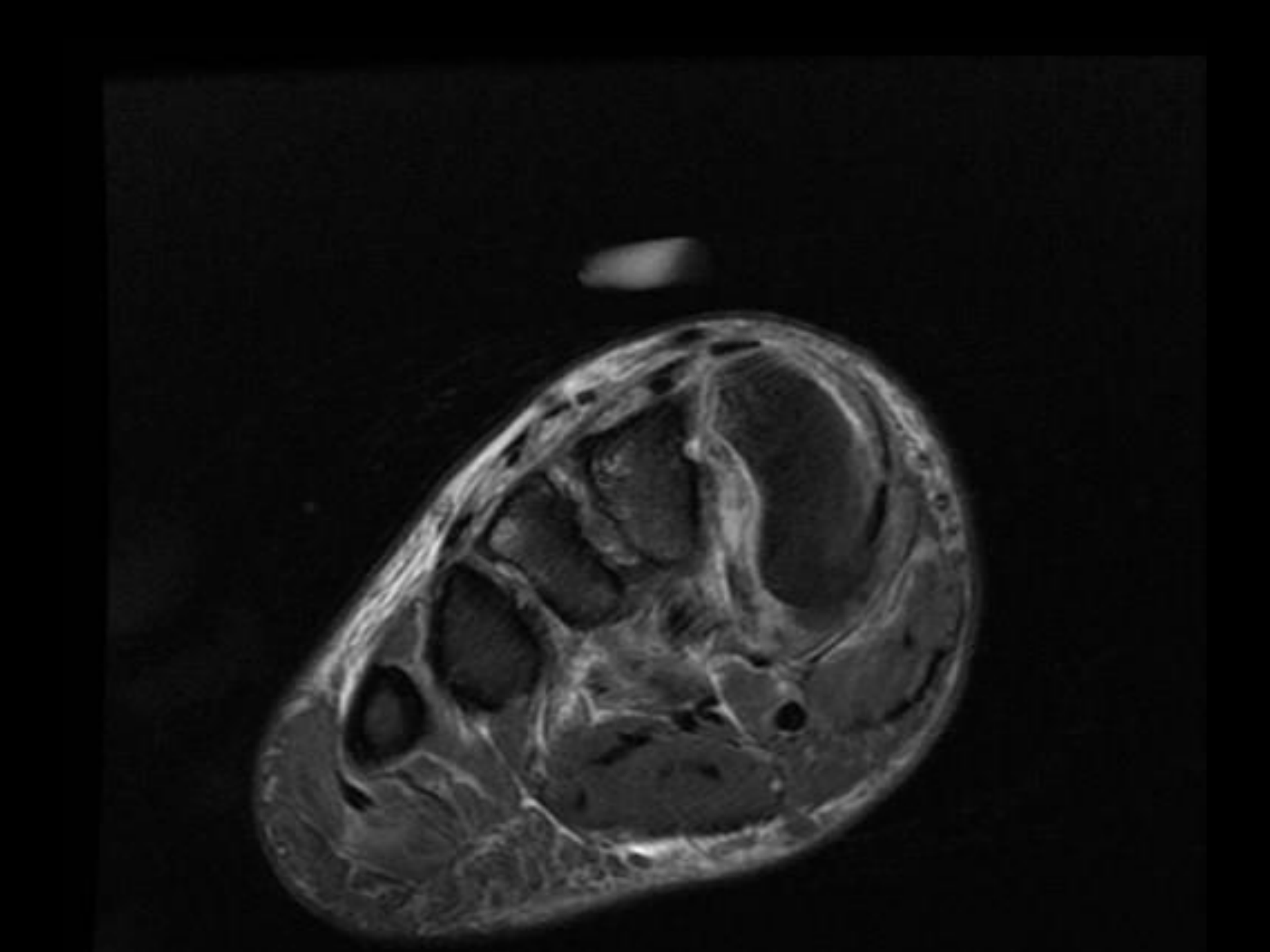


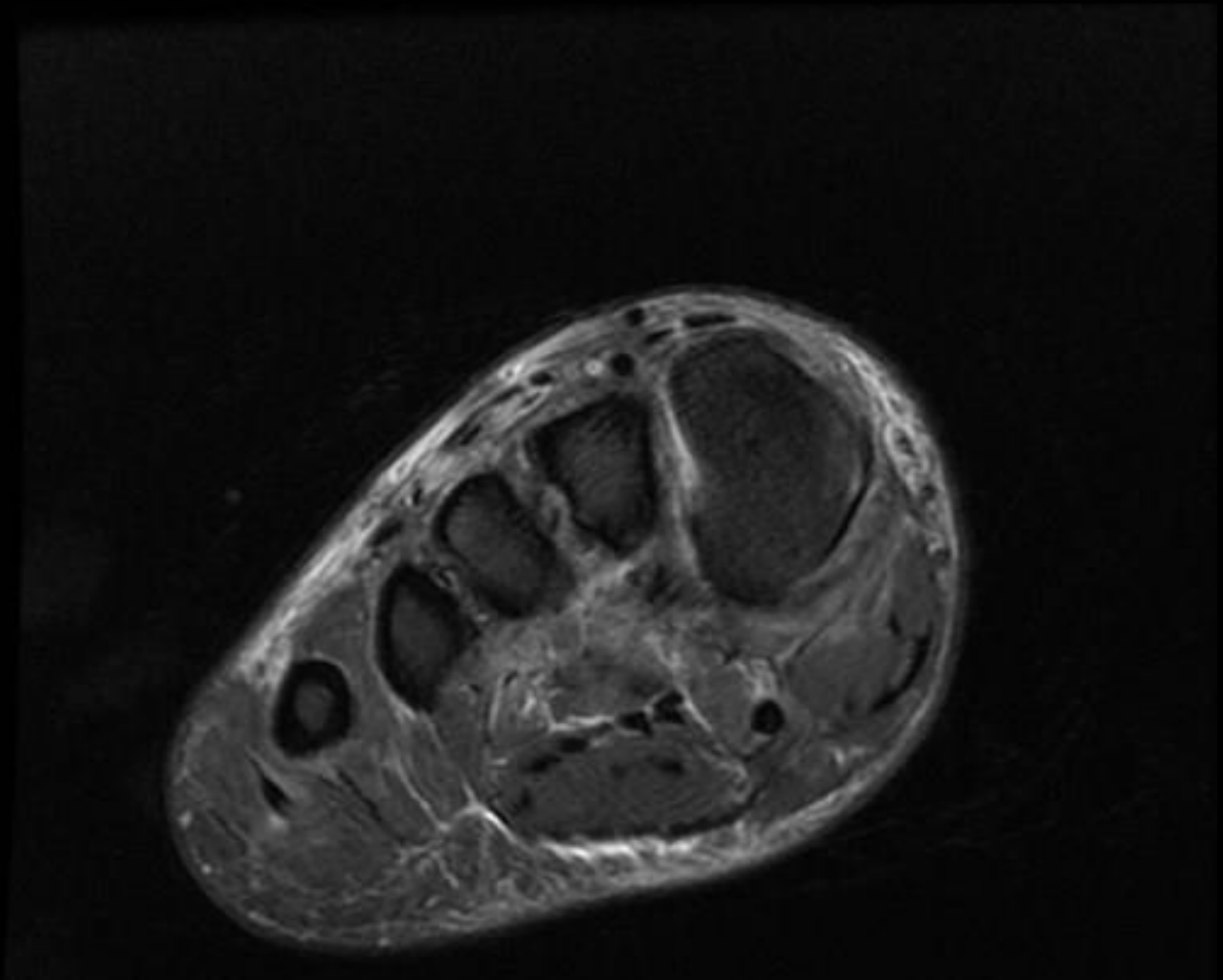


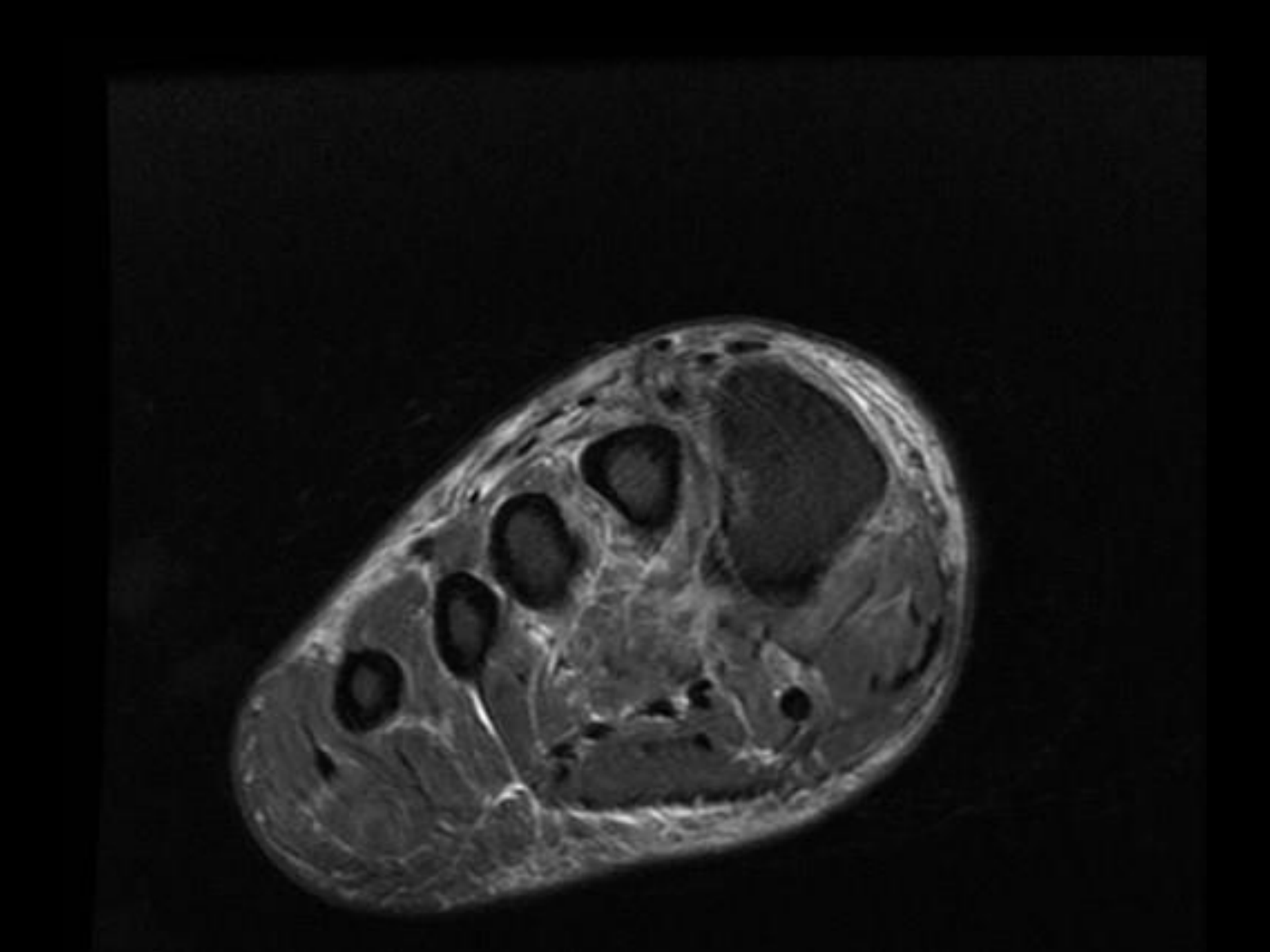


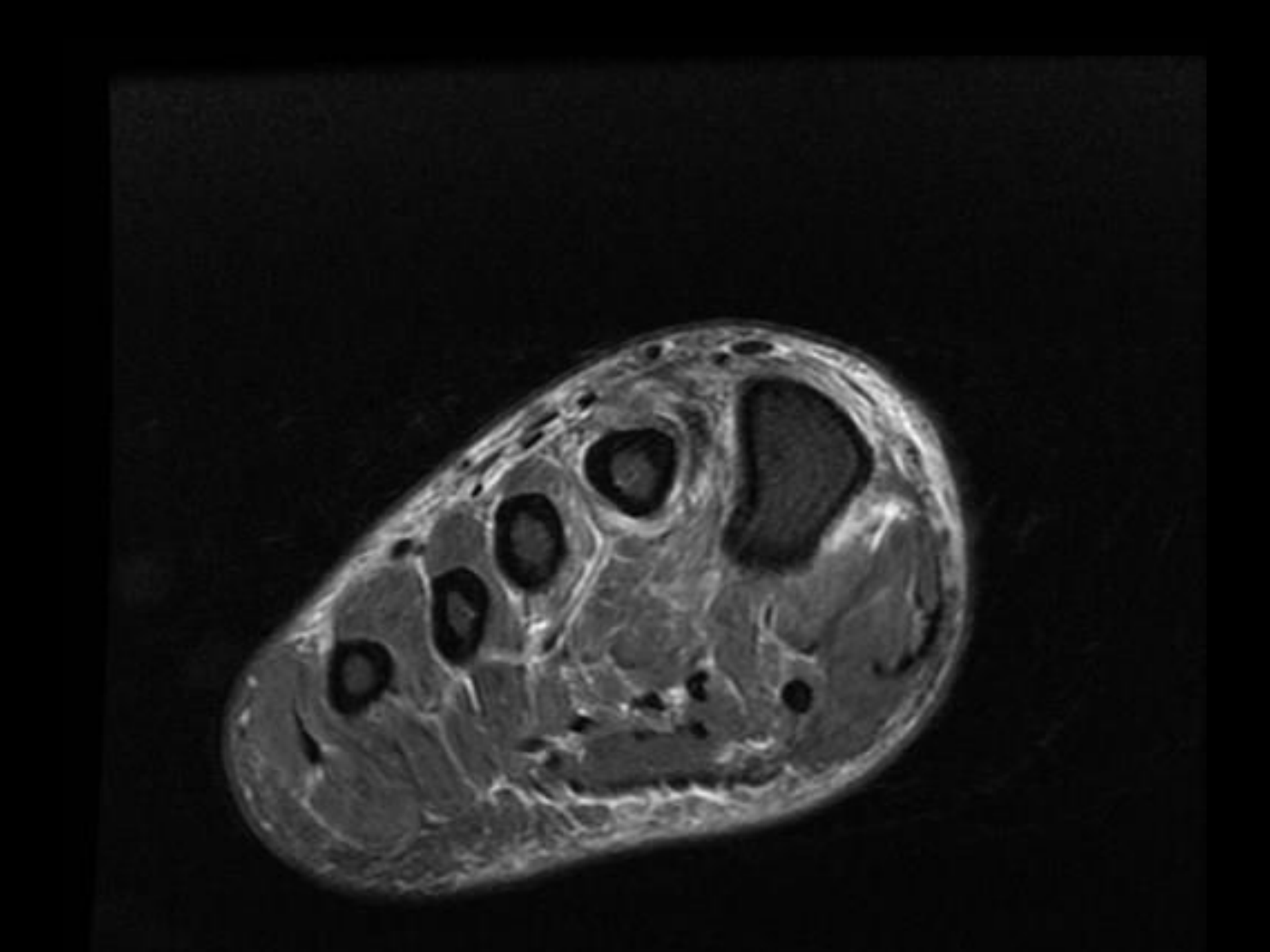


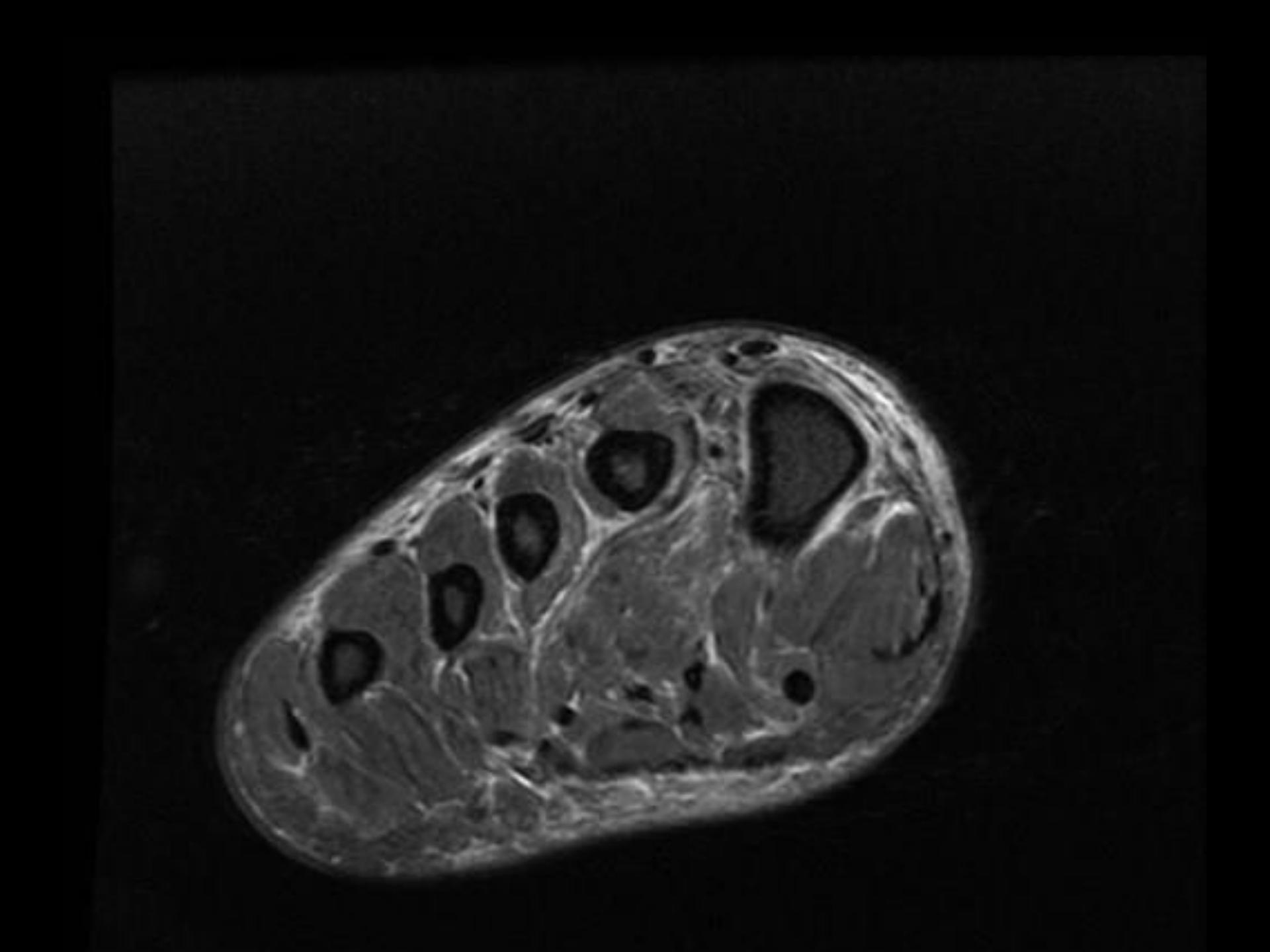


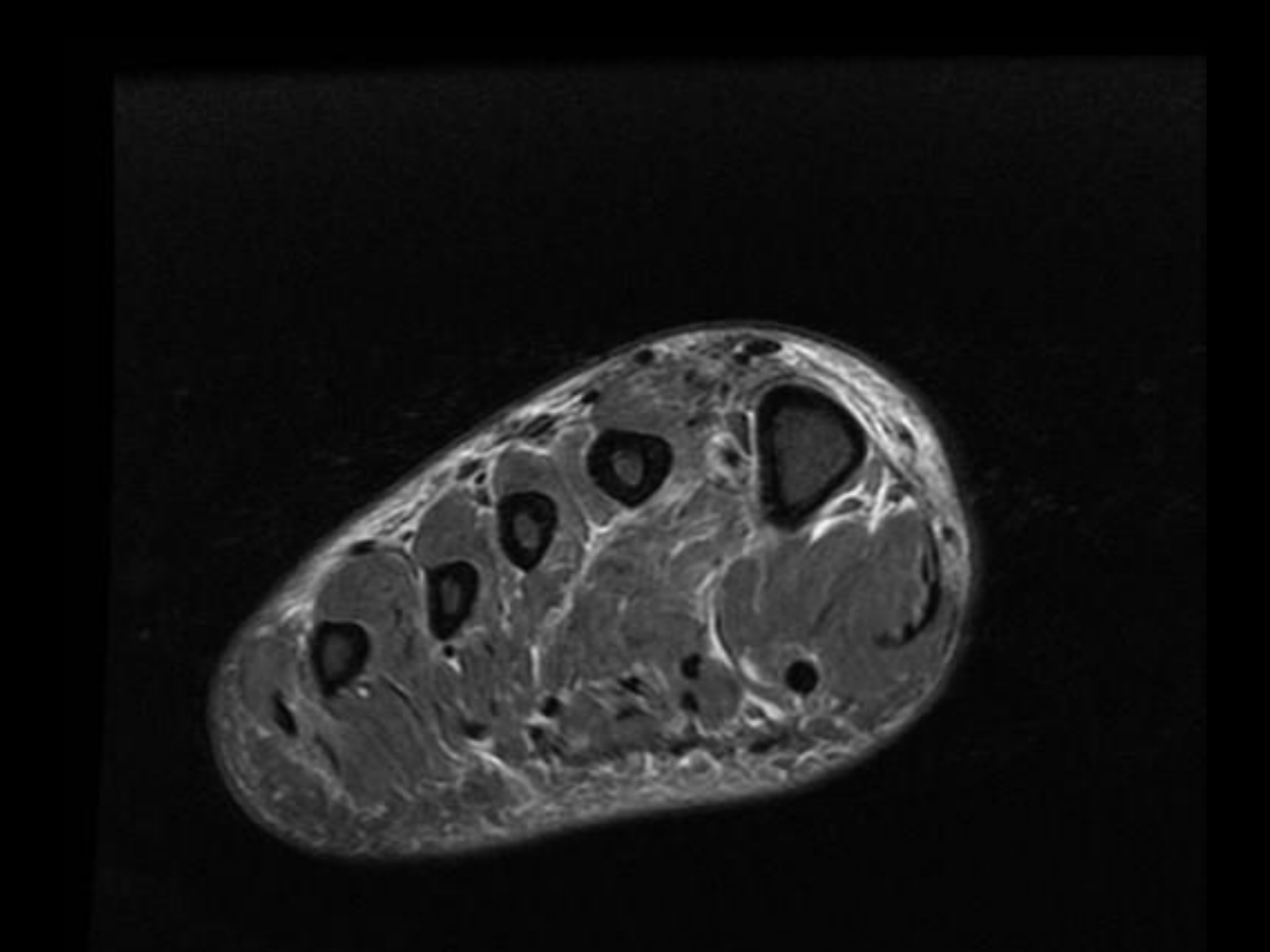


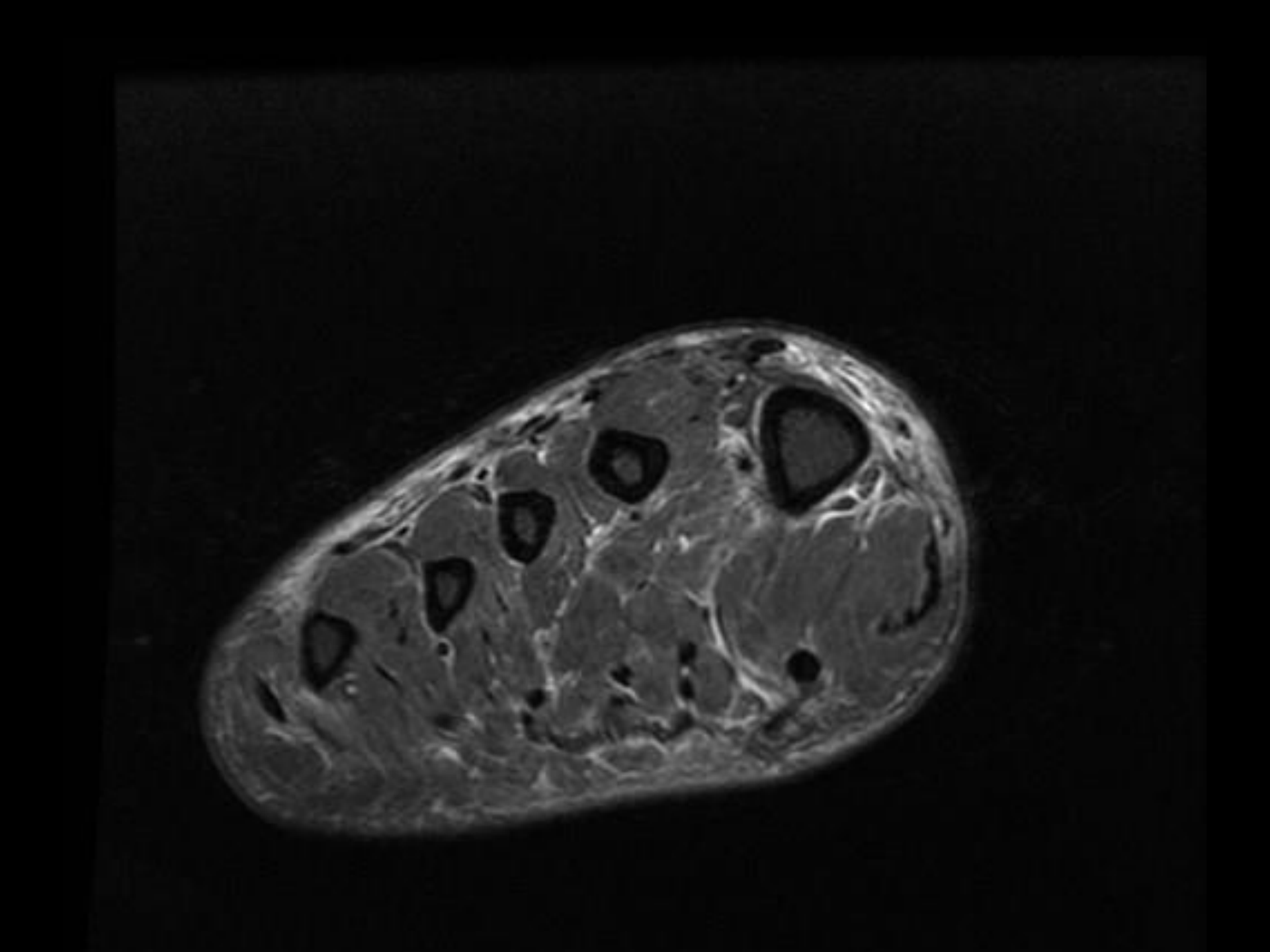


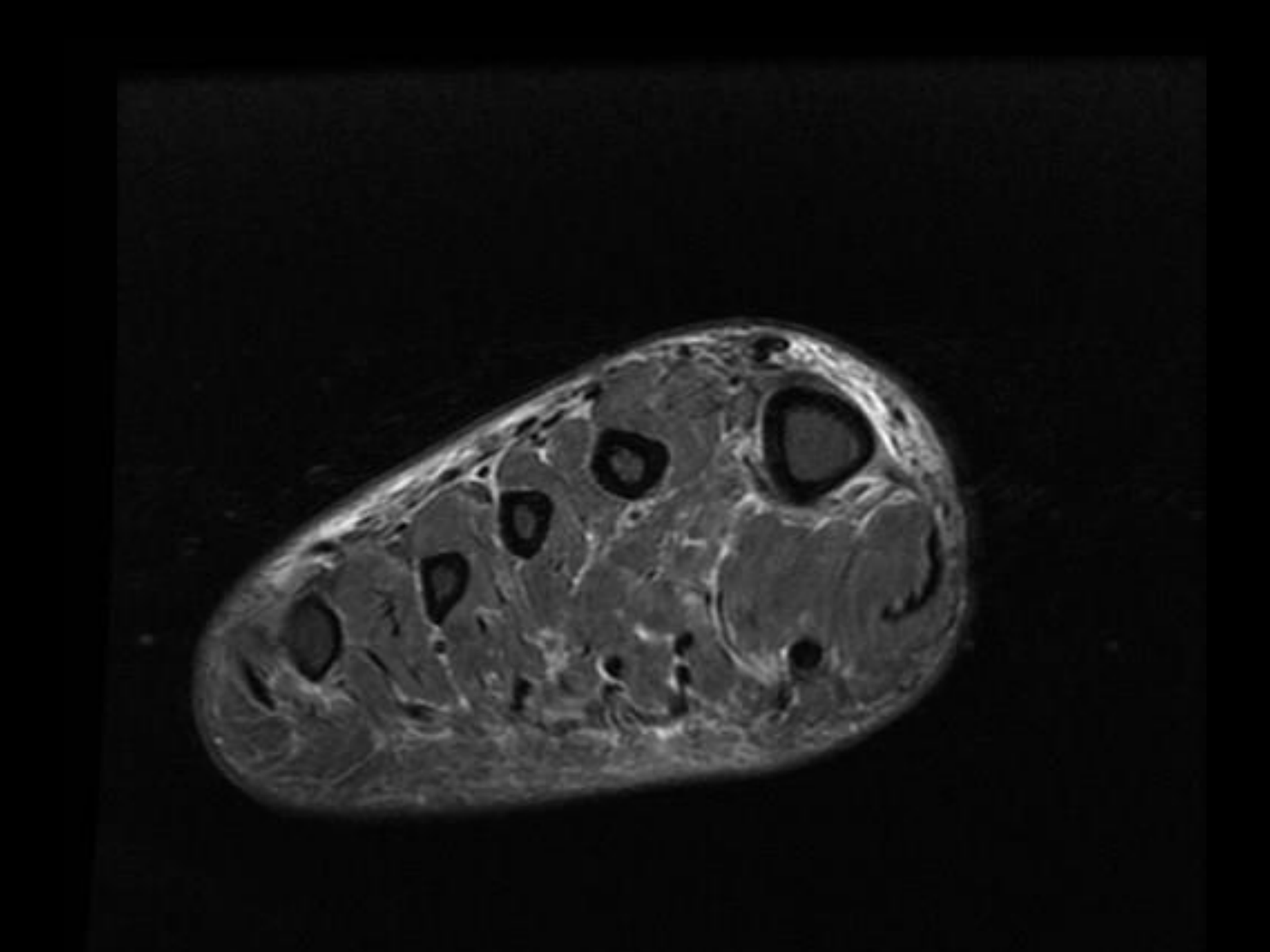


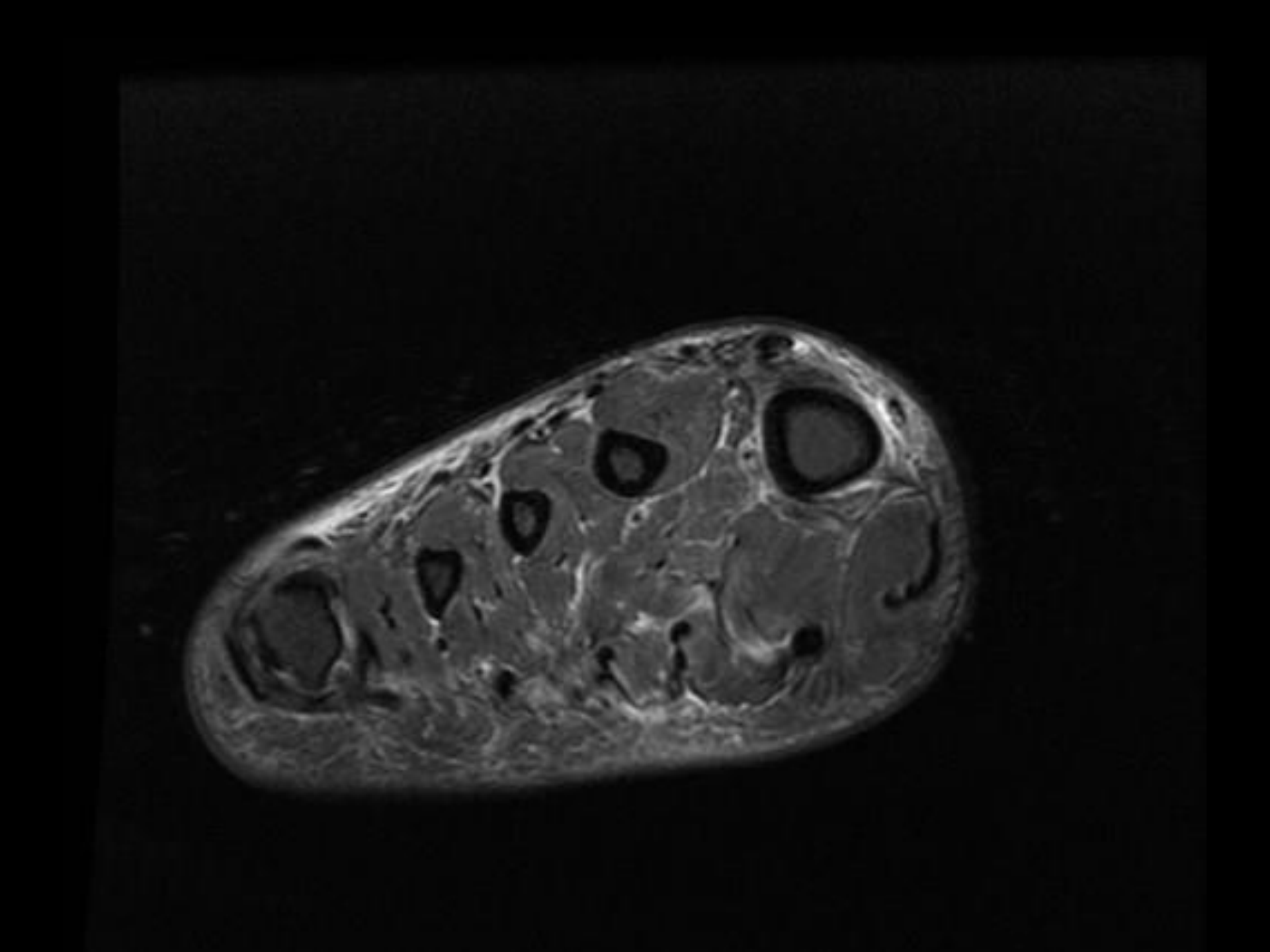


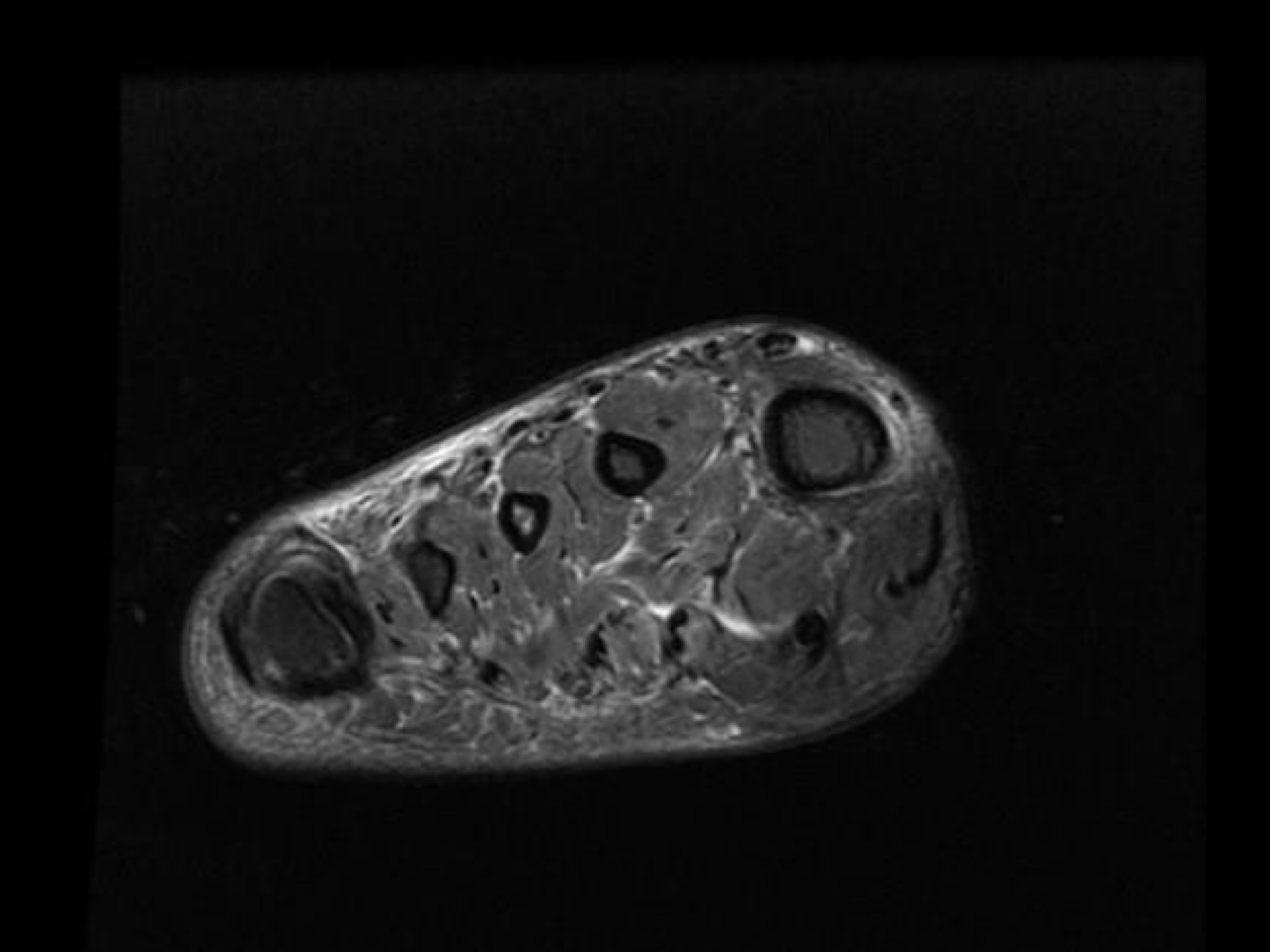


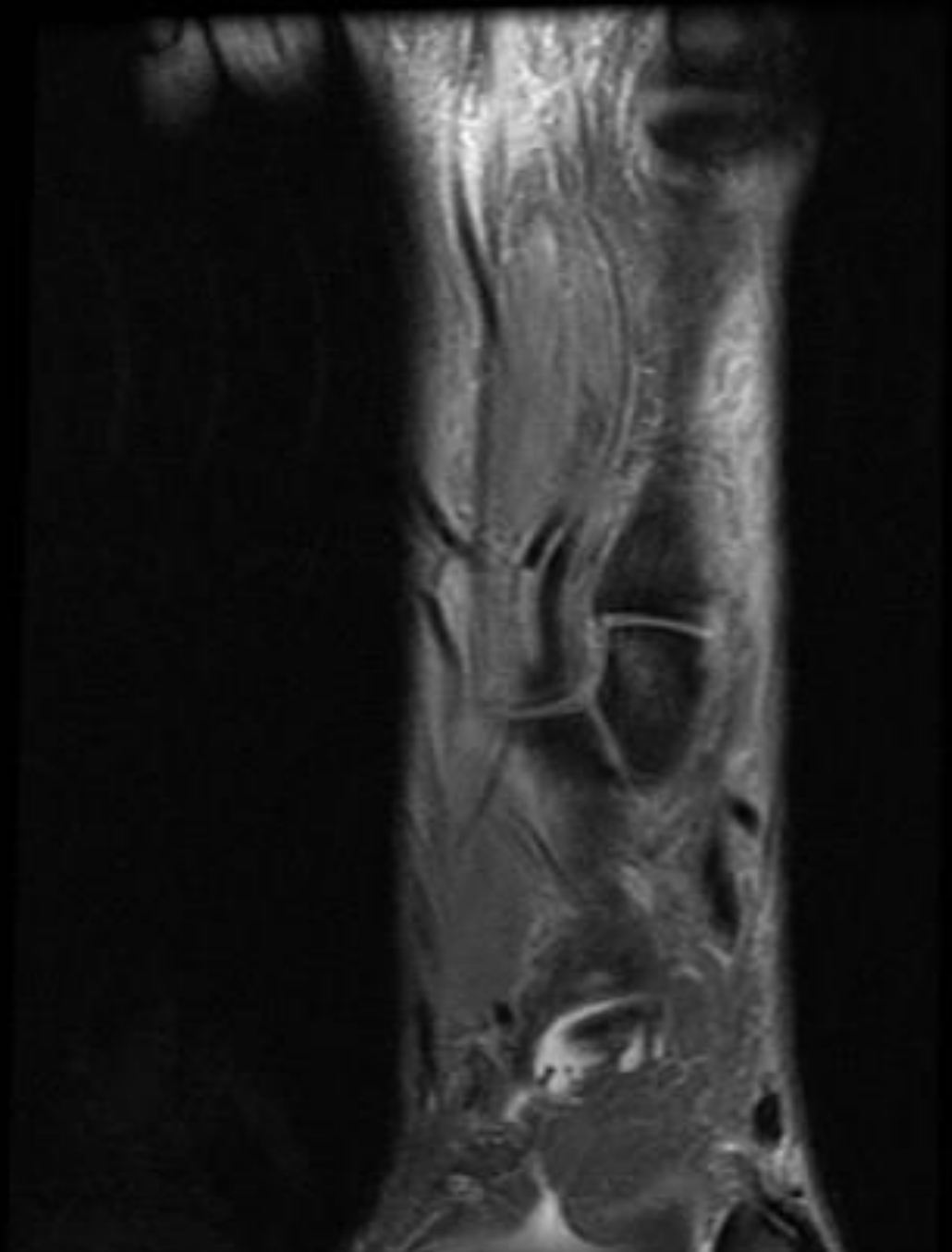


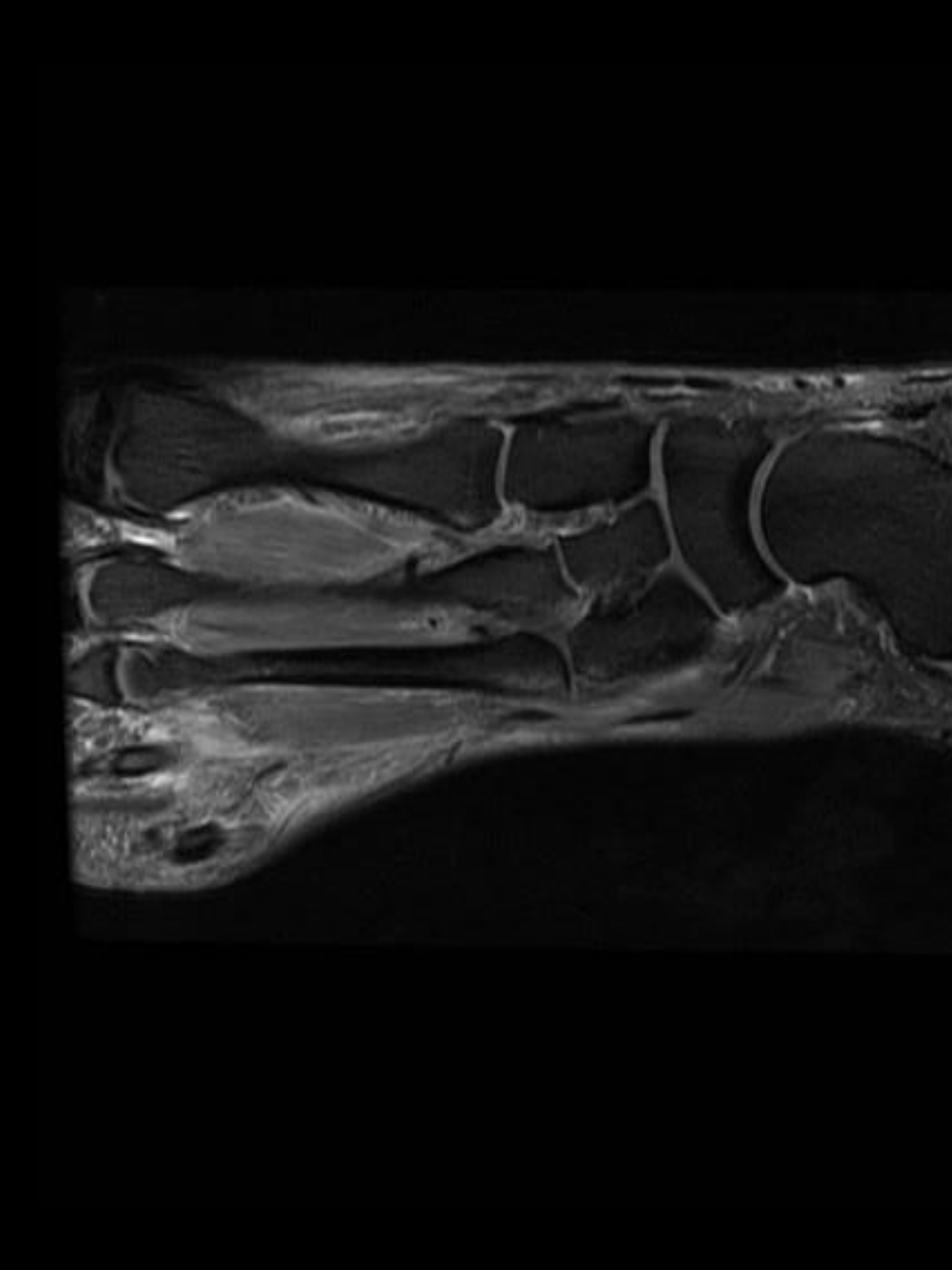


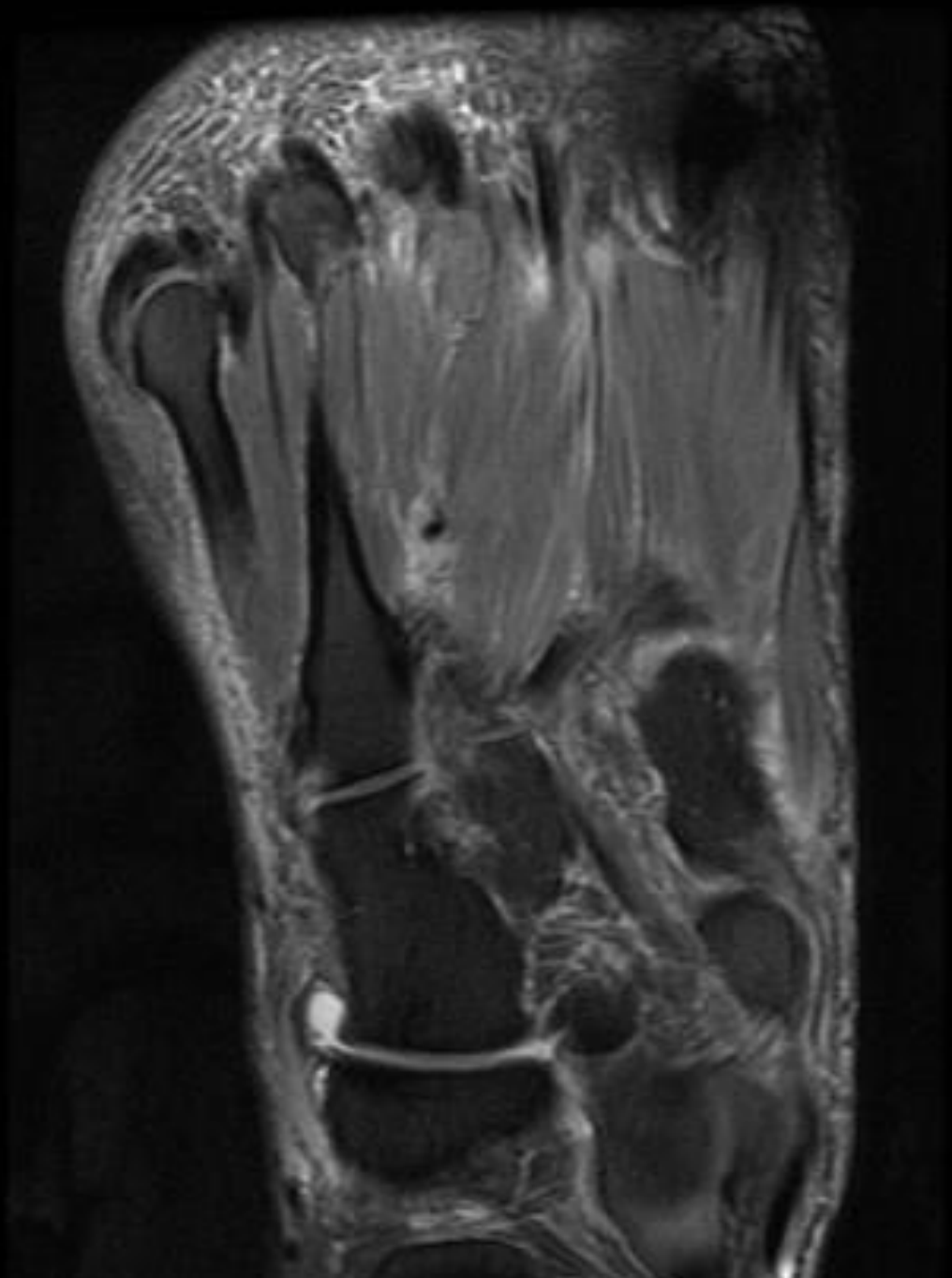


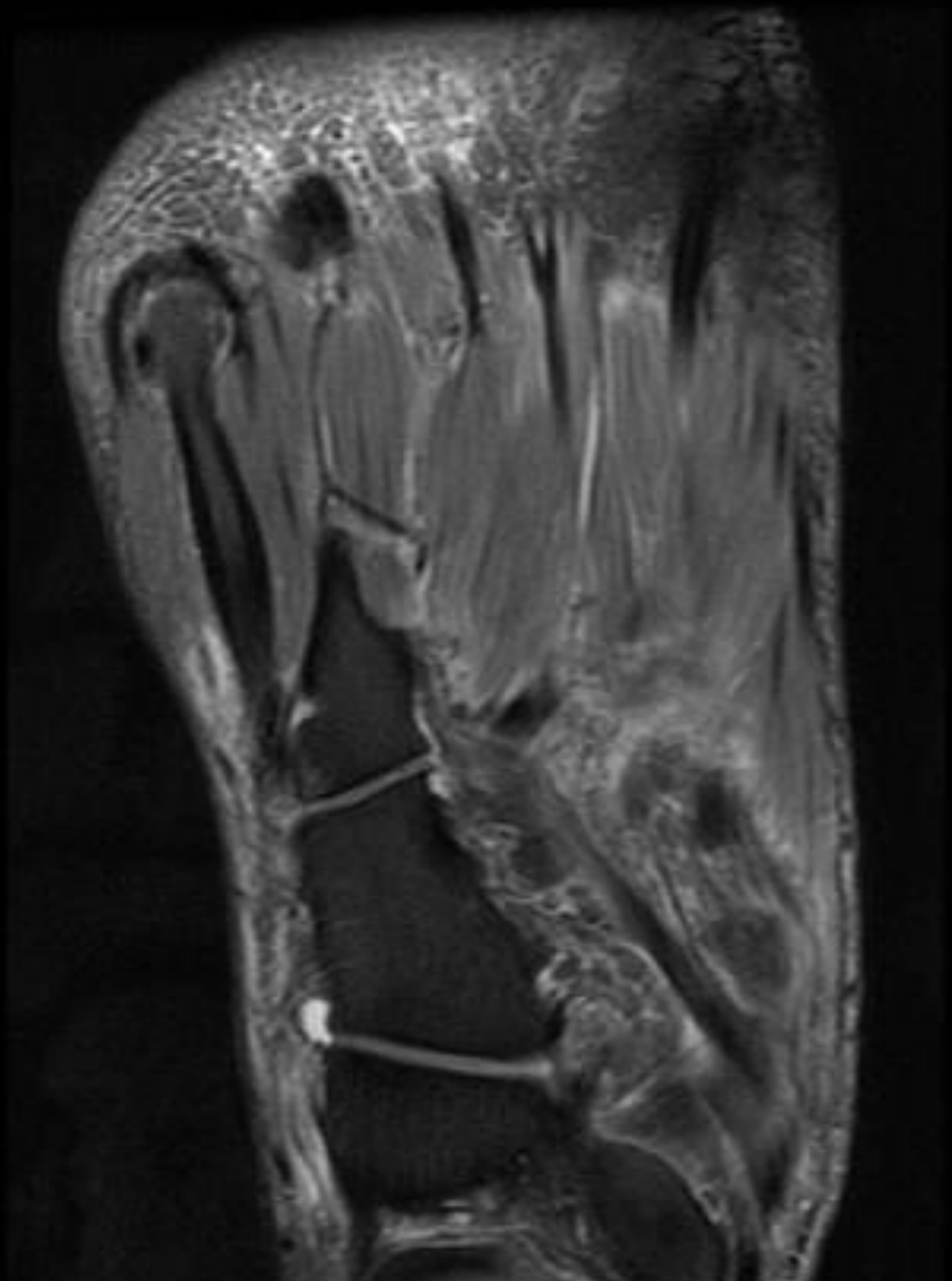


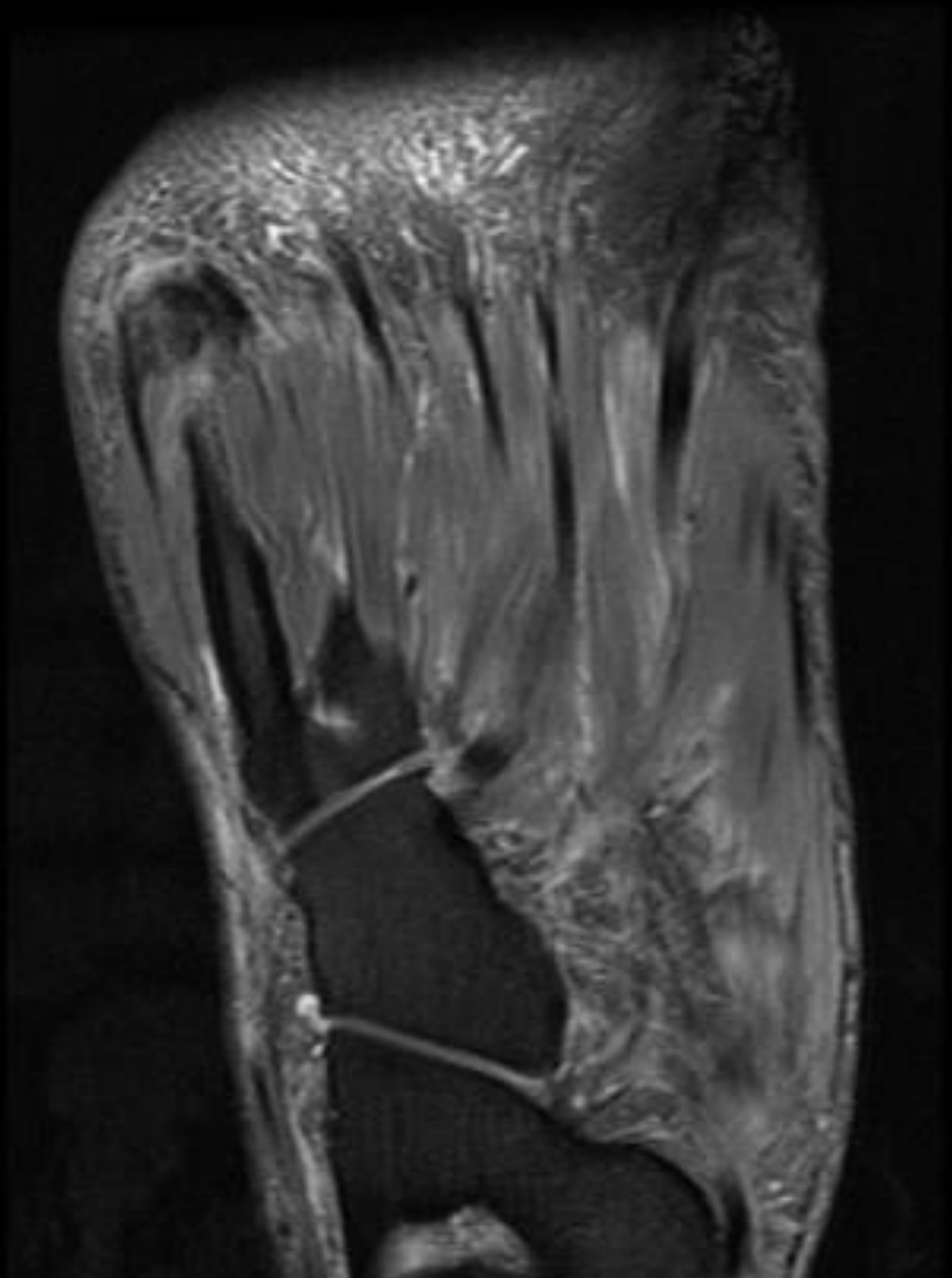


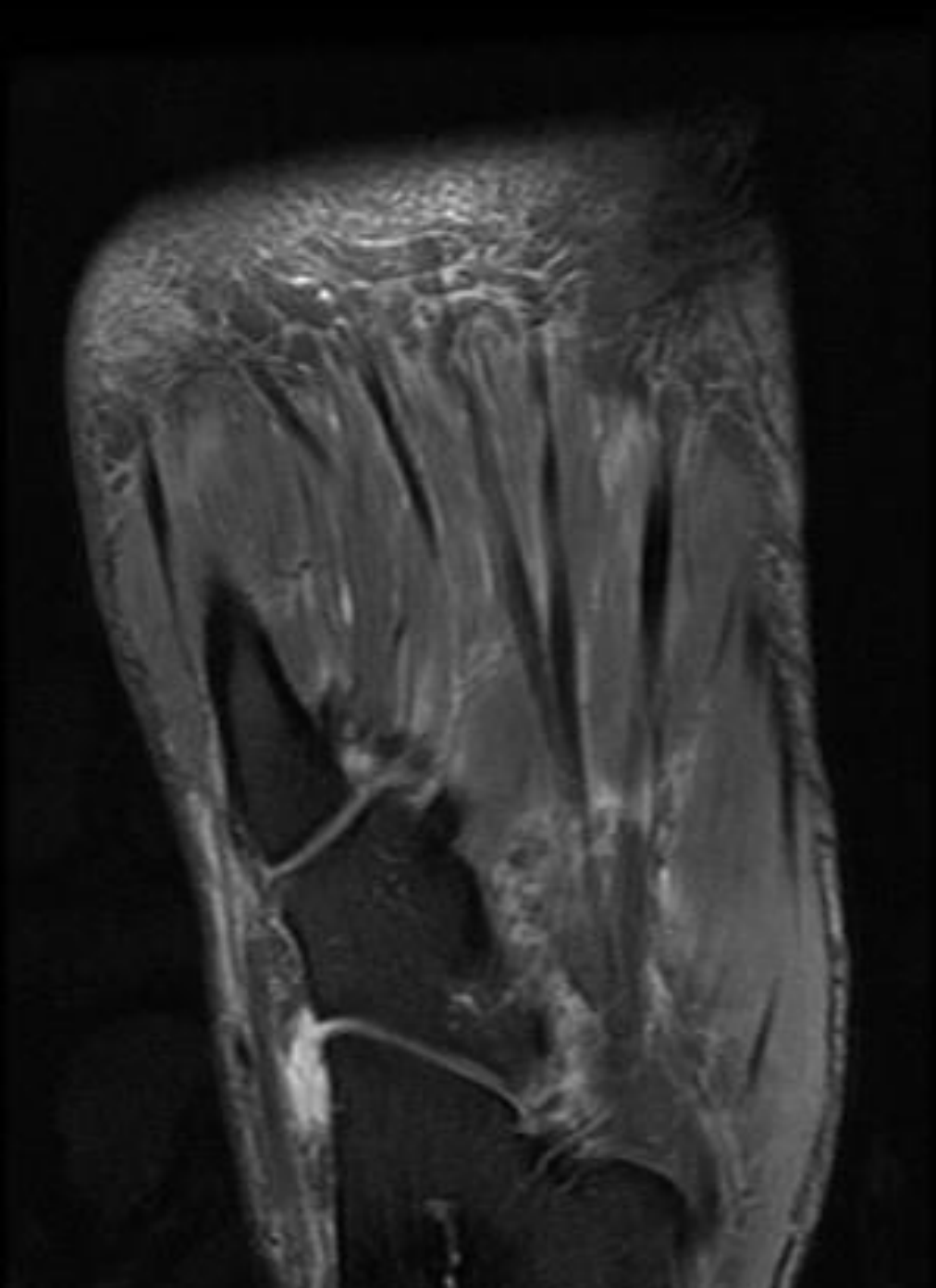












Connie Montgomery MD

Raikin Study (2009)

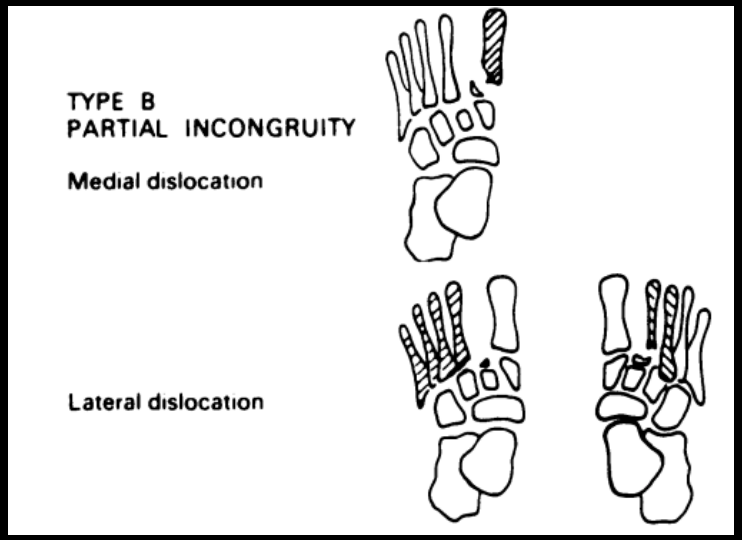
- 21 suspected Lisfranc sprains
- 17 ruptured pC1-M2M3*
- 13 ruptured dC1-M2 (interosseous)
- 3 ruptured pC1-C2
- 18 ruptured pC2-M2
- Fluid along lateral margin of M1
- 9 fractures
- 81% unstable on stress under anesthesia

Raikin Conclusions

- Predictor of instability
  - pC1-M2M3 (94% PPV)
- Not predictors of instability
  - dC1-M2*, pC1-M1, pC2-M2, dC1-C2
- pC2-M2
  - Clinical confounder
  - May result in unnecessary surgery
  - MRI can help differentiate

Kaar Study (2007)

- Cadaver study (10 specimens)
- Instability > 2 mm C1-M2 space
- Disruption of interosseous C1-M2
  - Insufficient to produce instability
- Transverse instability
  - C1-M2 and pC1-M2M3
  - Abduction stress > WB x-rays
- Longitudinal instability
  - C1-M2 and C1-C2
  - Adduction stress > WB x-rays for C1-C2 widening
  - C1-M2 diastasis better seen on fluoroscopy



Hardcastle et al

Stress Maneuvers

Karr et al

Kaar - Additional Conclusions

- Difficult to detect low-energy injuries on WB x-rays
- Absent C1-M2 and pC1-M2M3, WB x-rays actually decreased diastasis at TMTs
  - Tie-rod effect of plantar fascia
  - Dorsal translation of M2 on C2 (transverse)
  - Dorsal translation of C1 on M2/C2 (longitudinal)

Potter (1998)

- Referred to interosseous Lisfranc (C1-M2) as dorsal
- Dorsal weaker than plantar
- Diastasis measured vs contralateral foot
- No MRI if clear diastasis on WB x-rays
- MRI beneficial if x-rays/clinical are equivocal

Baron Guillaume Dupuytren

Lisfranc could not become a professor of the Faculty of Medicine in Paris because of his enmity with Dupuytren.

"The best of surgeons, the worst of men."

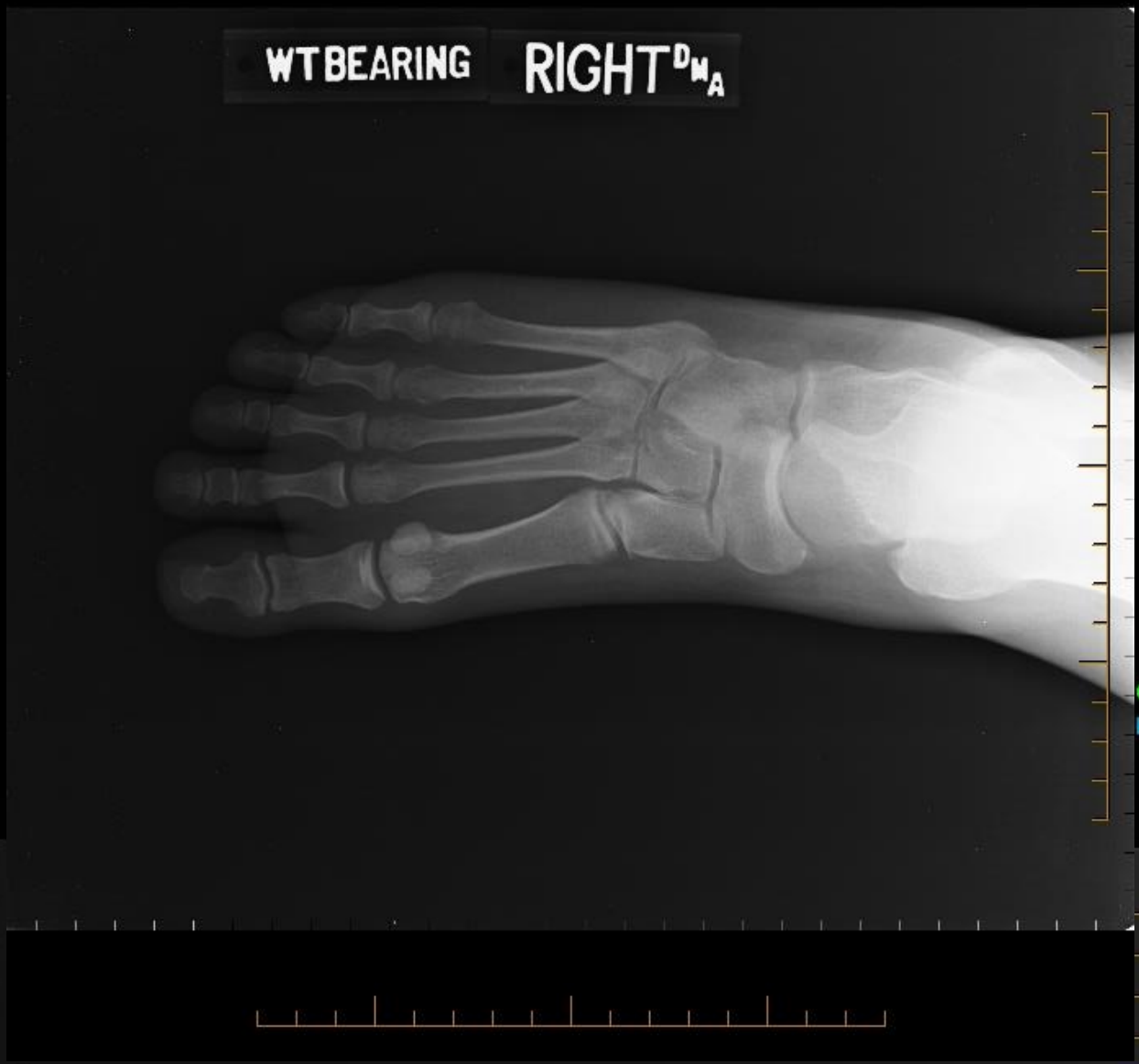
- Pierre-François Percy, chief surgeon to the Grand Armée of Napoléon I

Wikipedia

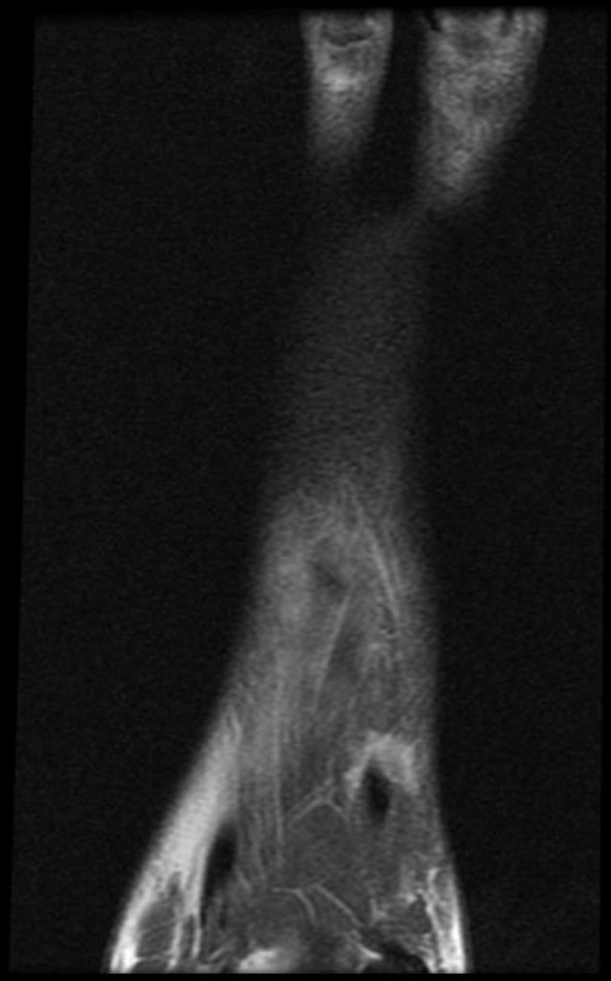
46 year old female with volleyball injury

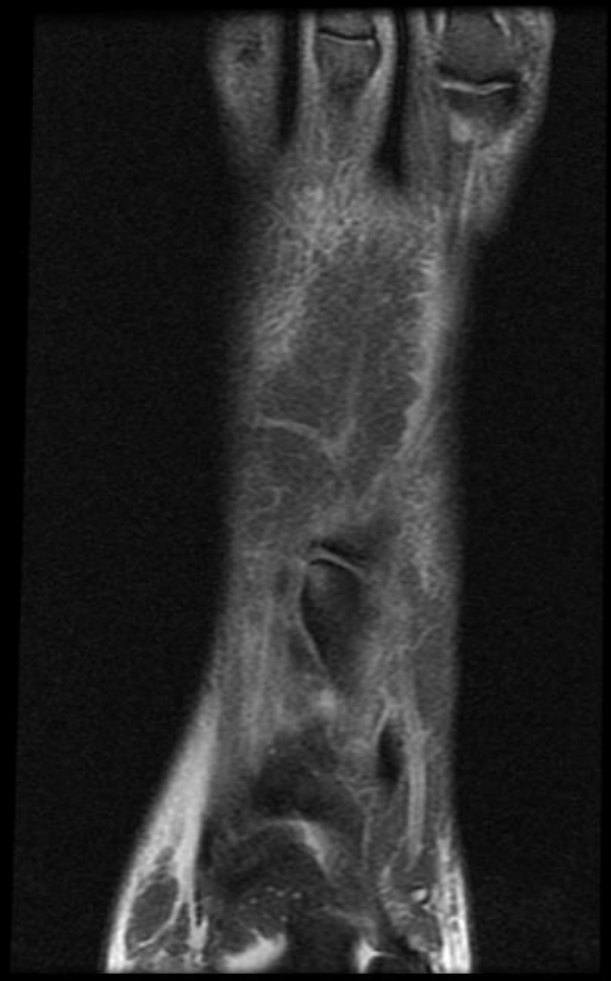

RIGHT D M A

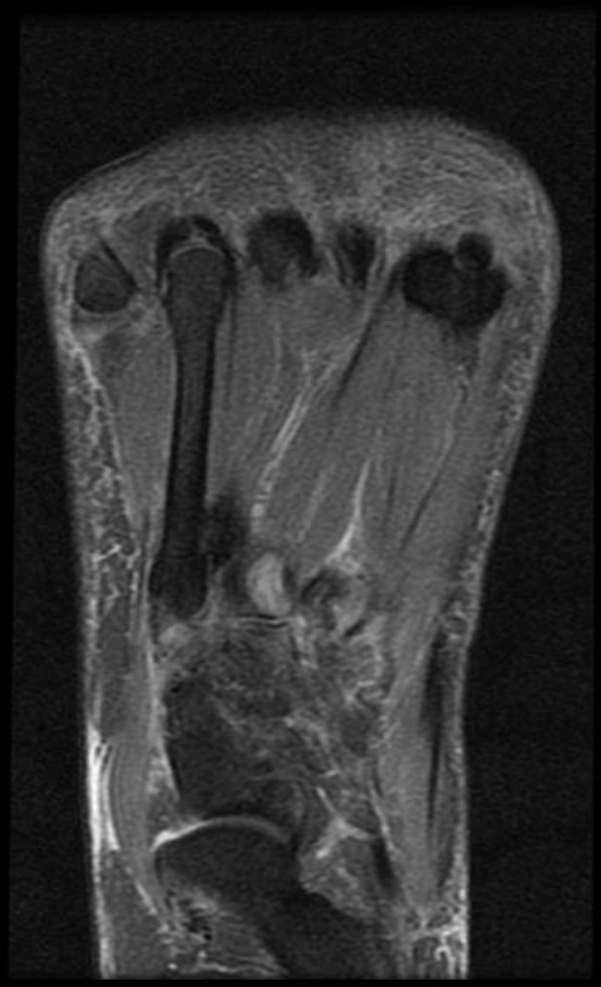

RIGHT D M A

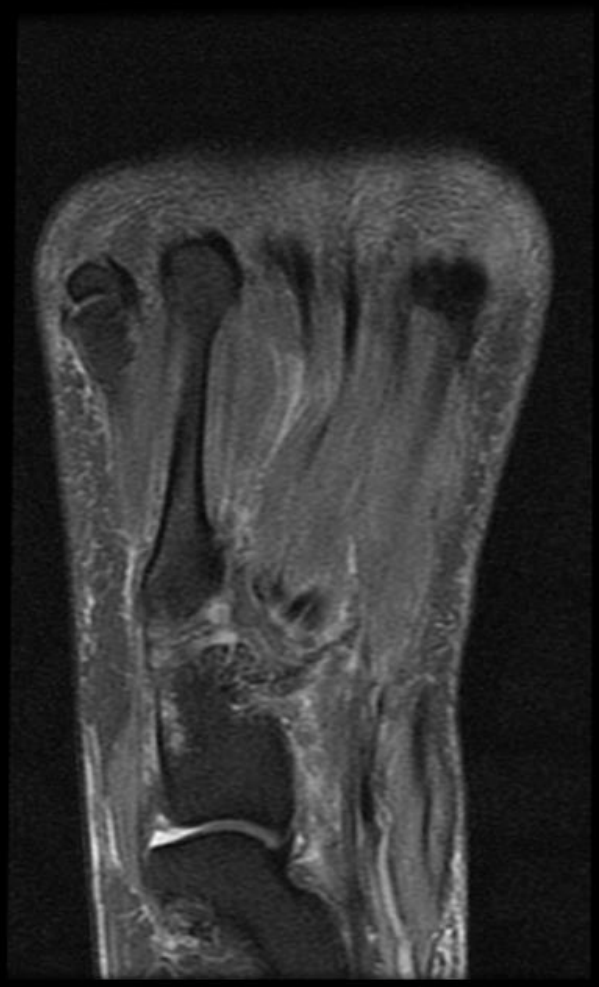

WT BEARING
RIGHT DMA

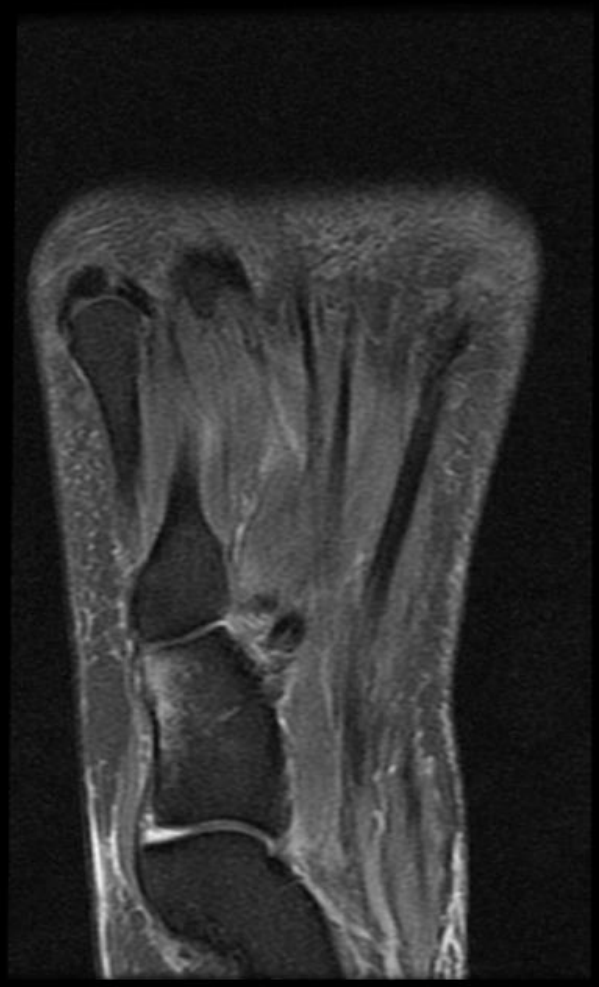

RIGHT DMA

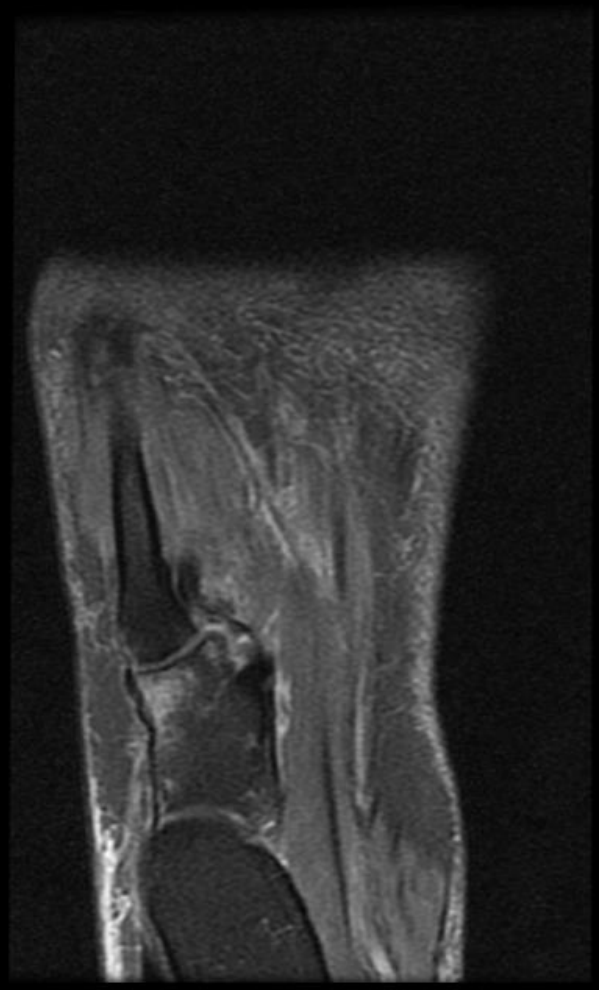


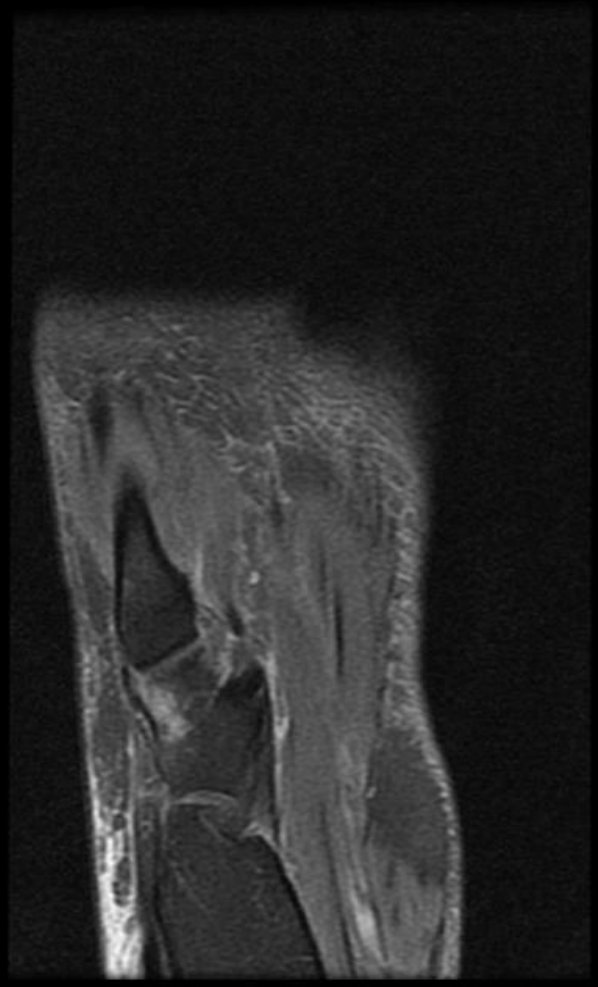


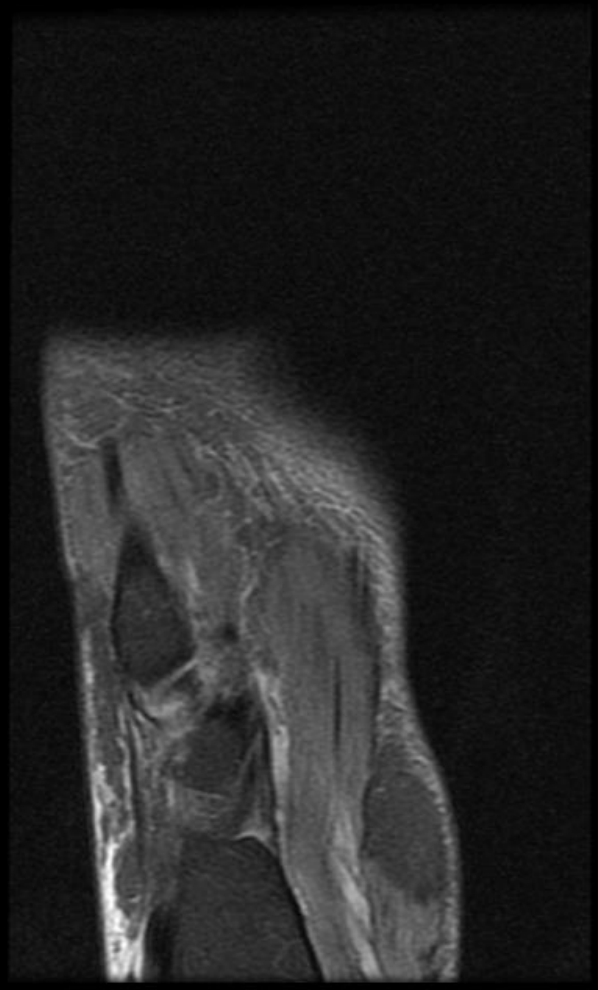


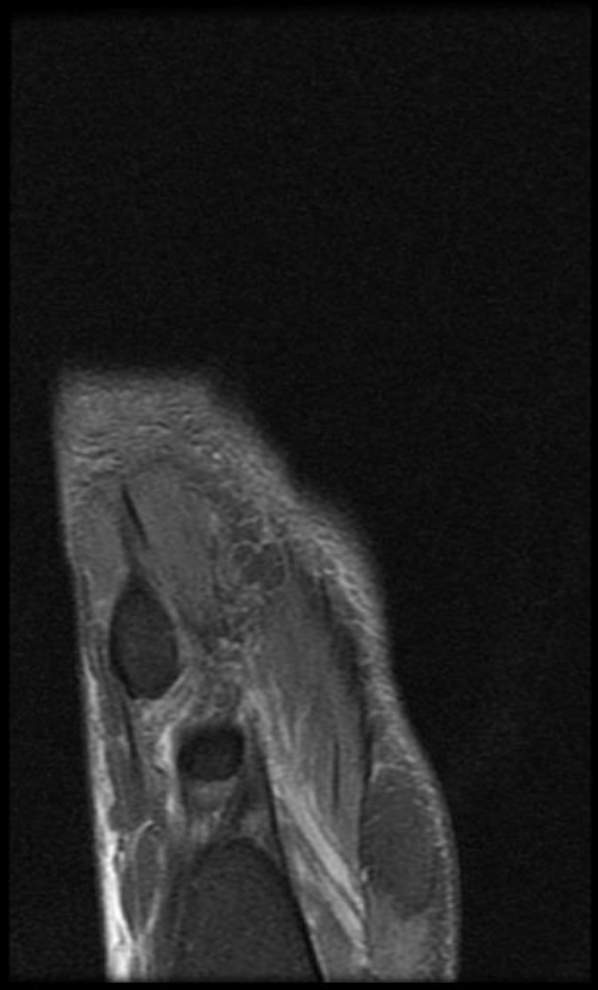


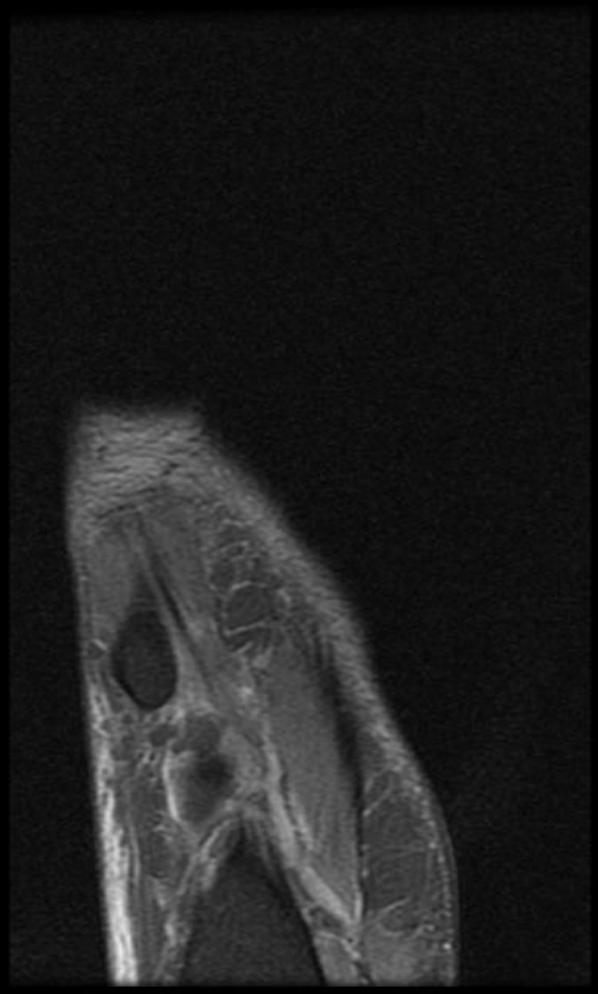


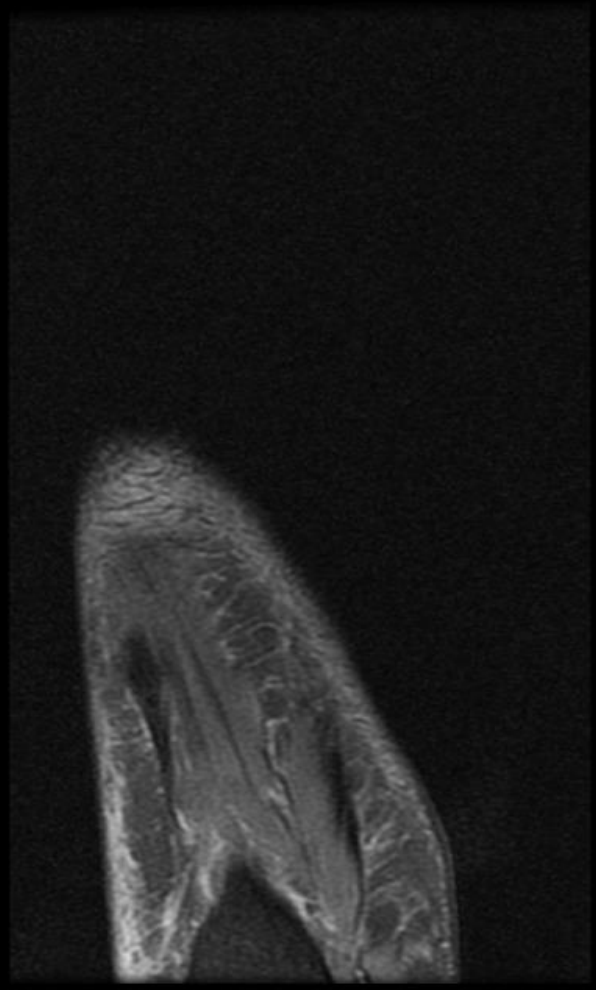


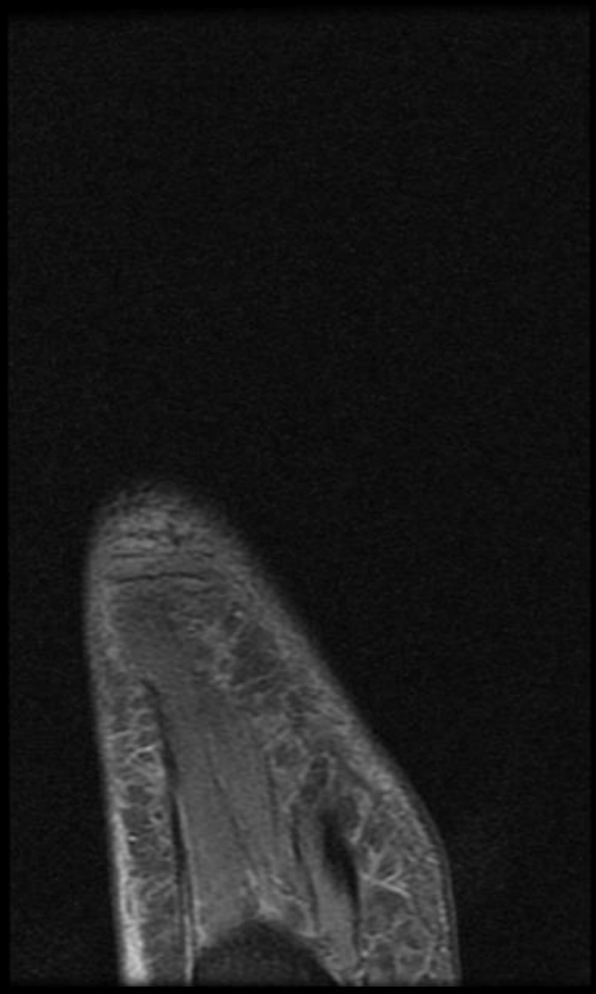


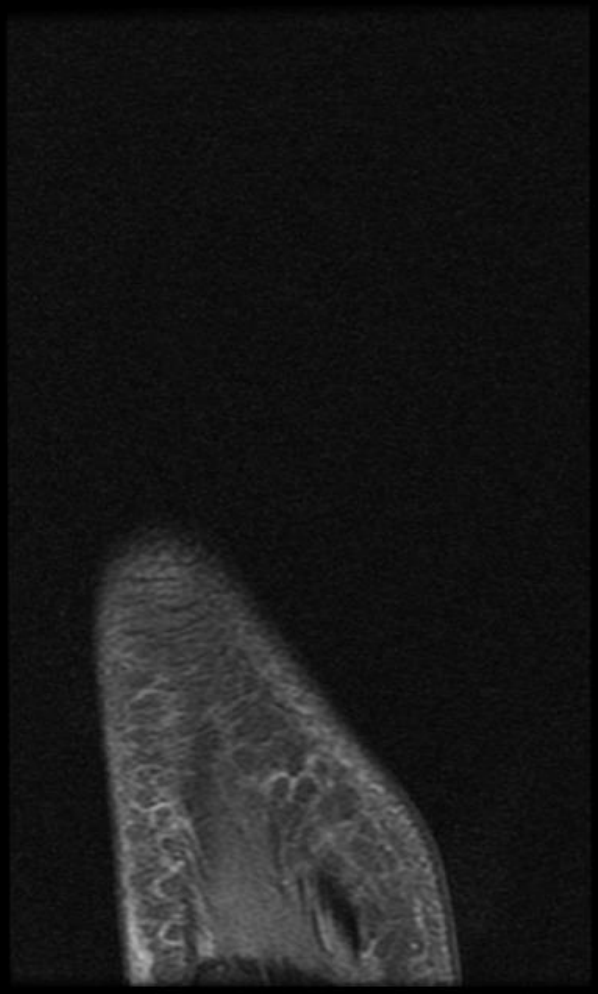


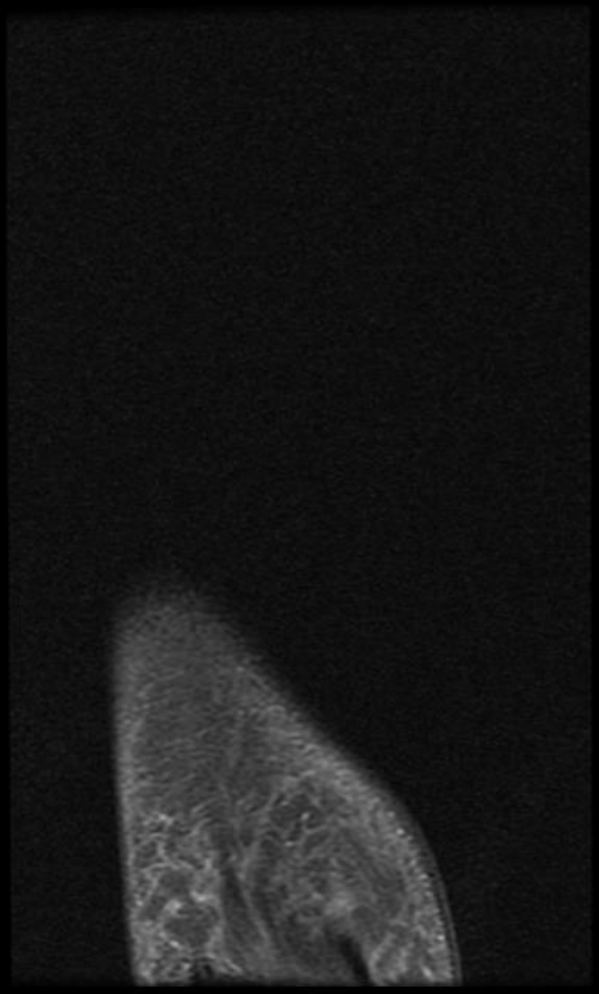












Therapeutic Algorithm (Raikin)

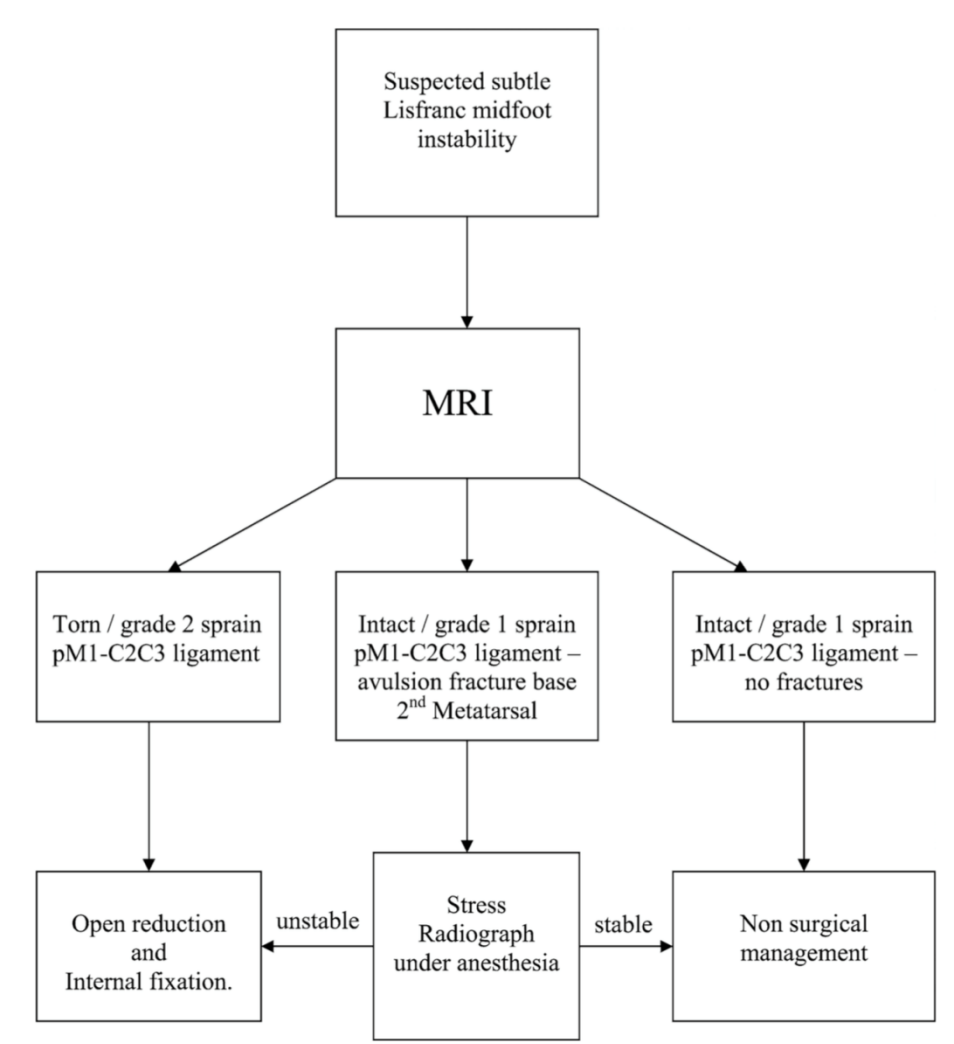


Fig. 6
Diagnostic and therapeutic algorithm for the treatment of a suspected subtle midfoot Lisfranc ligament complex injury. MRI = magnetic resonance imaging.

Raikin et al

Treatment – Low Grade

- N&V Stage I – conservative
  - Non-weightbearing cast 6 wks
  - If pain, removable boot for + 4 wks
  - F/u x-ray in 2 wks for increasing diastasis
  - Risk of OA
- N&V Stage II and III
  - Surgical
  - Anatomic alignment
    - Prevent OA and midfoot collapse
  - Non-weightbearing for 8-12 wks

Closed Reduction

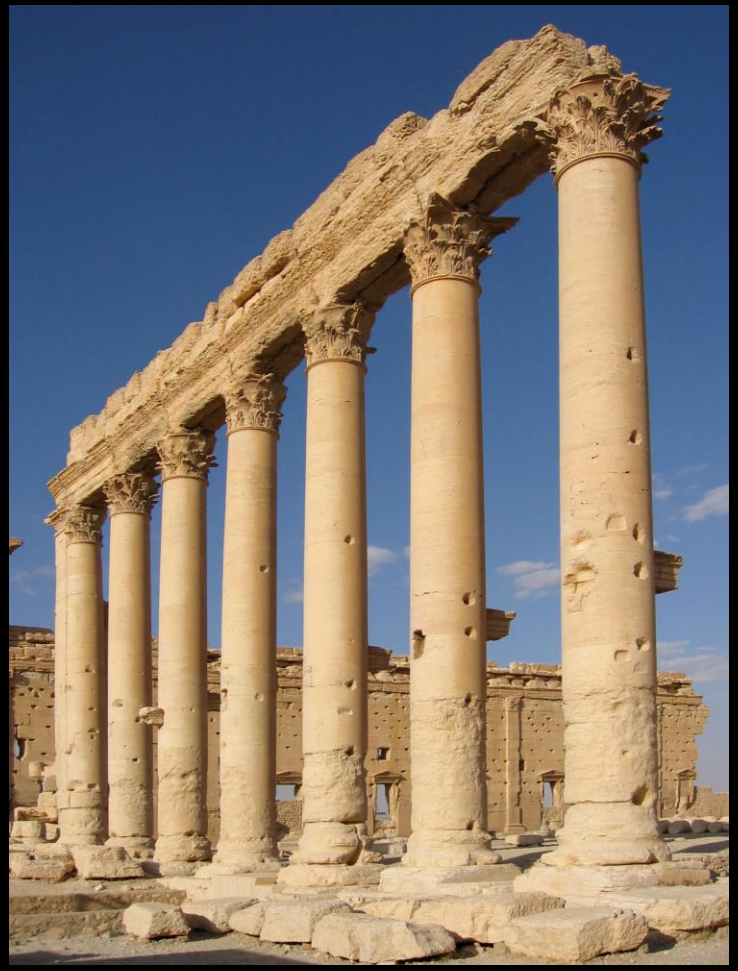
- Fluoroscopy
- Percutaneous screws
- Higher likelihood of failure
  - Entrapped osseous fragments
  - Entrapment of ATT or PLT

ORIF

- Screw fixation of medial and middle TMT joints > Kirschner wires
  - Rigidity
- Removal of hardware
- Hardware failure
- Articular surface damage
- OA
  - 50% radiographic signs; 8% require arthrodesis
- Arthrodesis for comminuted fx

Lateral Column Injuries

- 4th and 5th TMT
  - Reduced : no surgical Rx
  - Not reduced: percutaneous fixation for 6 wks



Wikipedia

48 year old professor tripped and fell with persistent forefoot pain

Brady Huang MD

3 month follow up

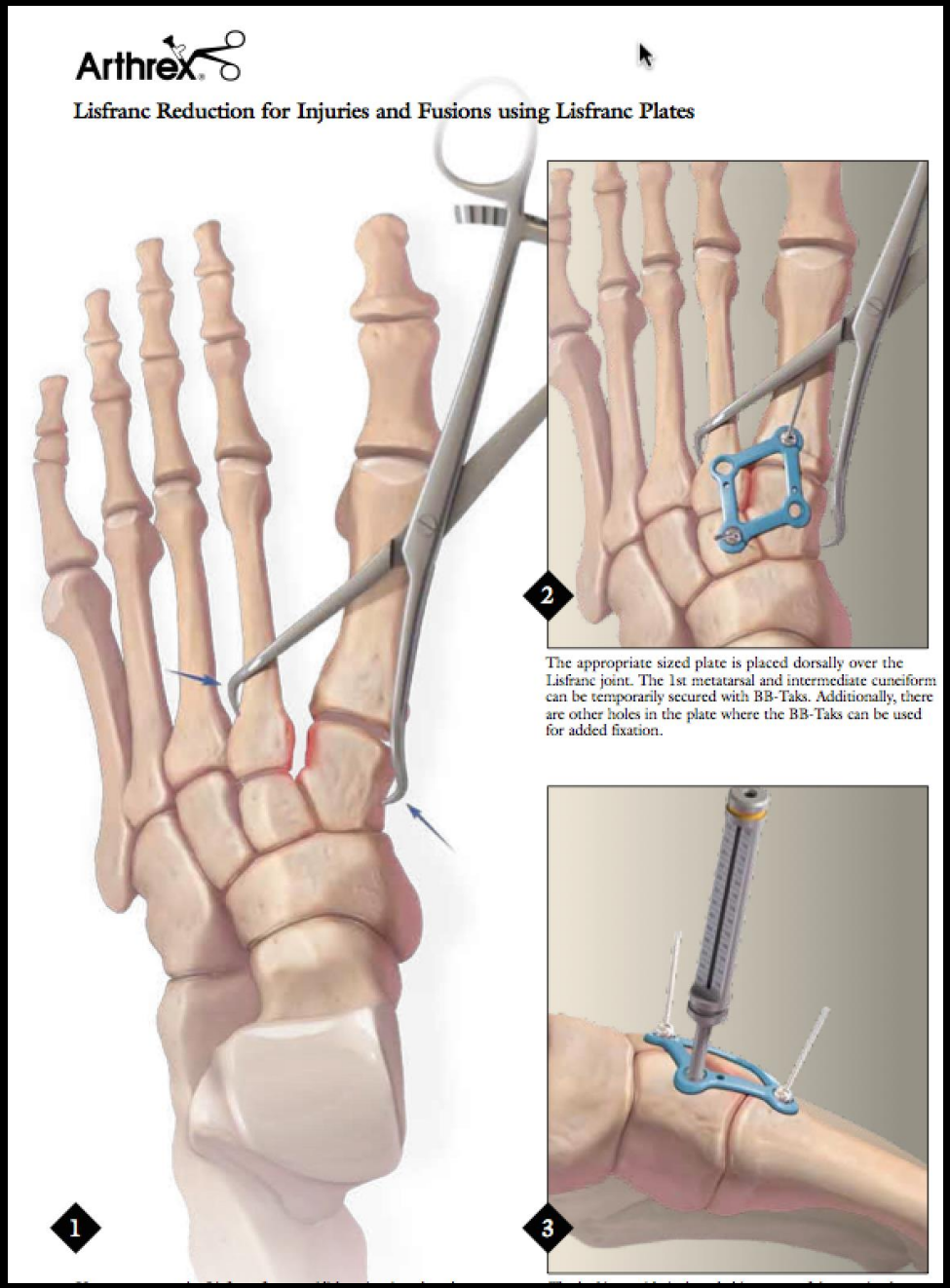
Brady Huang MD

4 month follow up

Brady Huang MD

6 month follow up

Brady Huang MD



- Compression along the Lisfranc ligament
- Allows visualization of Lisfranc joint during healing process
- Eliminates joint damage that occurs with screws and wires
- Preserves joint surfaces and larger surface area for bony fusion

Mini Pathria MD

Kuo (2000) - Outcomes

- Best long-term
  - Anatomic reduction
  - Early accurate diagnosis
  - Prompt treatment
- Purely ligamentous injuries worse prognosis
- Posttraumatic arthritis: non-anatomic > anatomic reduction

Recommendations

- High index of suspicion
- Cross-sectional imaging
  - Limitations of radiographs
- Be consistent with anatomy

References

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