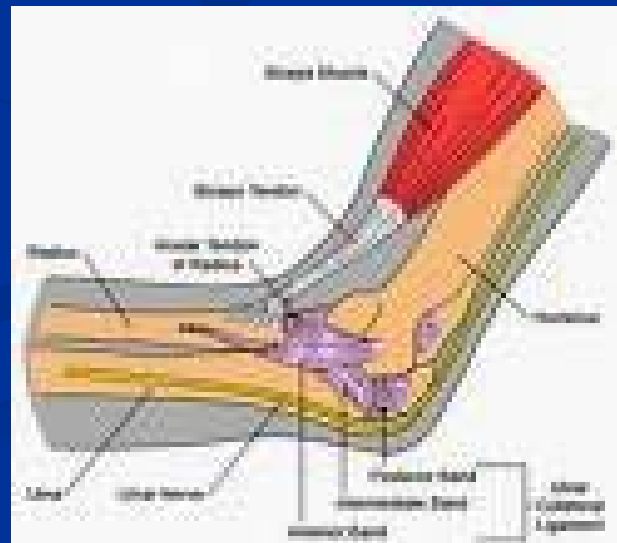
MRI of the Pediatric Elbow

Dorothy Bulas MD



Three articulations

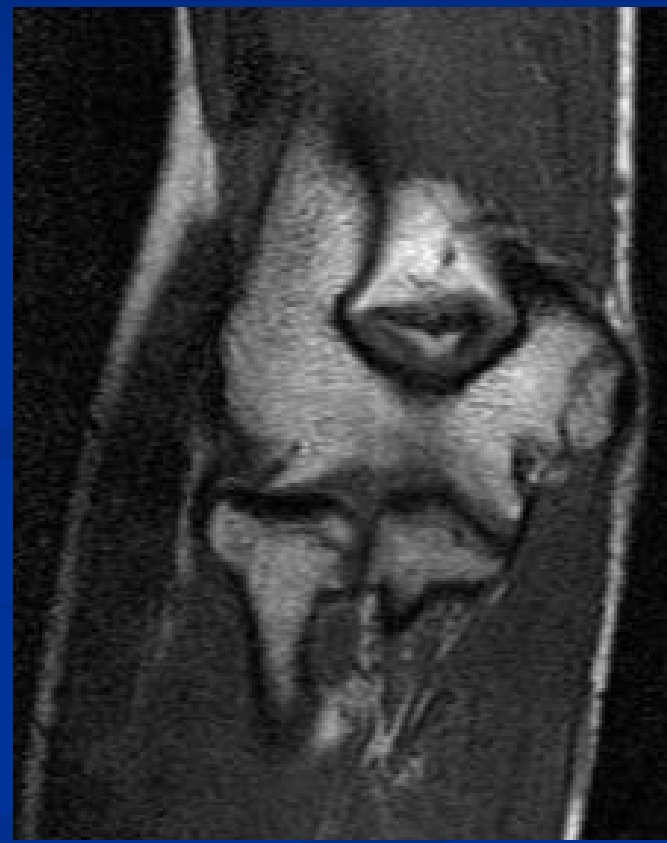
- **Humero - ulnar**
  - Trochlea and trochlear notch of ulna
  - Allows flexions/extension

Three articulations

- **Humero-radial**
  - Capitellum and radial head
  - Hinge and pivot

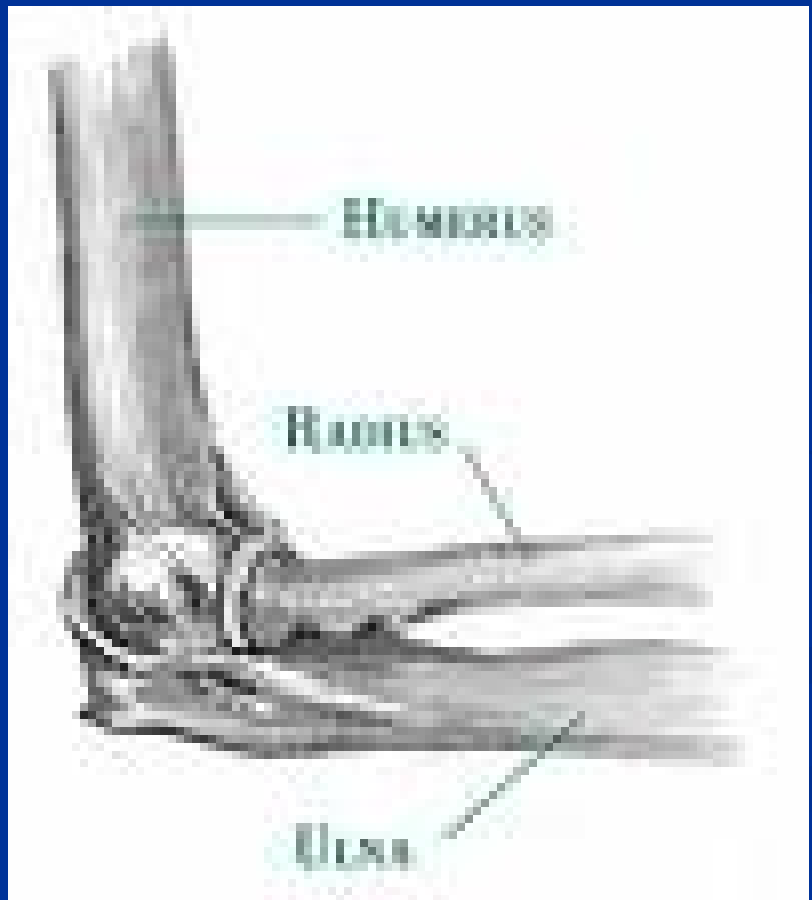
Three articulations

- **Proximal radioulnar joint**
  - Radial head and sigmoid notch of ulna
  - Pivots
  - Anular ligament provides stability
  - Supination by biceps brachii and supinator
  - Pronate by pronator teres and pronator quadratus



Joint Capsule

- Encloses 3 articulations



Motion – flexor muscles

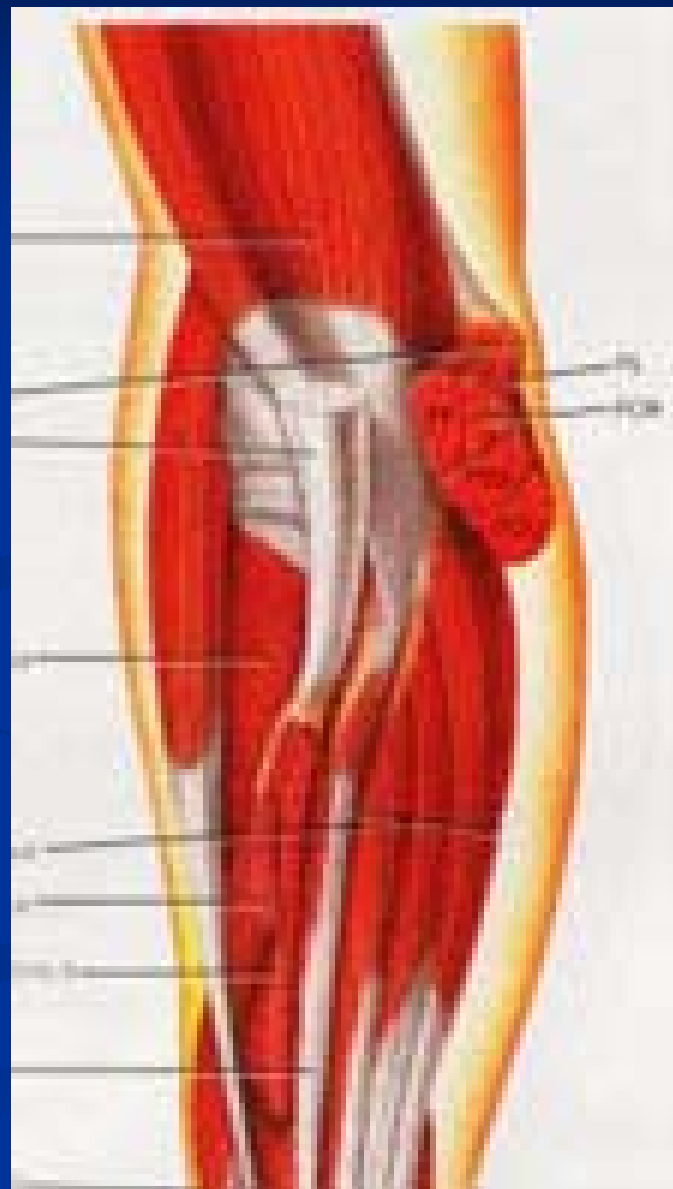
Flexor

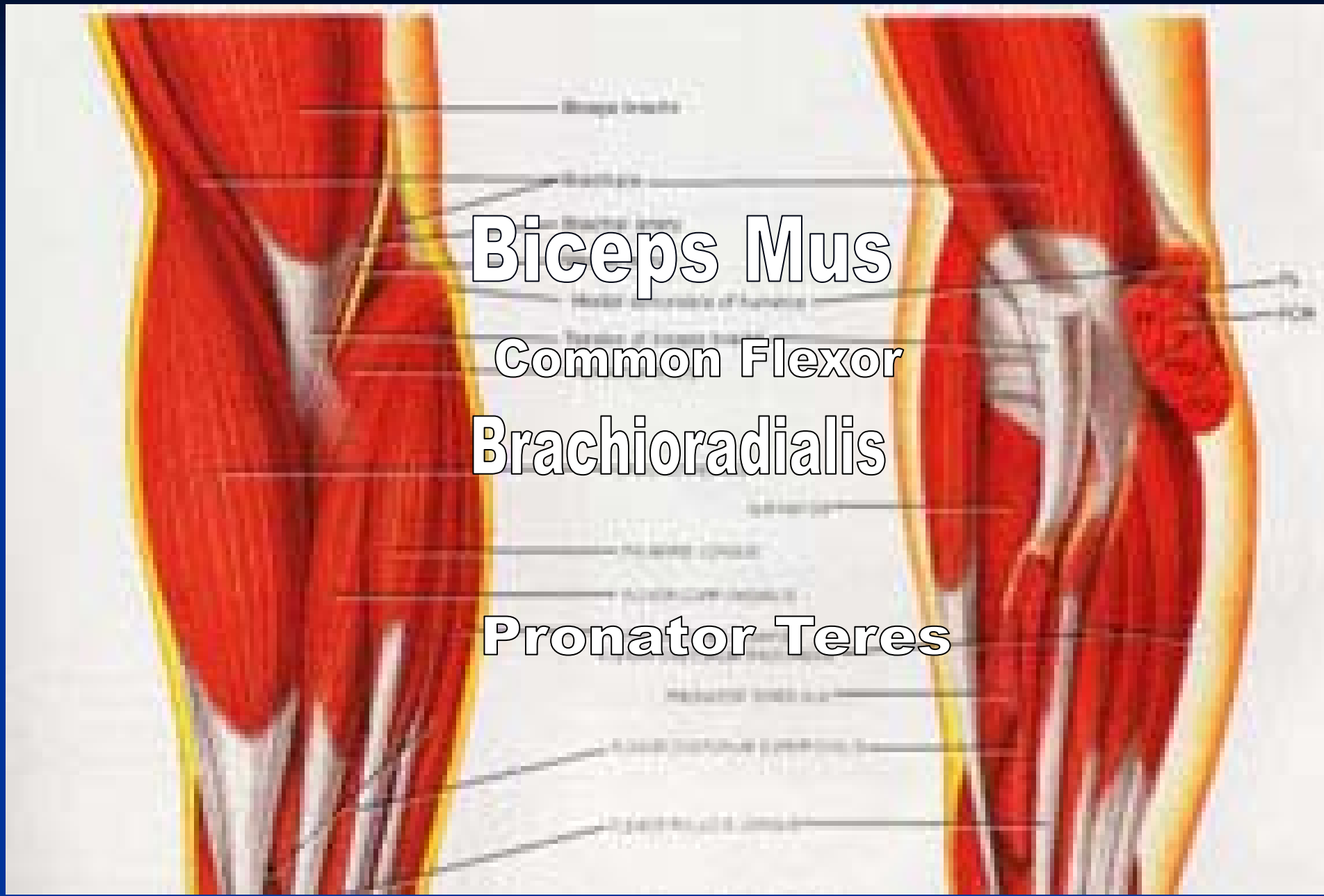
- Brachialis muscle
- Biceps Brachii muscle
  - Oblique insert on radial tuberosity
- Brachioradialis muscle

Flexor /pronator group

Inserts on med epicondyle

- Pronator Teres muscle
- Flexor Carpi radialis/ulnaris




Biceps Mus
Common Flexor
Brachioradialis
Pronator Teres

Biceps tear

Complete Biceps Tendon Rupture

- T2 FS
- absence of distal biceps tendon, fluid adjacent to the radial tuberosity
- retraction of completely torn biceps tendon,
- soft tissue edema within the antecubital fossa.

Lateral aspect

- Brachioradialis muscle
- Extensor carpi radialis longus/brevis muscle-
  - important in lateral epicondylitis (tennis elbow)
- Common extensor tendons from lateral epicondylar region

Motion- Extension

- Triceps inserts on olecranon
- Anconeus Epitrochlearis

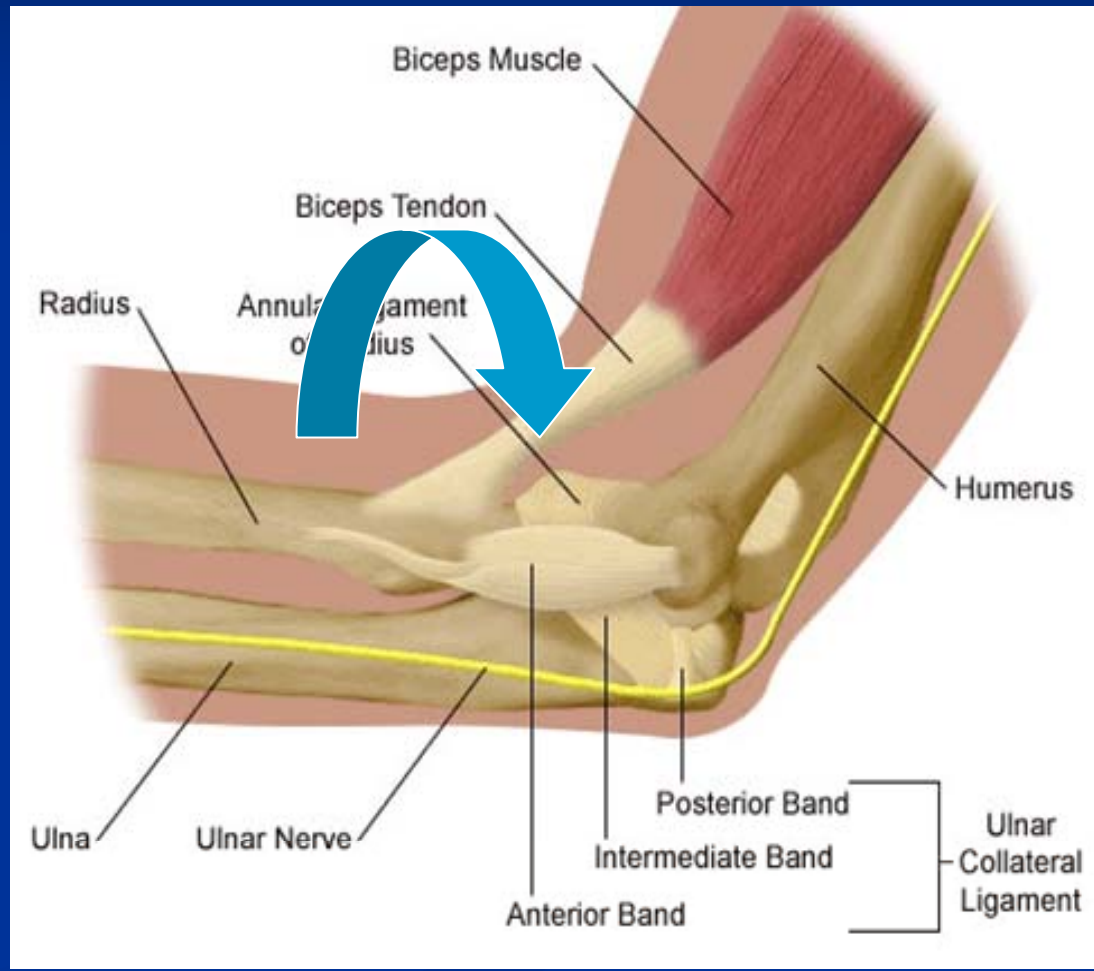
- Triceps tendon rupture

Anconeus Epitrochlearis Muscle

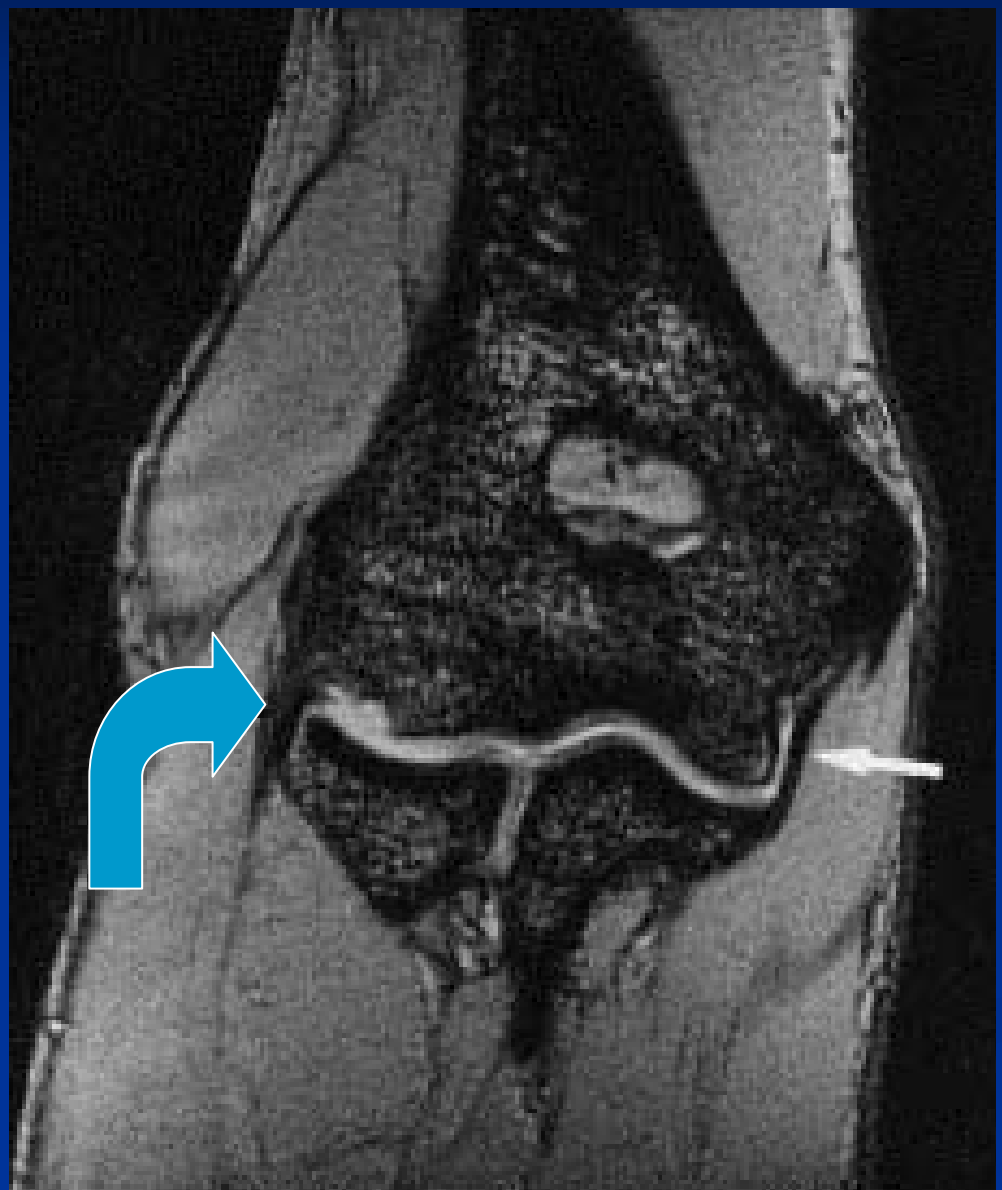
- Same course as cubital tunnel retinaculum
- Medial olecranon to inferior medial epicondyle
- Keeps ulnar nn in position
- 11% of population

Lateral Ligaments

- Radial Collateral Lig - blends with annular lig
- Lateral Ulnar Collateral Lig – lateral epicondyle

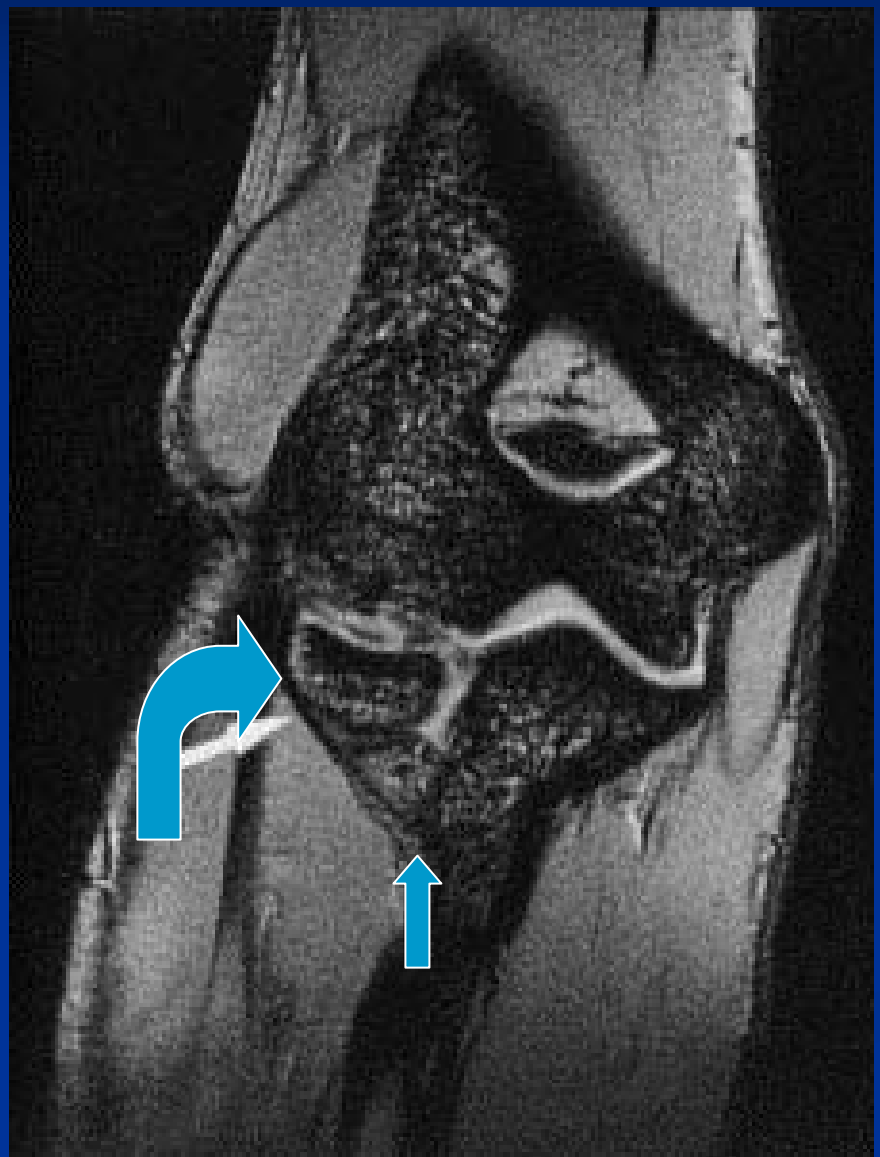


Radial (lateral) Collateral Ligament



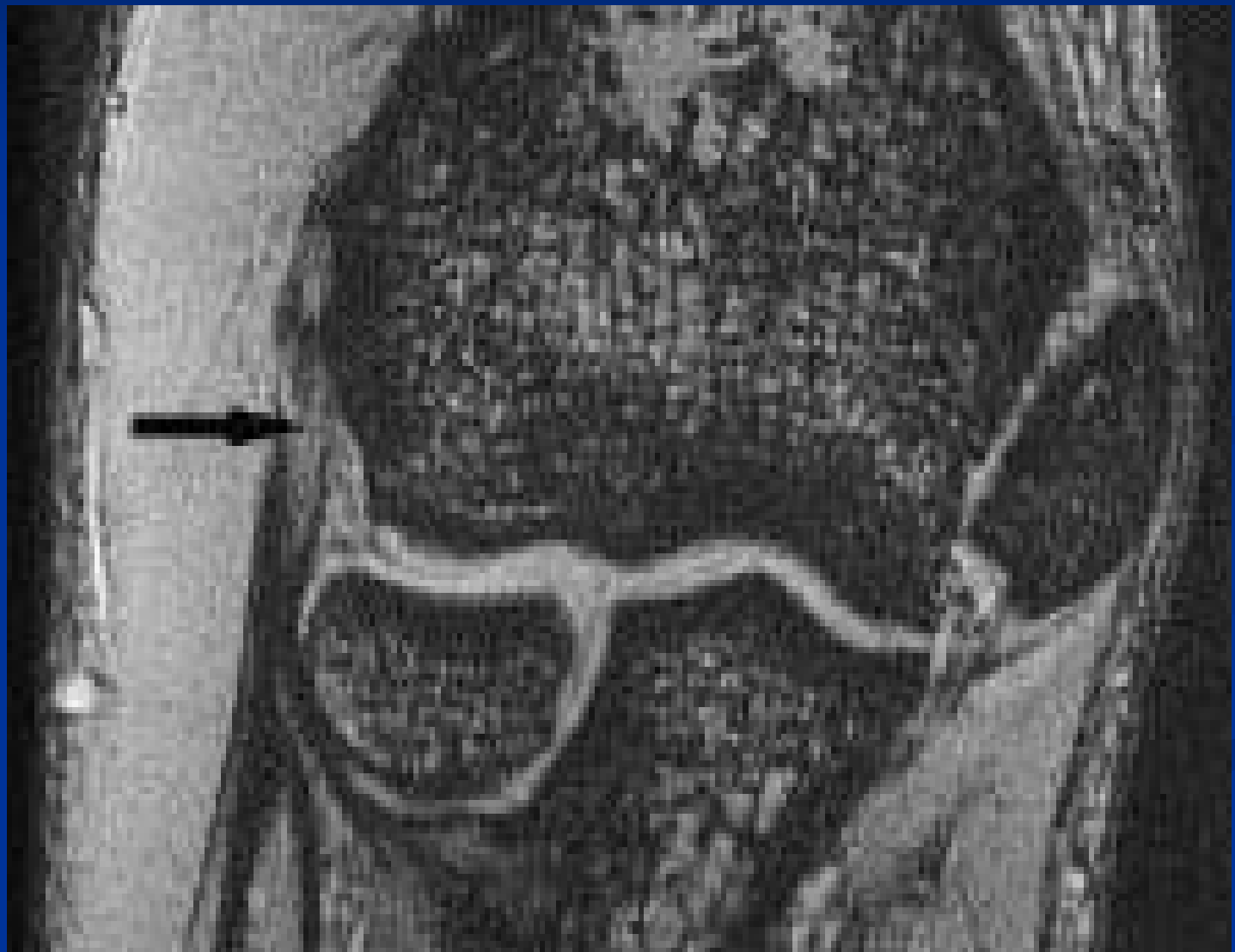
- extends from the lateral humeral epicondyle to proximal radius.

Lateral ulnar collateral ligament



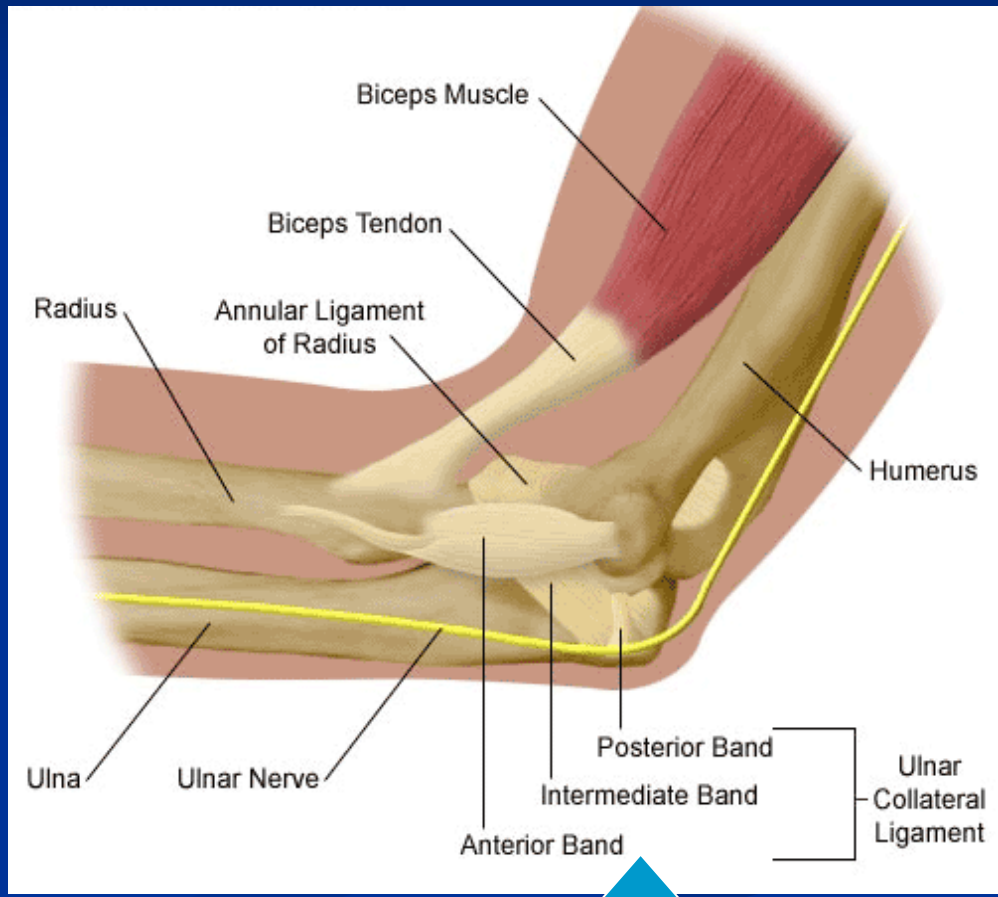
- originates on the lateral humeral epicondyle and courses posteriorly around the radial neck to insert on the supinator crest of ulna.
- obliquely oriented
- may not be seen in entirety on a single coronal image

Lateral ulnar collateral ligament partial disruption

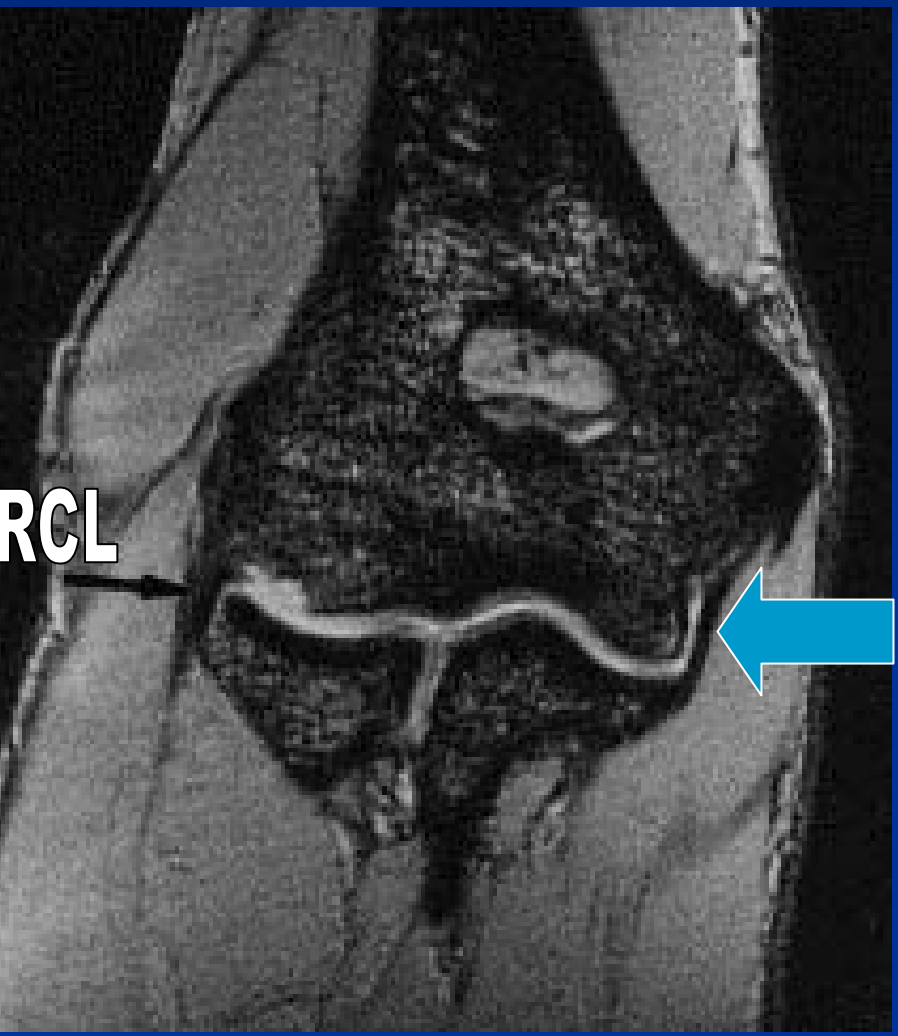


Ulnar (medial) Collateral Ligament

- UCL/MCL
- Med epicondyle
- 3 components
  - Anterior band <u>most important</u>
  - Posterior band
  - Transverse band



Anterior band of ulnar collateral ligament (UCL/MCL)

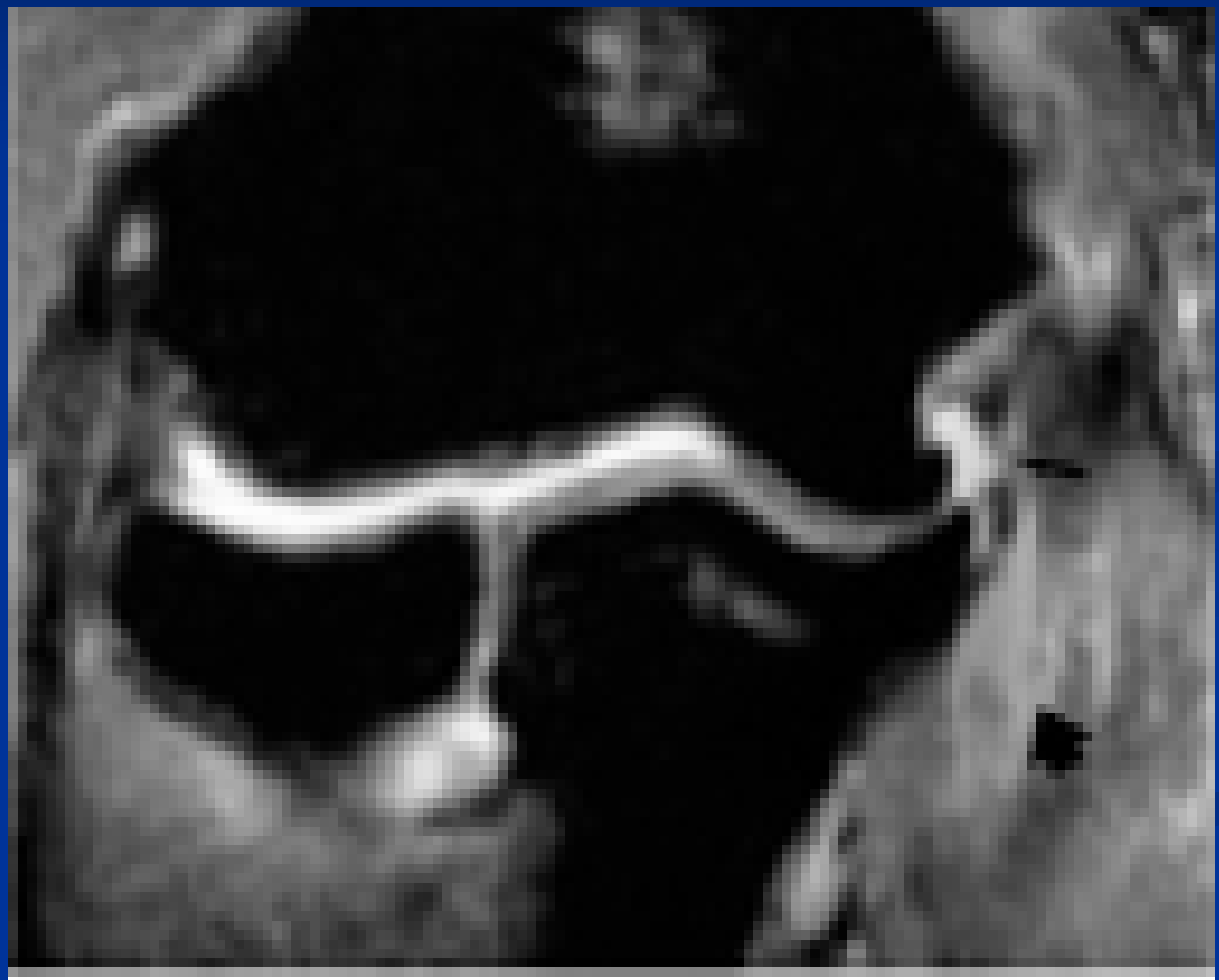


- Coronal GRE homogeneously low signal of collateral ligaments.
- anterior band of medial collateral lig is taut in extension
- courses from medial humeral epicondyle to coronoid process of ulna, deep to the origin of the flexor-pronator tendon.

Anterior band/bundle ulnar collateral ligament (UCL/MCL)

- Coronal T1 FS
- nl low signal ant. band of UCL extending from med. epicondyle to med. aspect base of coronoid process.
- Distal insertion of UCL within 1 mm of the articular margin of the coronoid process

Partial tear UCL ant bundle



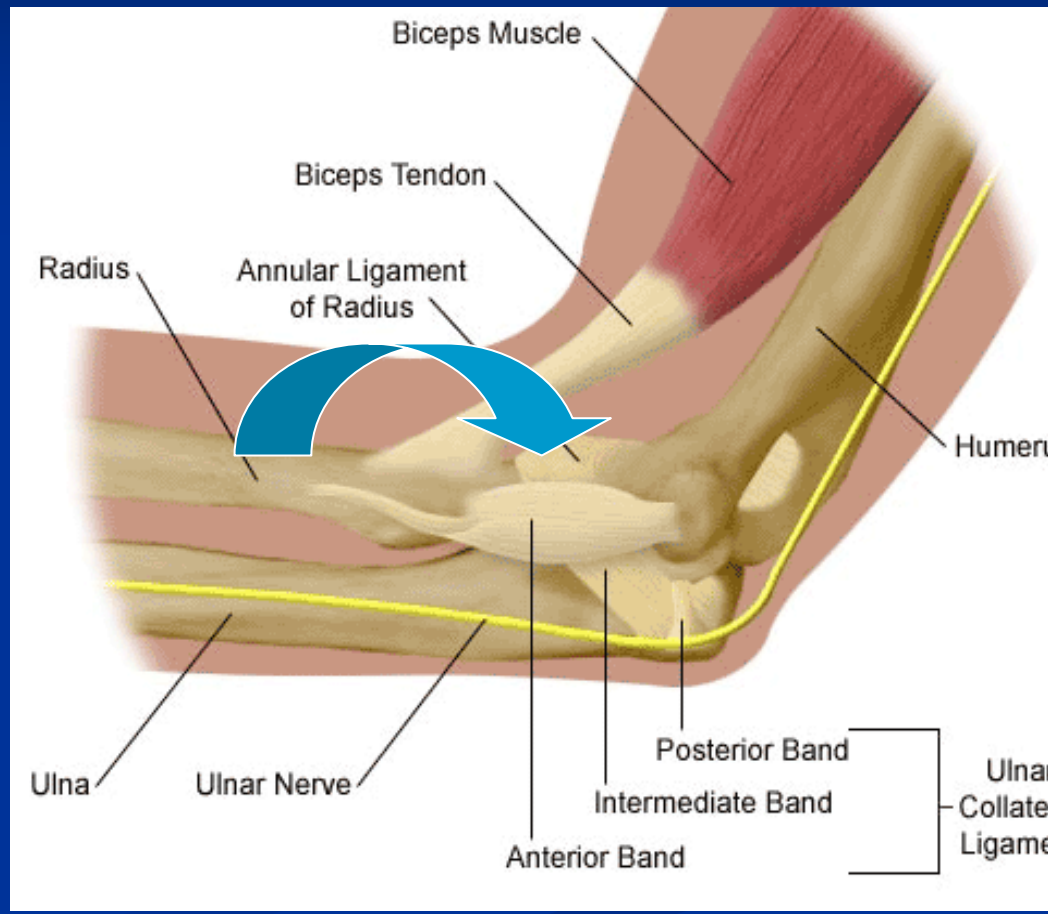
Collateral Ligament Abnormalities

- Ulnar (medial) collateral ligament (UCL) tear - anterior/posterior/tx contribute to valgus stability
  - Best seen on coronal plane
  - Common in throwing athletes

- Radial (Lateral) collateral ligament (RC
  - Not as important to stablity

Ligaments

- Prox radio ulnar jt
  - Annular lig –
    - ant post radial notch of ulna
  - Quadrate lig –
    - radial neck to ulna distal to annular lig

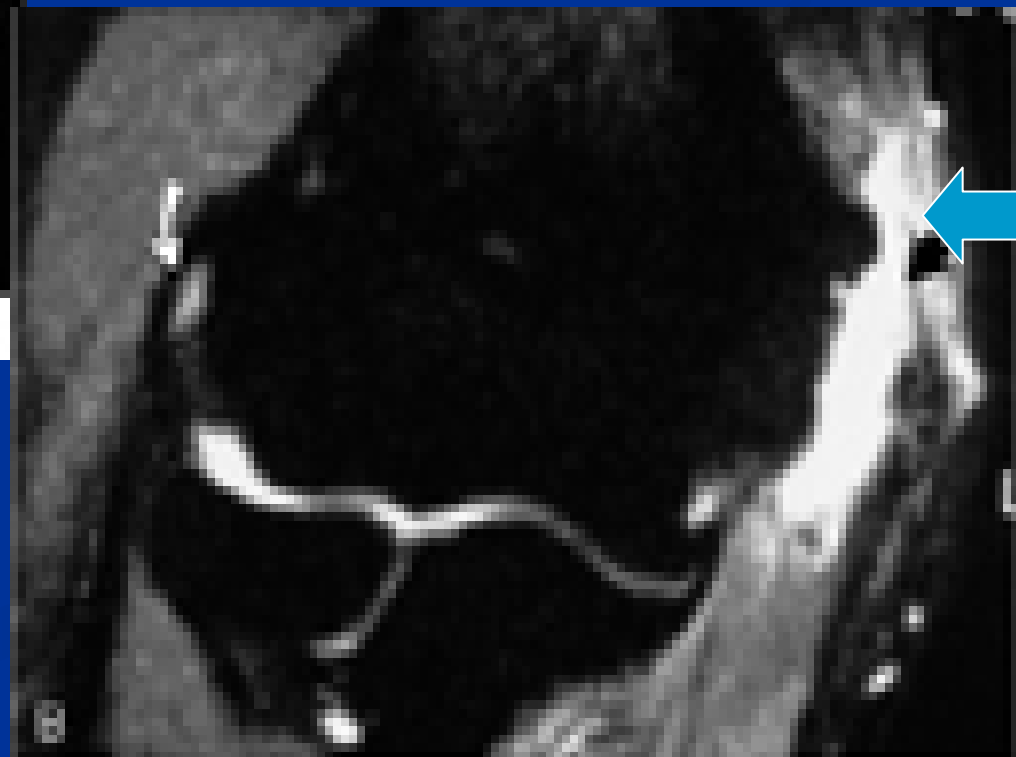


Tendons

- Common flexor tendon
  - Superficial to medial collateral lig
  - Composed of flexor pronator group –
    - flexor carpi radialis, flexor carpi ulnaris,
    - flexor digitorum superficialis,
    - pronator teres, palmaris longus

Flexor Tendon Tear

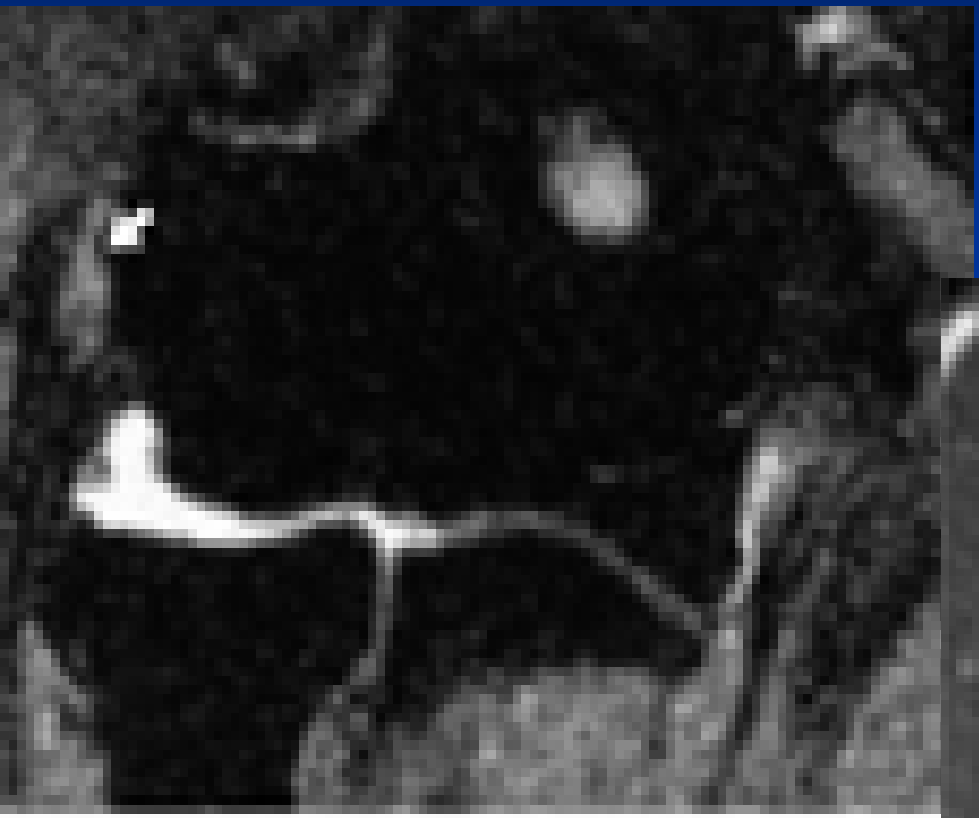
Rupture common flexor tendon



Tendons

- Common Extensor tendon
  - Lateral epicondyle
  - Superficial to radial collateral ligament
  - Composed of extensor-supinator group.

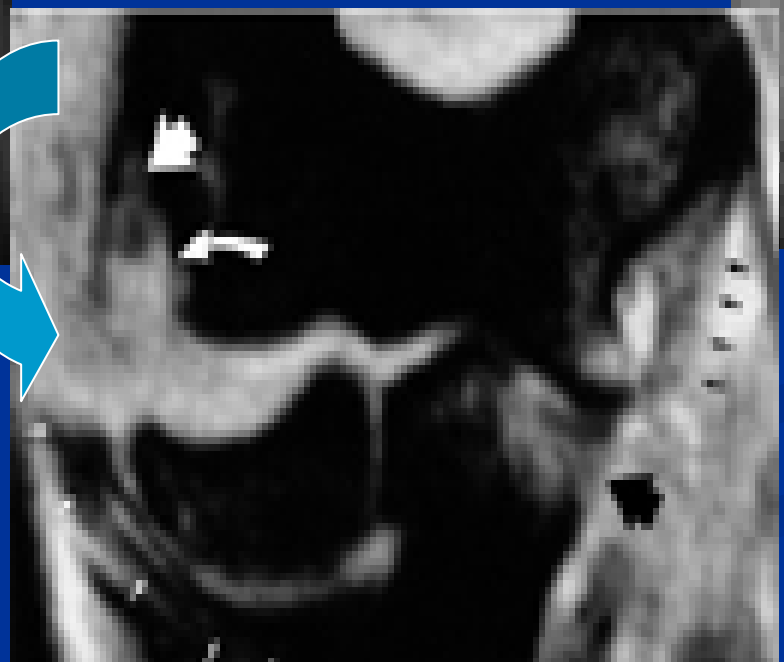
Tendinosis
Common extensor tendon



Lateral common extensor Tendinosis

- 57-yo with chronic lateral elbow pain.
- Cor T2-w shows thickening and abnormal intermediate signal intensity within the common extensor tendon origin (*arrowhead*).

Partial tear of common ext tendon



Bursae

- Posterior
  - Subcutateous olecranon bursa
  - subtendinous olecranon bursa
- Anterior
  - Bicipitoradial bursa
- Lateral
  - Radioulnar bursa

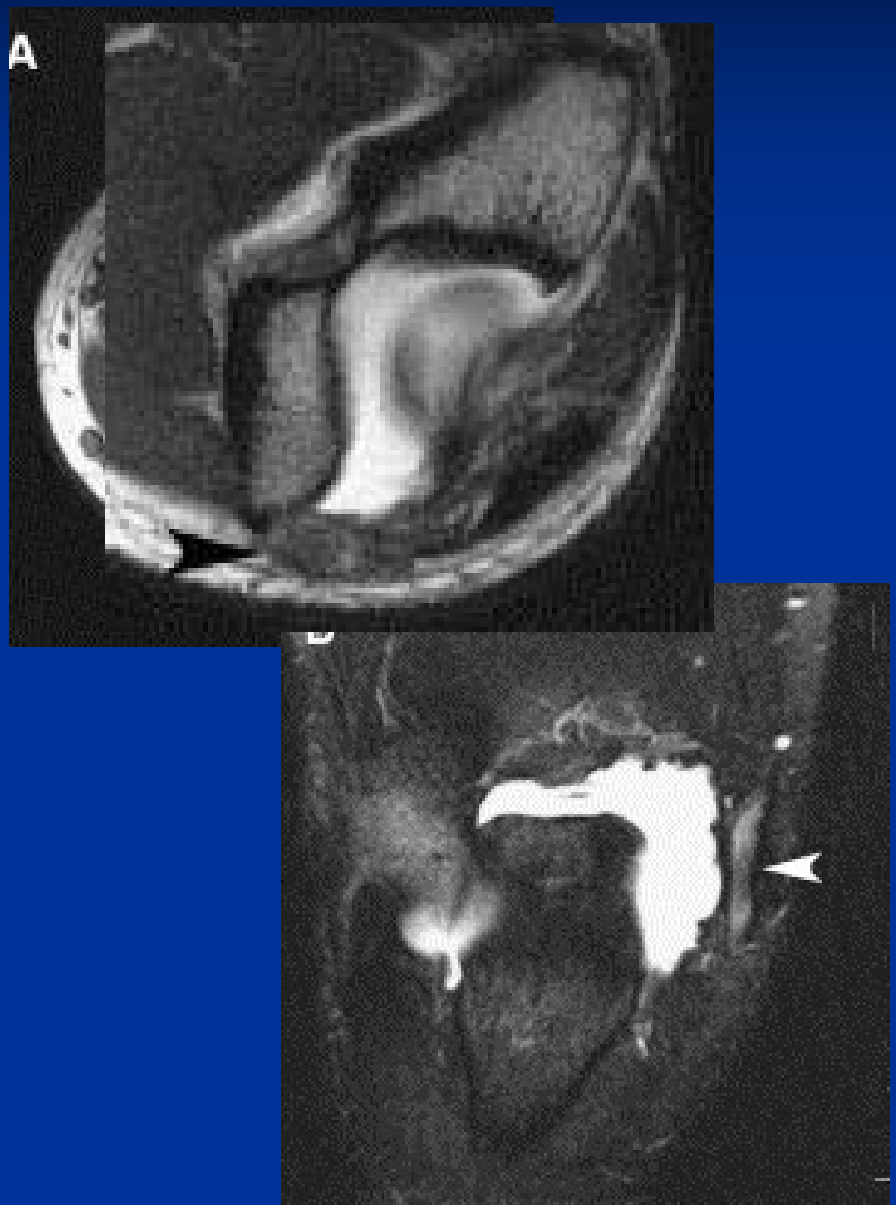
Nerves

- Radial NN lat to brachialis mus
- Median NN (ant) med to brachialis mus
- Musculocutaneous NN
- Medial cutaneous NN
- Ulnar NN (post) most vulnerable to trauma –
  - superficial location in restricted space of cubital tunnel.
  - Axial T1w depict size/shape of NN
    - normally surrounded by fat
  - Axial T2w or STIR inc signal with neuritis
    - surrounded fat becomes thick and inc T2w

Ulnar NN compression

- Most common neuropathy - Paresthesias along ulnar hand or elbow pain
- Usually at cubital tunnel behind medial epicondyle
- Repetitive throwing – flexion - stretch arcuate ligament and medial bulging UCL compress cubital tunnel
- NN may sublux
- Edema of flexor carpi ulnaris and flexor digitorum profundus

Cubital Tunnel Syndrome



- 19 yo baseball pitcher med. elbow pain / ulnar neuropathy.
- Axial T1w enlarged ulnar nerve (*arrow*) within the cubital tunnel.
- *Cor T2w* thickened, edematous ulnar nerve as it passes posterior to the medial epicondyle.

- (*From* KijowskiR, Magnetic resonance imaging of the elbow. Part II: Abnormalitiesof the ligaments, tendons, and nerves. Skeletal Radiol 2005;34:1–18

Cubital tunnel syndrome

- medial elbow pain and ulnar neuropathy.
- replacement of cubital tunnel retinaculum with anconeus epitrochlearis within the cubital tunnel.

- (*From* Kijowski R, Tuite M, Sanford M. Magneticresonance imaging of the elbow. Part II: Abnormalities of the ligaments, tendons,and nerves. Skeletal Radiol 2005;34:1–18; with permission.)

Vessels

- Brachial AA adjacent to Median NN
- Cephalic VV - anterior
- Basilic VV – medial

Normal variants

- Supracondylar avian spur
  - 5 cm prox to medial epicondyle 3%
- Ligament of struthers
- Accessory origin of pronator teres from supracondylar spur may compress median nn
- Os supratrochleare mimic loose body
- Patella cubiti sesamoid in distal triceps tendon

Technique

- Scanned at patients side or
  - superman position prone over head
- Localizer
- Sports injury
  - Axial T2 FS
  - Sag T2 FS
  - Cor PD FS

Technique

- Loose body, capitellum osteochondritis dissecans, NN impingement, biceps/tri teat
  - Axial T1w
  - Sag T1w
- MCL or epicondylitis
  - Ax PD FS
  - Cor T1w
  - Cor STIR

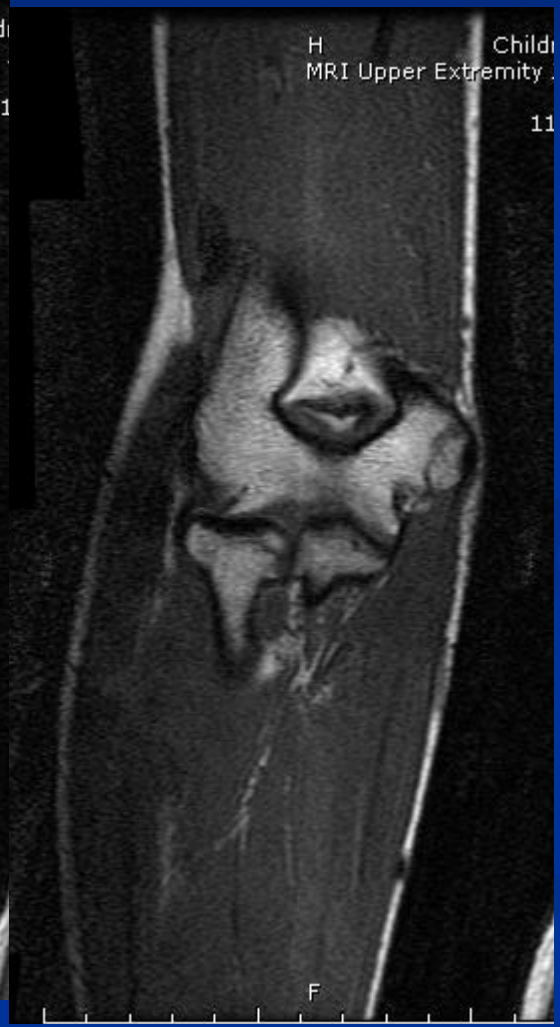
MR imaging- Supplemental

- **Coronal** with 20 degree post inferior tilt for medial col and lat ulnar col lig
- **FABS**- **F**lexed elbow **AB**ducted arm, **S**upinated forearm.
- Superman w/ elbow flexed demonstrates distal biceps tendon

Arthrography

- Partial MCL tear or loose body
- stability of capitellar osteochondral fx - Gd
  - Loc
  - Ax T1w
  - **Sag T1 FS**
  - **Cor T1 FS**
  - Sag T2w FS
  - Cor T2w FS

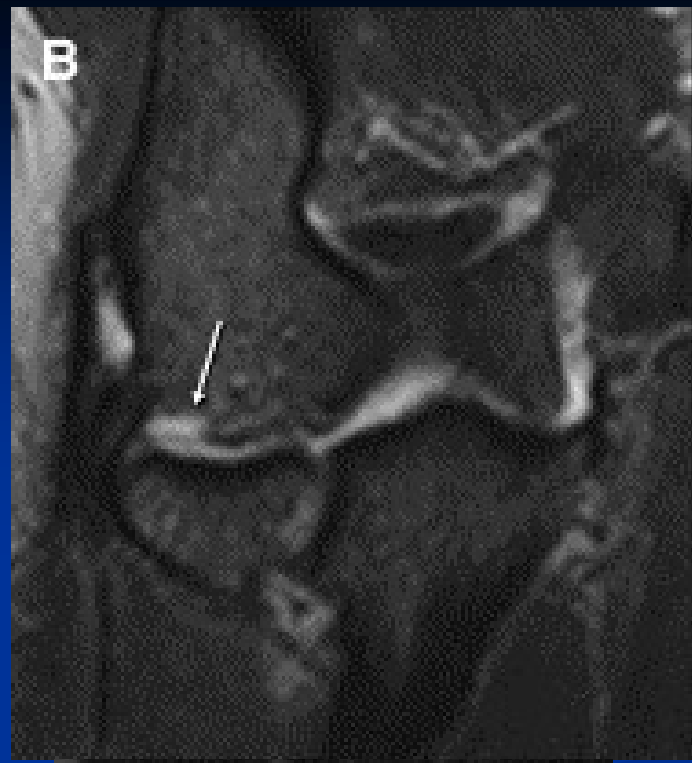
Normal elbow T1w coronal



Normal Elbow – Cor STIR

Pitfalls

- Pseudodefect of capitellum nl groove
  - mimics osteochondral fx
  - nl nonarticular flat posterior aspect of lateral condyle
  - nonarticular portion of lat condyle adjacent to radius simulating osteochondral lesion

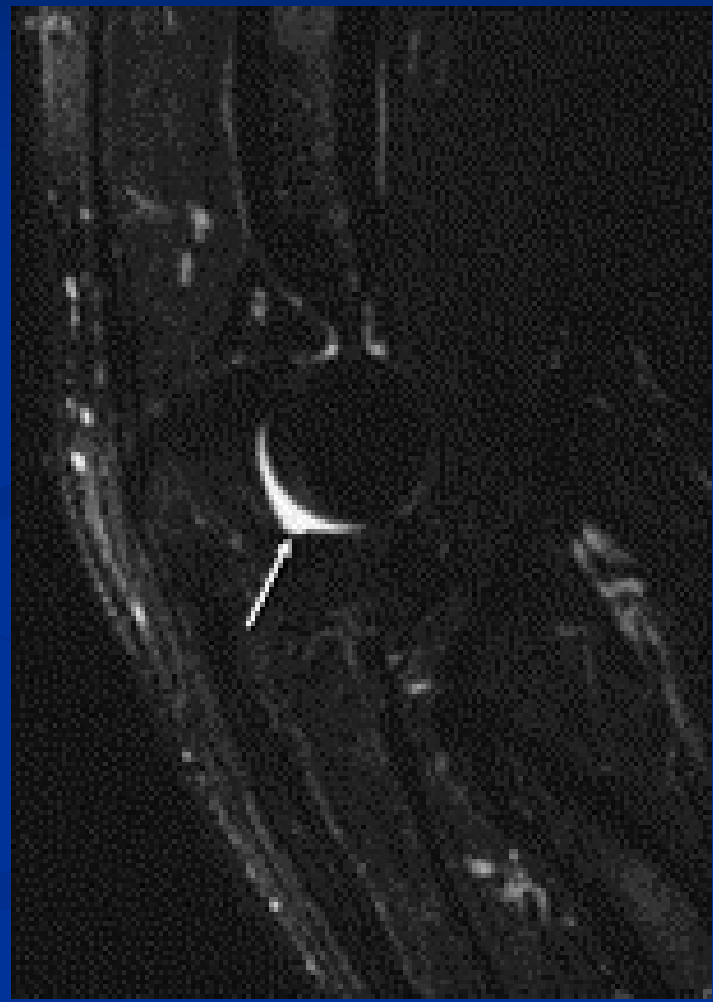


Pitfalls

- Two other normal anatomic variants occur in trochlear groove at junction of olecranon and coronoid processes.
  - Pseudo defect of midtrochlear notch
  - Transverse mid-trochlear ridge

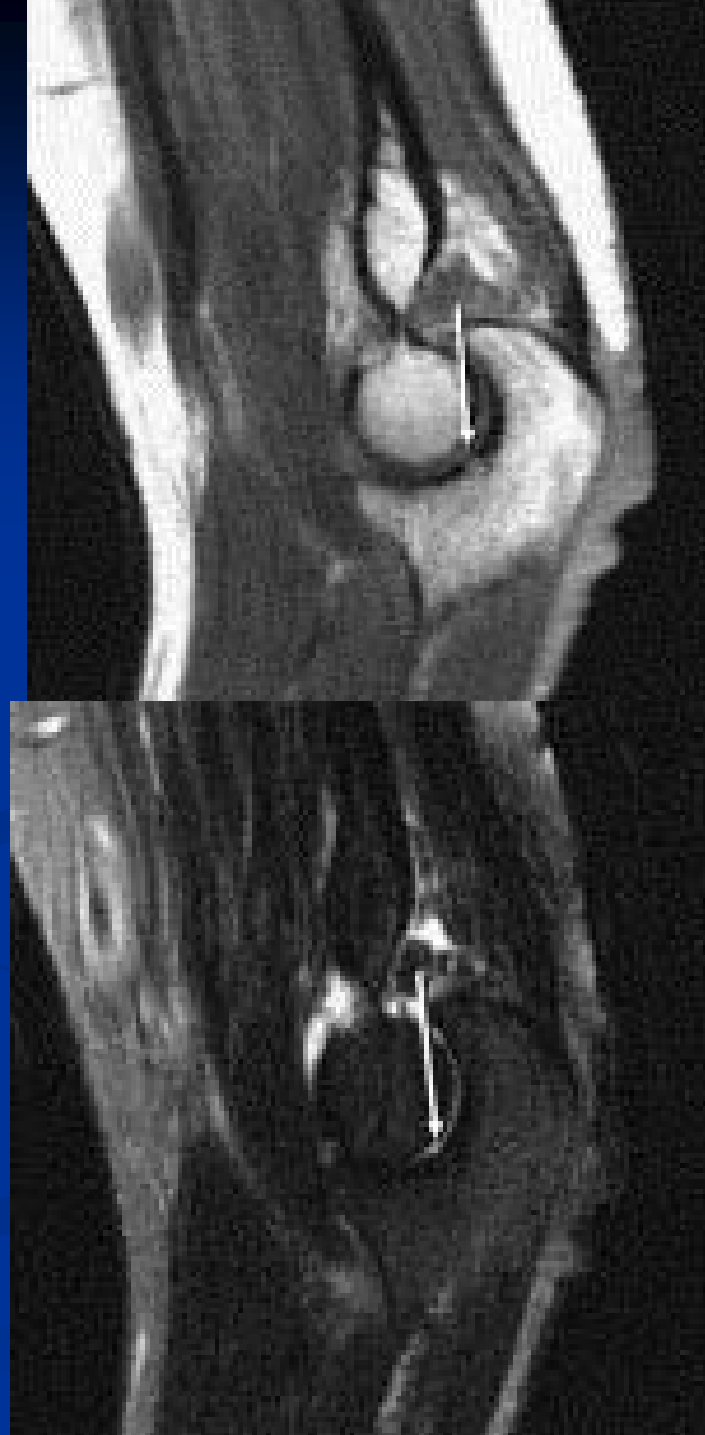
Pitfalls - Pseudo defect of midtrochlear notch

- Junction of olecranon/ coronoid
  - small focal absence of cartilage (*arrow*) in the midportion of trochlear groove = normal variant notch.
  - sagittal image, often filled with fluid mimicking a focal chondral defect .
  - Most prominent at medial and lateral margins of the trochlear groove.



Pitfalls –Transverse mid-trochlear ridge

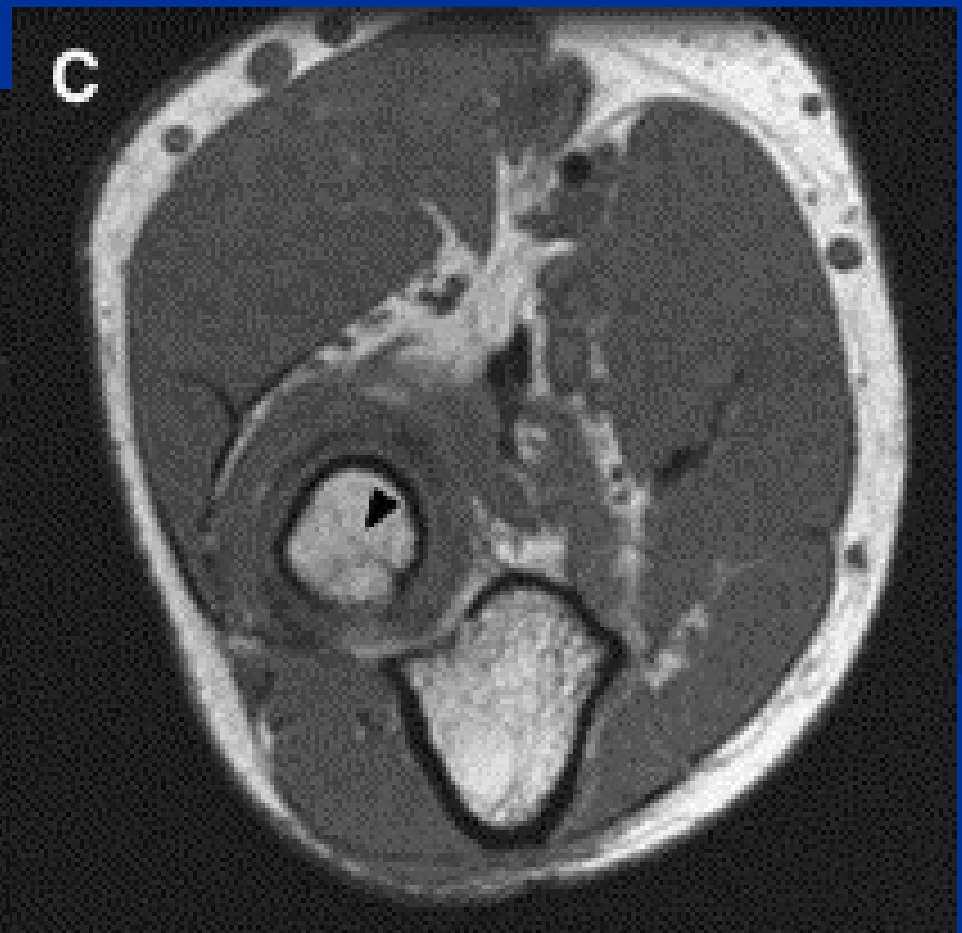
- more central in the trochlear groove at junction of olecranon and coronoid.
- Ridge usually only 2- 3 mm high does not extend above thickness of adjacent hyaline cartilage.



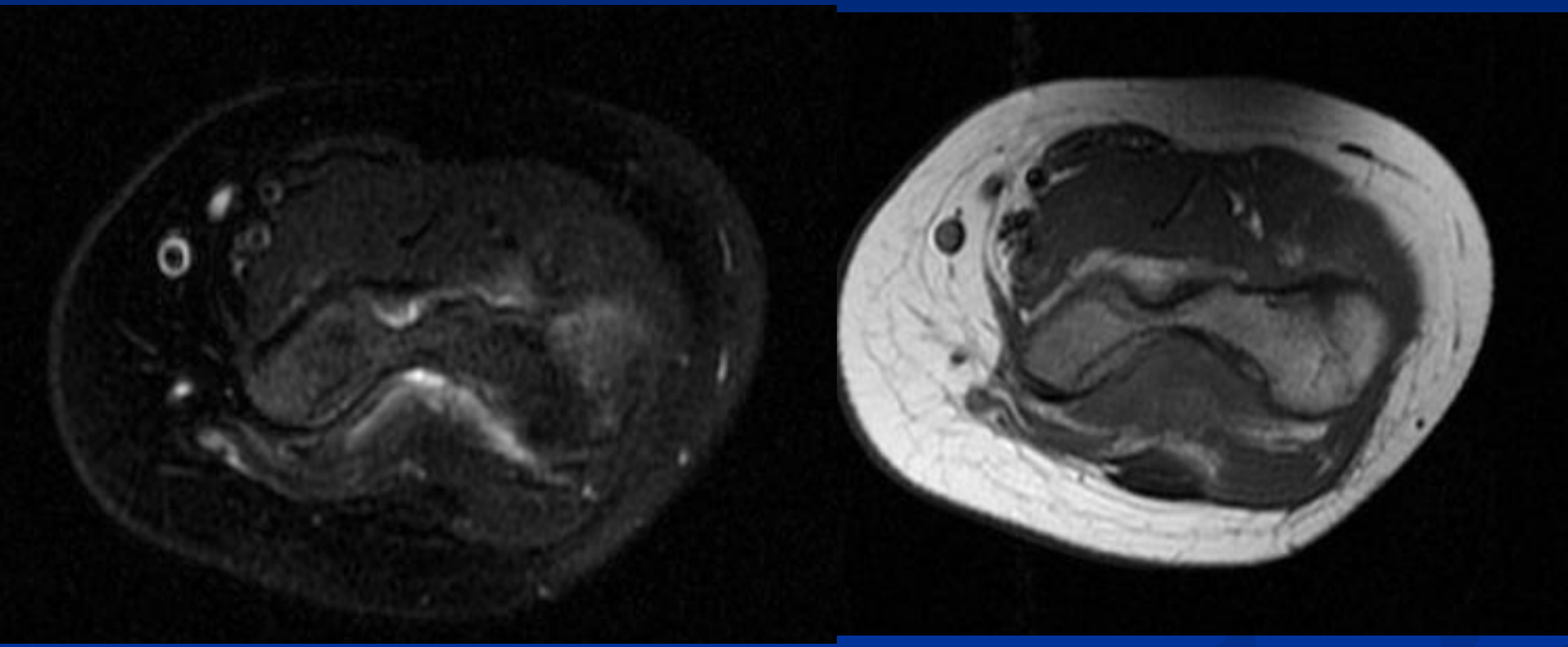
Nondisplaced Fractures

- Occult Fx – radial head
- Avulsion Fx – sublime tubercle , determine if MCL intact or fibrous nonunion
- Little Leaguers elbow stress injury –
  - medial epicondyle apophysis
- Fatigue fractures – olecranon
  - staging helpful in predicting recovery

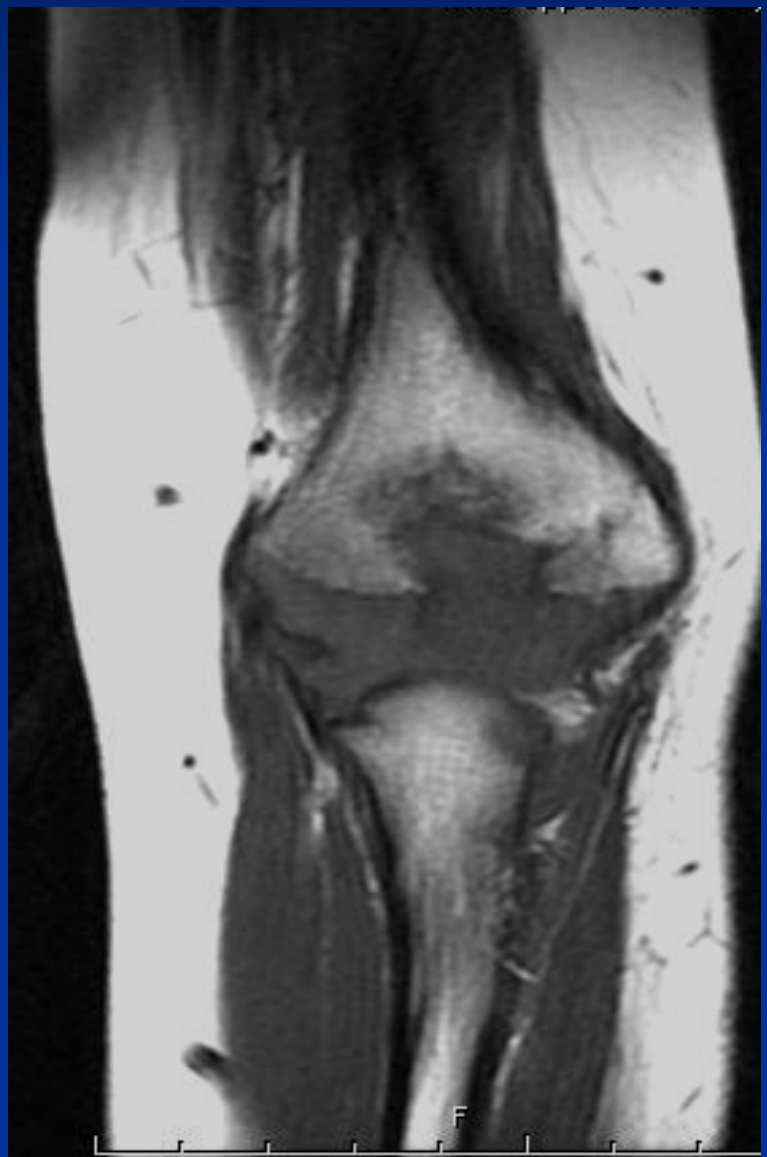
Occult Fracture radial head

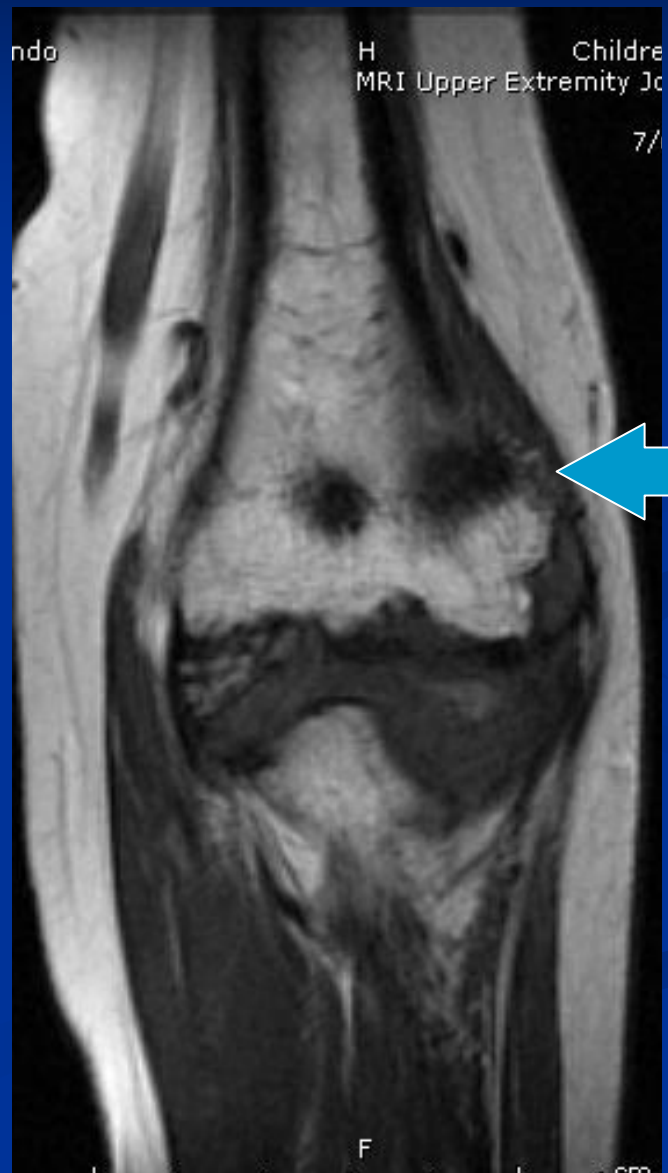


Healing lat condyle fx

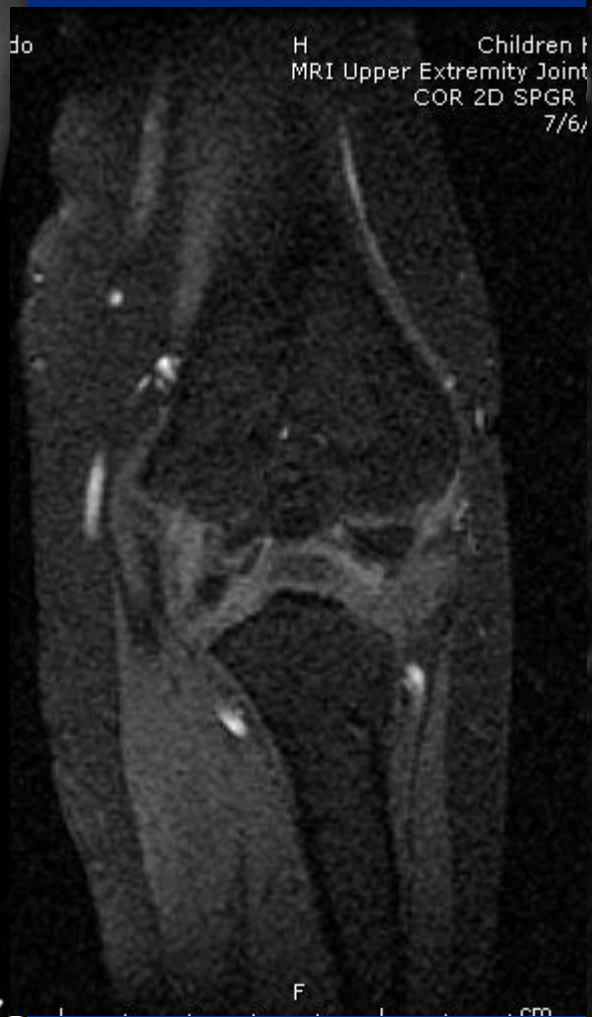


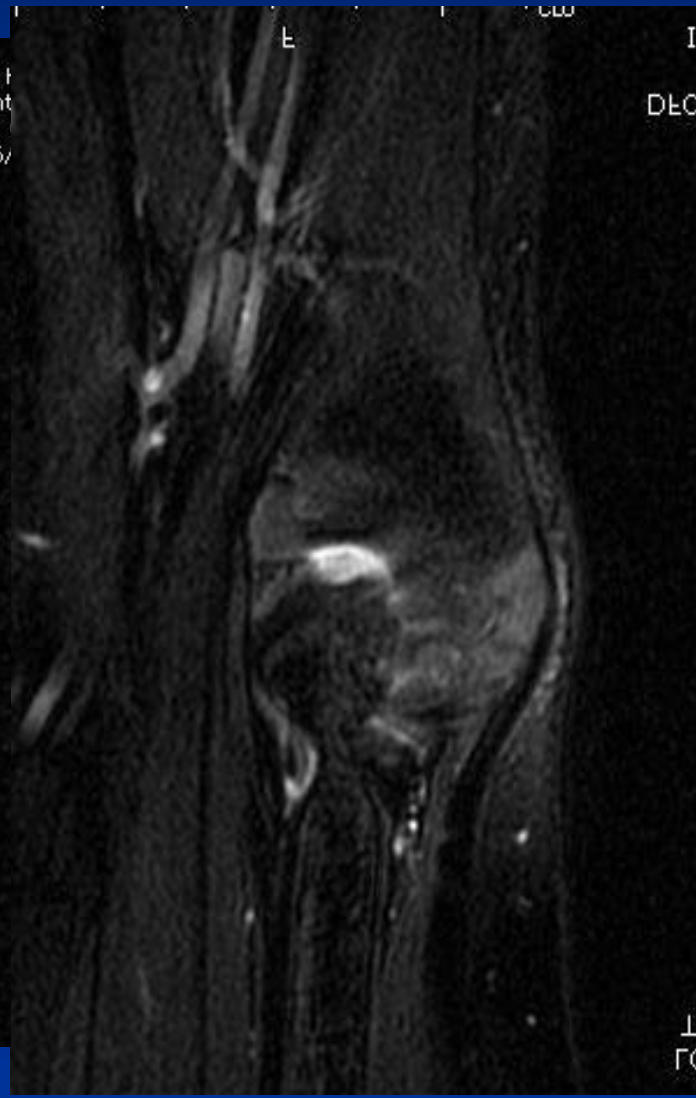
Fracture lateral condyle





Fatigue Fracture Olecranon – irreg epiphysis





Loose Bodies

- X-ray - Intra-articular bodies difficult to dx.
  - cartilage or ossified but located deep in olecranon or coronoid fossa obscured by superimposed bone structures.
- CT scans excellent for ossified bodies, but intra-articular contrast necessary for chondral bodies.
- MRI can show chondral intra-articular bodies
  - if small amount of joint fluid need careful inspection of humeral fossae.
  - MRI > CT - show marrow edema, extra-articular lig injury.
  - well-performed MRI scan may not identify a loose body

Loose bodies

- Osteophytes or synovial hypertrophy can simulate loose body.
- MRI arthrogram preferred over CT because of superior soft tissue detail

Intra-articular loose bodies

- Axial T1-w arthrogram shows two intra-articular loose bodies (*arrows*) surrounded by joint fluid near the superior olecranon fossa

Osteophytes

- Athletes develop osteophytes,
  - cause pain /reduced range of motion.

- Pitchers with posteromedial impingement may develop osteophyte on olecranon, occasionally w/ adjacent chondromalacia with spur formation of humerus in adjacent olecranon fossa .
  - These osteophytes can be difficult to identify on Xray but shown well on MRI

Acute Injuries

- **Medial epicondyle avulsion** most common fx in adolescent throwing athlete
  - acute valgus stress exceeds of apophysis
  - Repetitive low magnitude forces cause chronic changes
- **Ulnar collateral lig rupture** has similar presentation
  - less common when physis open
  - Unlikely if peicondylar avulsion present

Acute Medial epicondyle avulsion

Xray

- Displaced with variable physeal widening or epicondylar rotation
- If subtle comparison view
- Can displace into joint

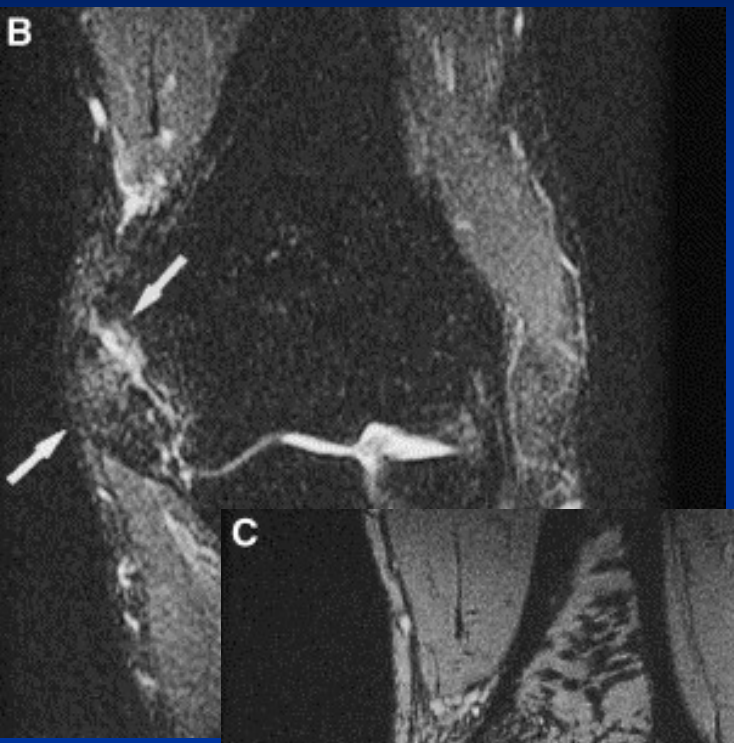
Acute Medial Epicondylar Avulsion

- Type 1 - under 14 yo large fragment entire apophysis
- Type 2 - > 15 yo large fragment
- Type 3 - > 15 yo small fragment (partial fusion)
- Controversial treatment -2-5 mm displacement for conservative vs operative therapy.
- Xray usually sufficient

Medial epicondylar apophysis avulsion injury - Type 1

- 9-yo
- GRE. Avulsion of inferior medial epicondylar apophysis (*arrows*), anterior bundle of the UCL is attached.
- Coronal T2w FS hyperintensity in soft tissues surrounding the avulsion
  - bone marrow edema in capitellum, indicative of early osteochondritis dissecans.

Nonunion of Salter fracture through the medial epicondylar apophysis- Type 2



- 25-yo. widening and irregularity of the physis, with intermediate signal in the fracture site representing fibrous union. bone marrow edema
- Assoc elbow subluxation, injured lateral ulnar collateral ligament
- GRE - partial disruption of the proximal LUCL

Chronic Injuries – Little League elbow medial epicondyle

- Young athletes with stress patterns from throwing –
  - Tennis/football, javelin, baseball, gymnasts
- Tension overload on medial elbow-medial epicondyle, common flexor tendon, UCL
- Compression overload on lateral articular surface-capitellum and radial head
- Posteromed shear forces on posterior articular surface – less common
- Extension overload on lateral ligamentes and lat epicondyle

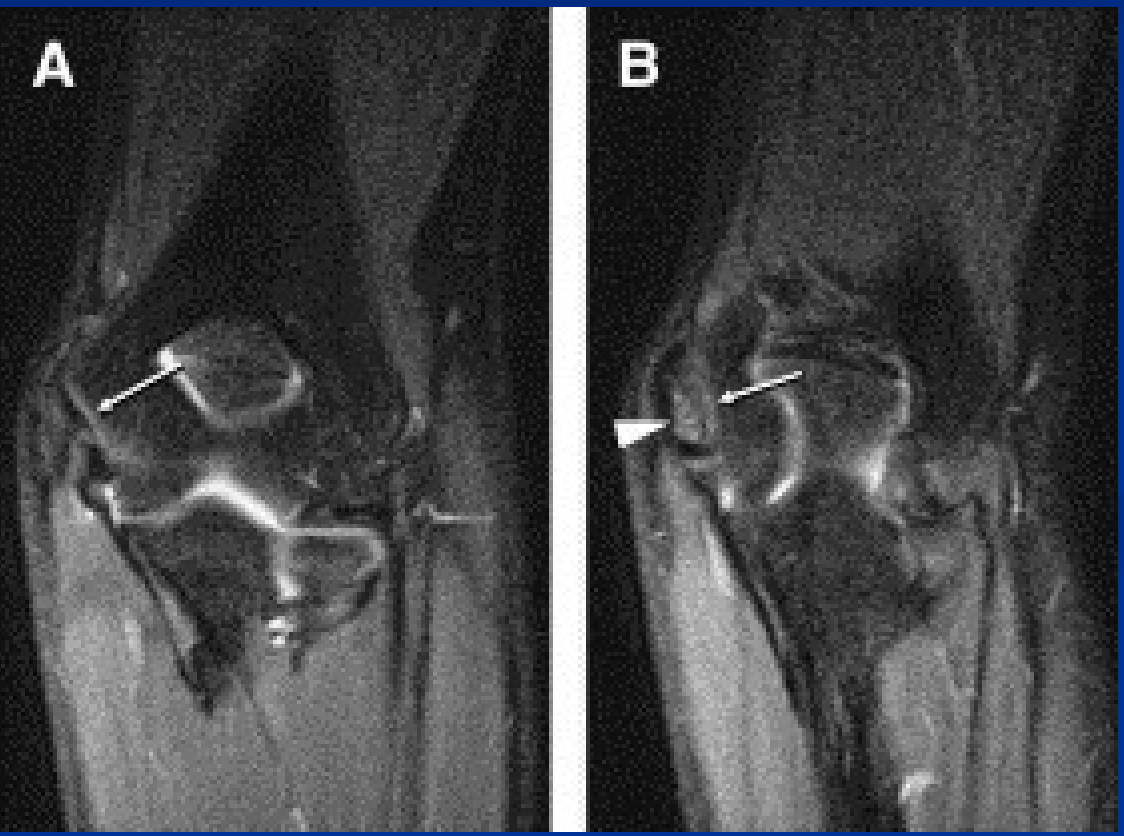
Chronic Injuries – Little League elbow medial epicondyle

- Repetitive forces cause chronic changes of medial tension and lateral compression most commonly
- Apophyseal growth plate weakest link- overgrowth, separation
- Differential UCL injury/medial epicondylitis Common flexor tendon,

Chronic Injuries – Little League elbow medial epicondyle

- XR fragmentation , separation overgrowth – may be asymptomatic with these findings (50%)
- MR not necessary can show physeal widening can differentiate UCL and med epicondylitis in older pt.
- Therapy conservative
- Inadequate Rx may have nonunion

Little League elbow



- 12-yo girl. T2-w high signal marrow edema adjacent to the medial epicondyle physis (*arrows*) and within the medial apophysis (*arrowhead*).

Little League elbow

- 12 yo valgus stress injured medial epicondylar apophysis, T2 FS bone marrow edema irregular apophysis
- GRE - physeal widening UCL injured hyperintense
- While both affected, most of stress to the **physis** rather than the ligament, typical before apophyseal fusion.

How to differentiate Little league medial epicondyle apophysitis vs UCL tear

Age

- Little League more common when physis open
- UCL tear less common when physis open

Radiograph

- UCL has a Normal xray or few calcifications
- Little League – wide physis, fragmented

Ulnar Collateral Lig injury

- More common once physis closed
- Pain increased during acceleration stages of throwing. Valgus instability
- Normal x-ray or calcifications –valgus view stability
- Tear of ant bundle of UCL irregular, laxity
- Poor definition, abn increased T1 and T2 signal in and around lig. Hemorrhage/ edema.

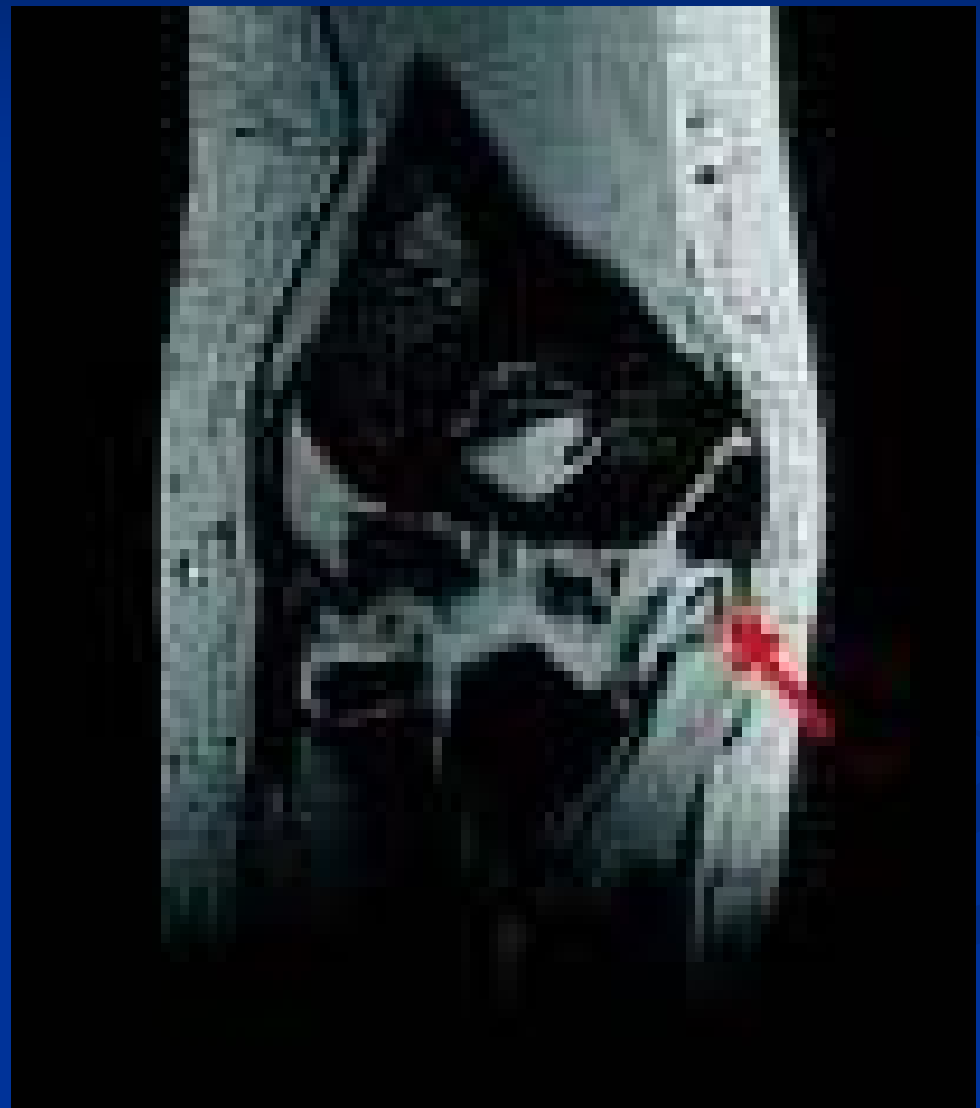
Ulnar Collateral Lig injury

- REMEMBER>>>
- Before physeal fusion, epicondylar insertion of UCL higher T2 and T1 than mature ligament. High elastin content low type 1 collagen
- Don't overinterpret UCL in young pt

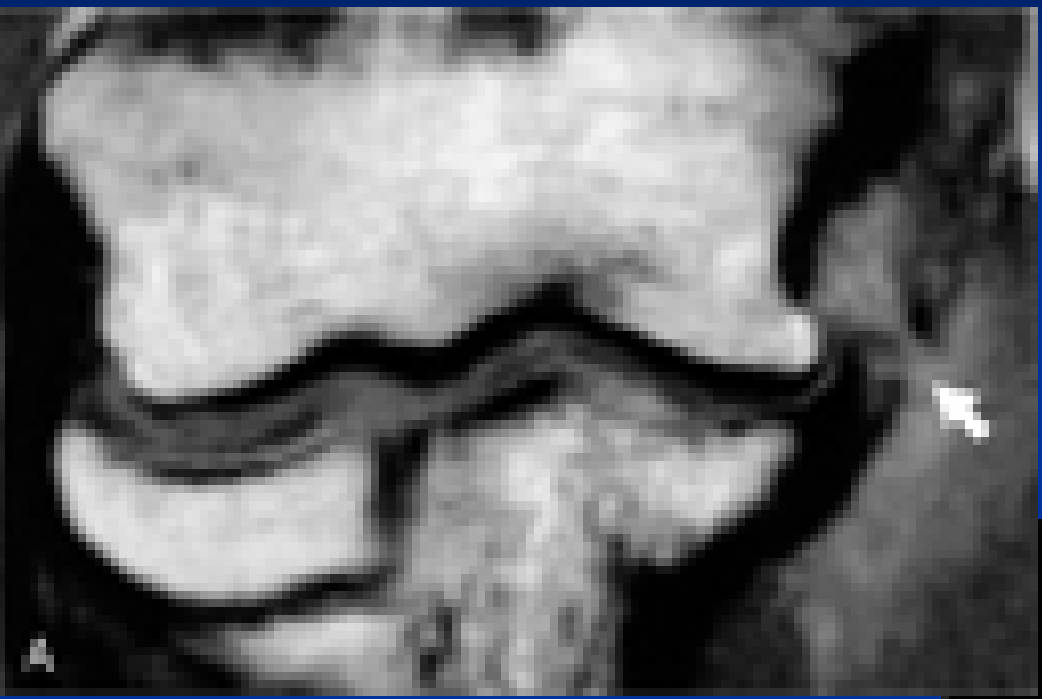
Full thickness Ulnar Collateral Lig tear

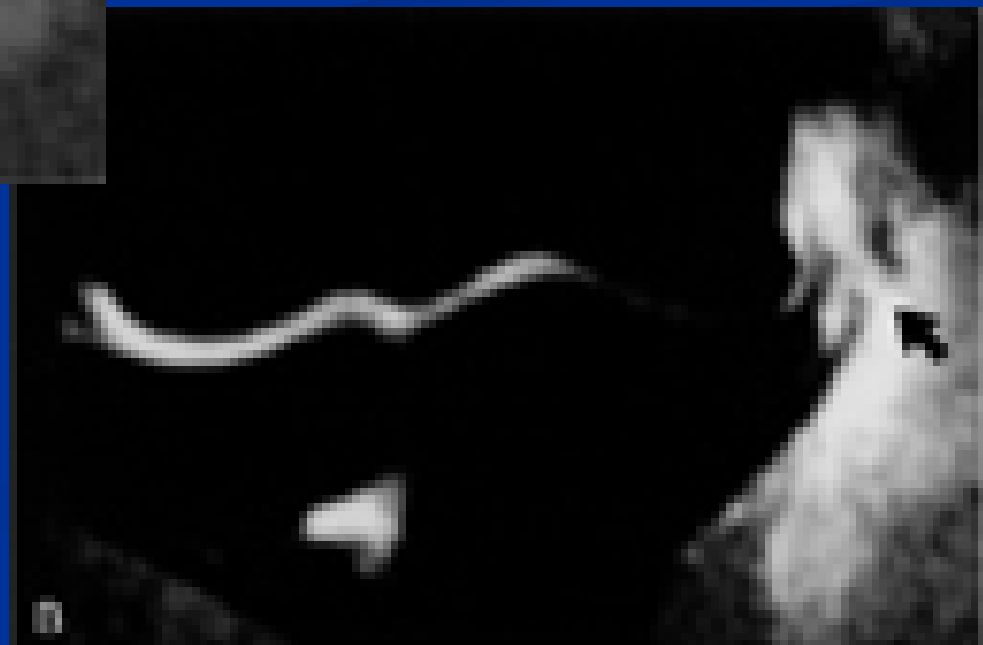
- 21-yo baseball pitcher w/ medial elbow pain.
- Coronal T2w FS
- complete disruption of distal fibers of the anterior bundle of the UCL with surrounding periligamentous edema

Full thickness Ulnar Collateral Lig tear

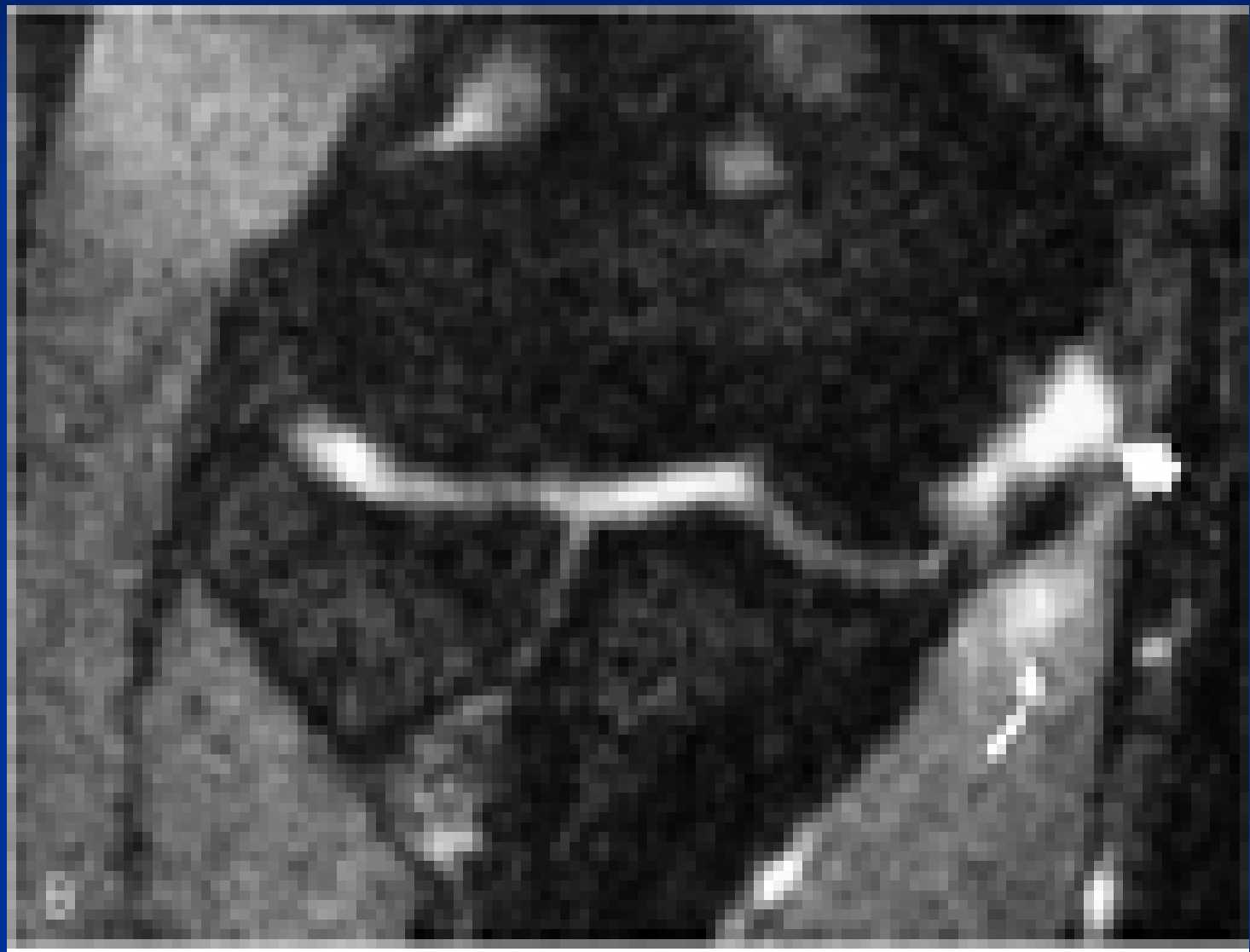


Tear UCL ant bundle





Chronic detachment MCL



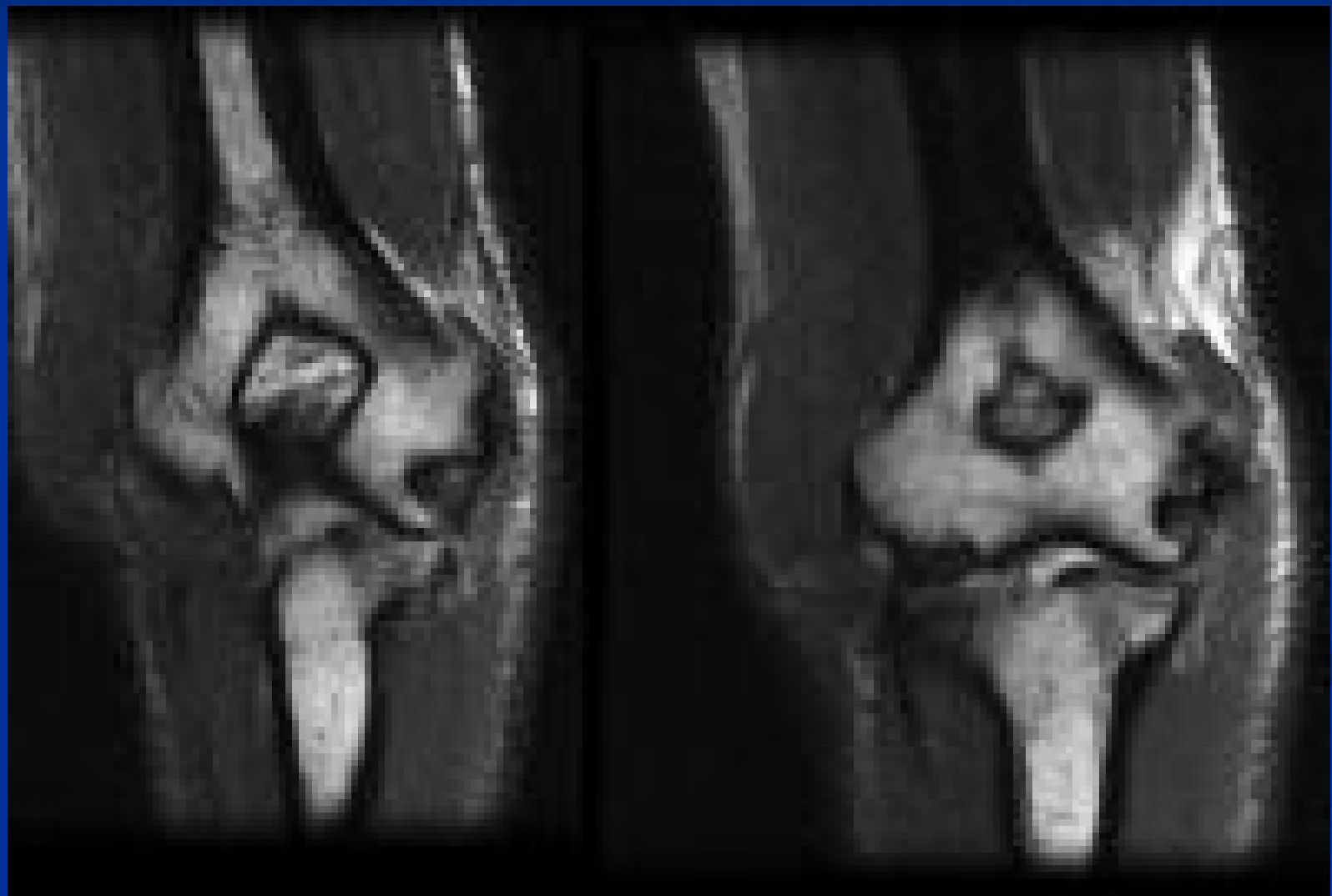
Pitfalls in diagnosing Ulnar Collateral Lig injury

- Full thickness UCL tear – discontinuous – easy!!.
- Partial thickness UCL more challenging.
  - 57% sensitive/100% specific.
- MR arthrography can help 86% sens
- T sign
  - leak of contrast around detached portion of UCL
- chronic tear shows abn thickening of ligament

Partial-thickness tear of ulnar collateral ligament

- 19 yo baseball pitcher with medial elbow pain.
- thickening, irregularity intermediate signal within intact anterior bundle of UCL w/ surrounding periligamentous edema

Ulnar collateral lig partial tear



Epicondylitis

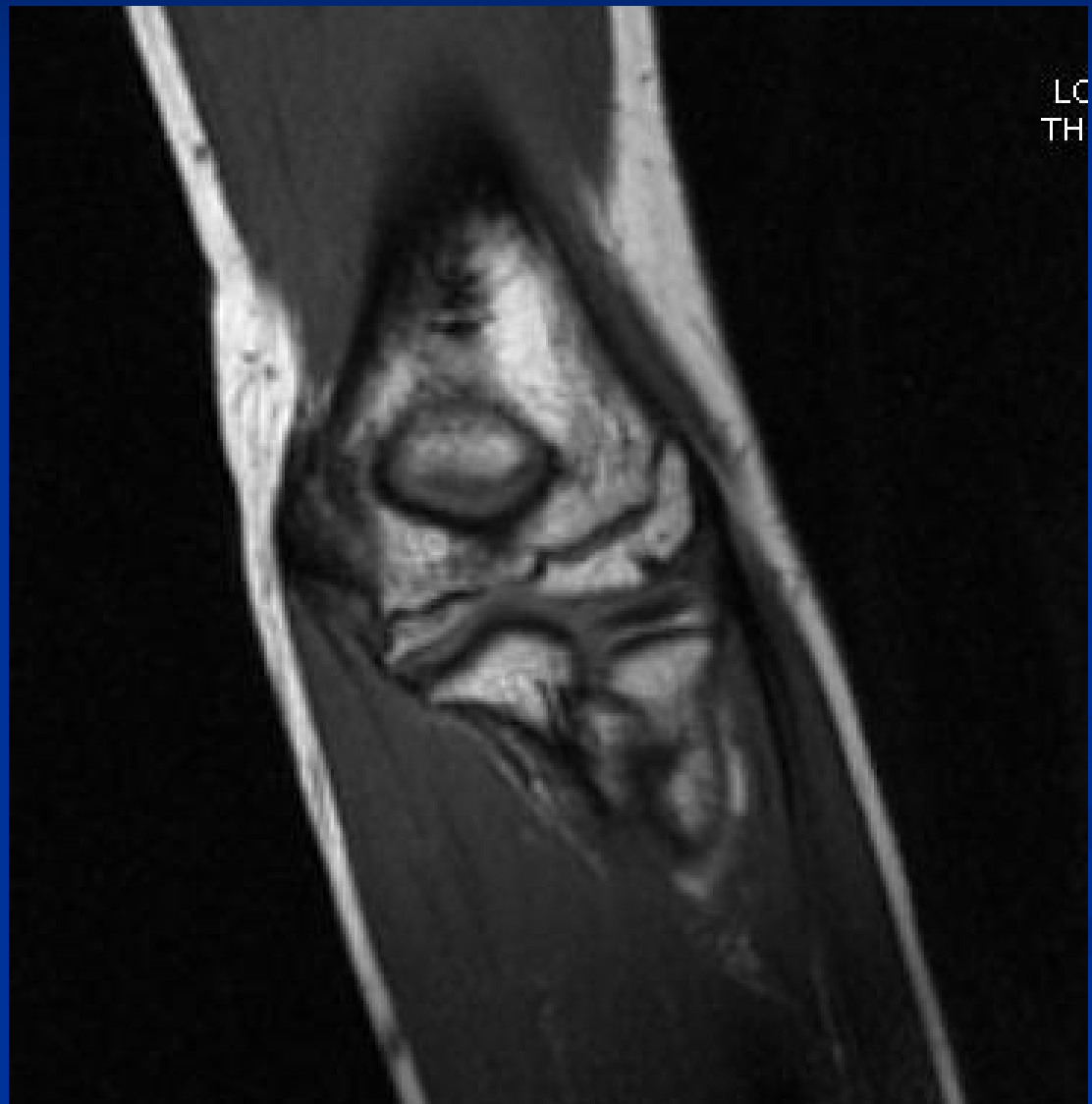
- Lateral “tennis elbow”
  - More common

- Medial pitchers/golfers
  - Common flexor tendon
  - Late adol, adult
  - Less common

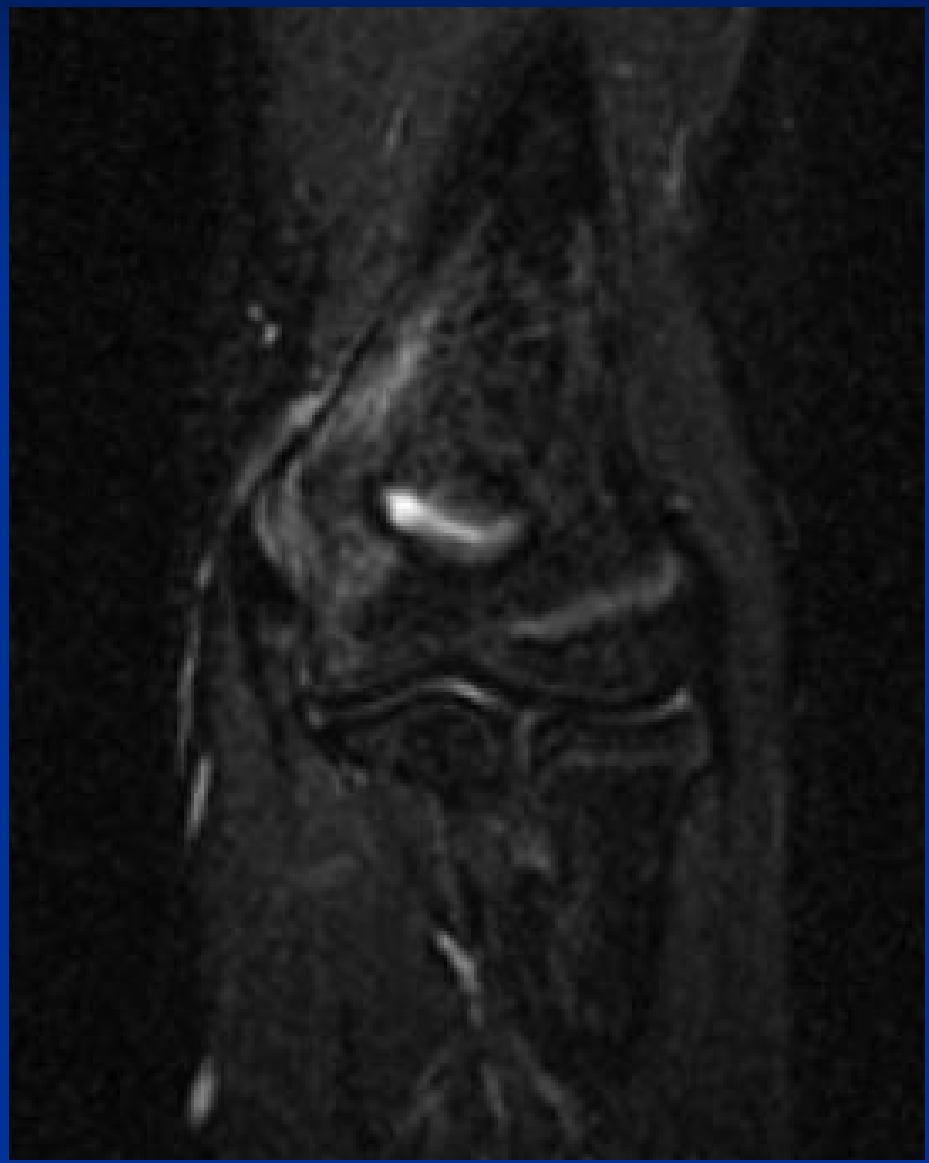
Medial Epicondylitis

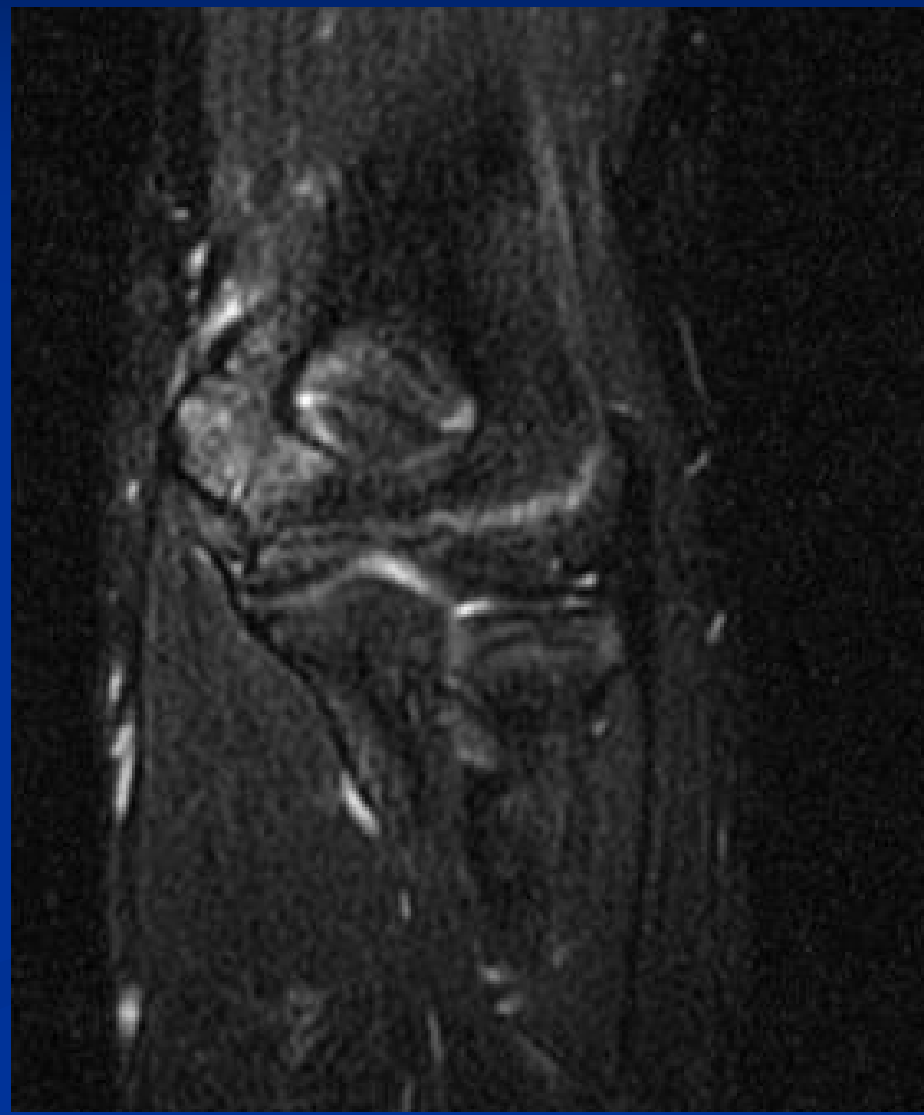
- Common flexor tendon avulsion at medial epicondylar insertion.
- Late adolescent / early adult
- Less common than lat epicondylitis
- Thick common flexor tendon increase T1 and T2 and peritendinous edema –
- CFT superficial to UCL often coexist with UCL tear

Medial epicondylitis

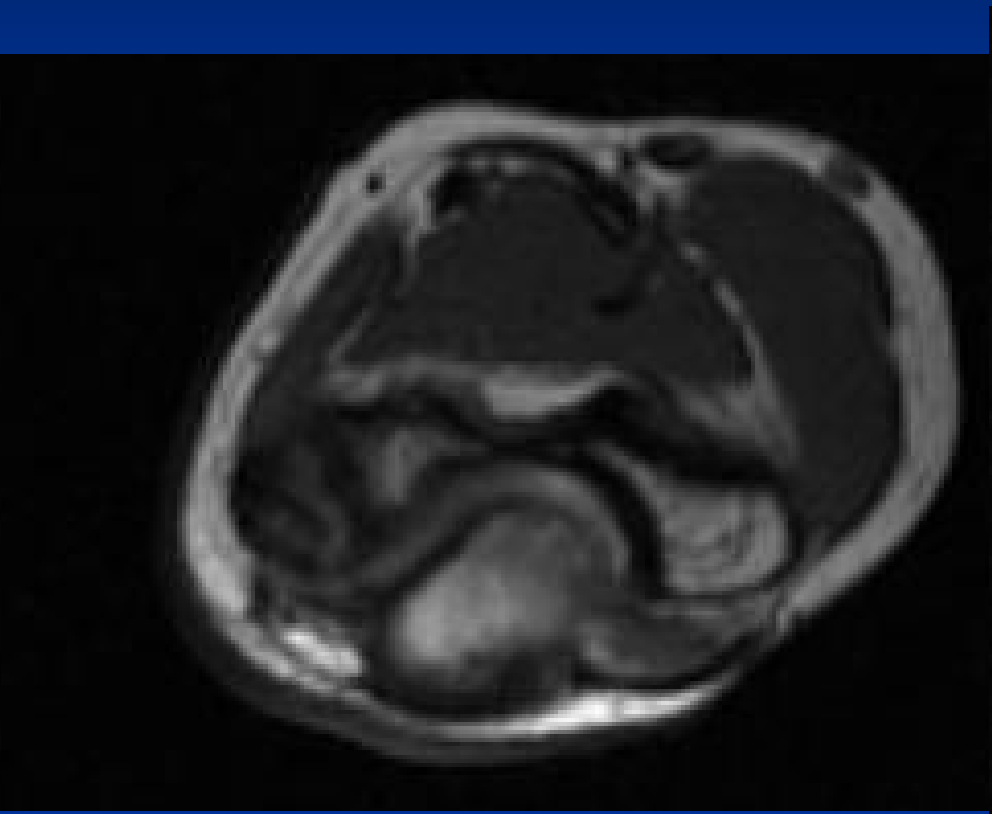


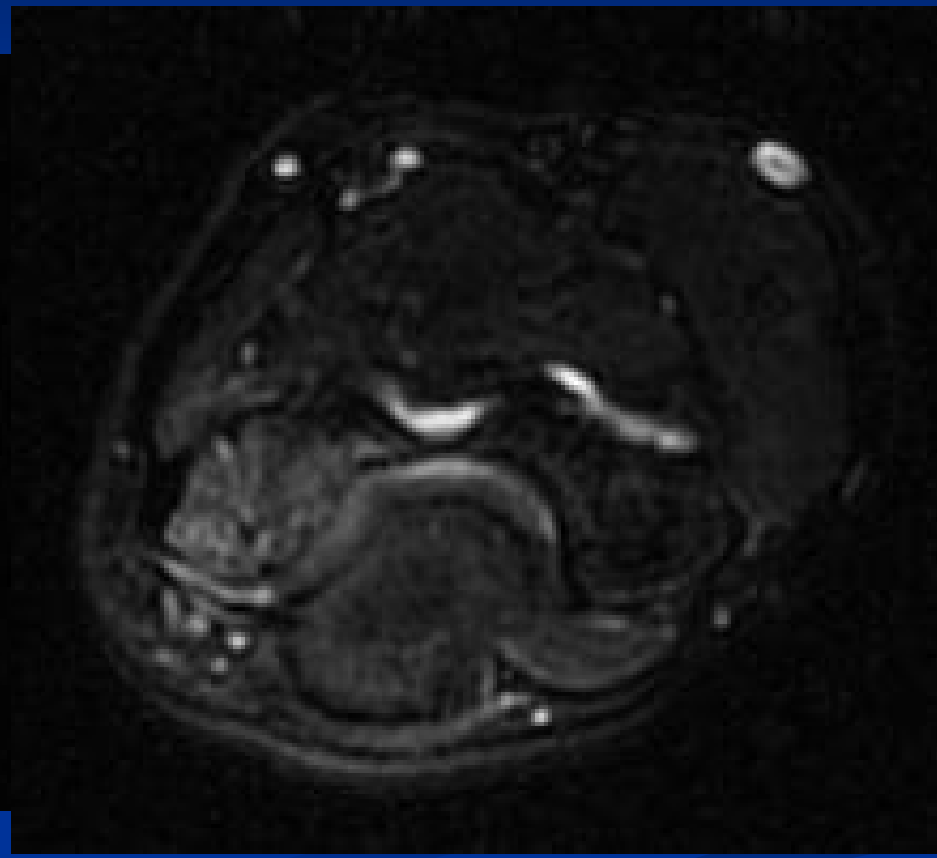
Medial epicondylitis



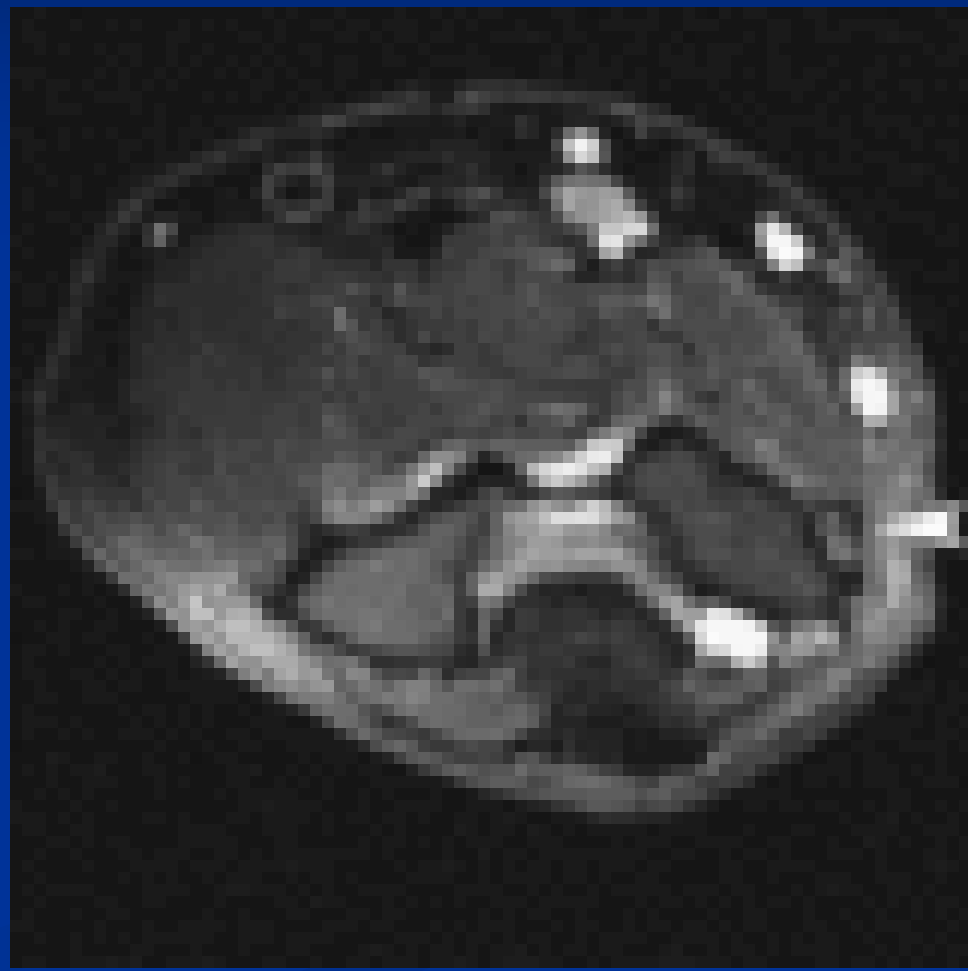


Medial epicondylitis

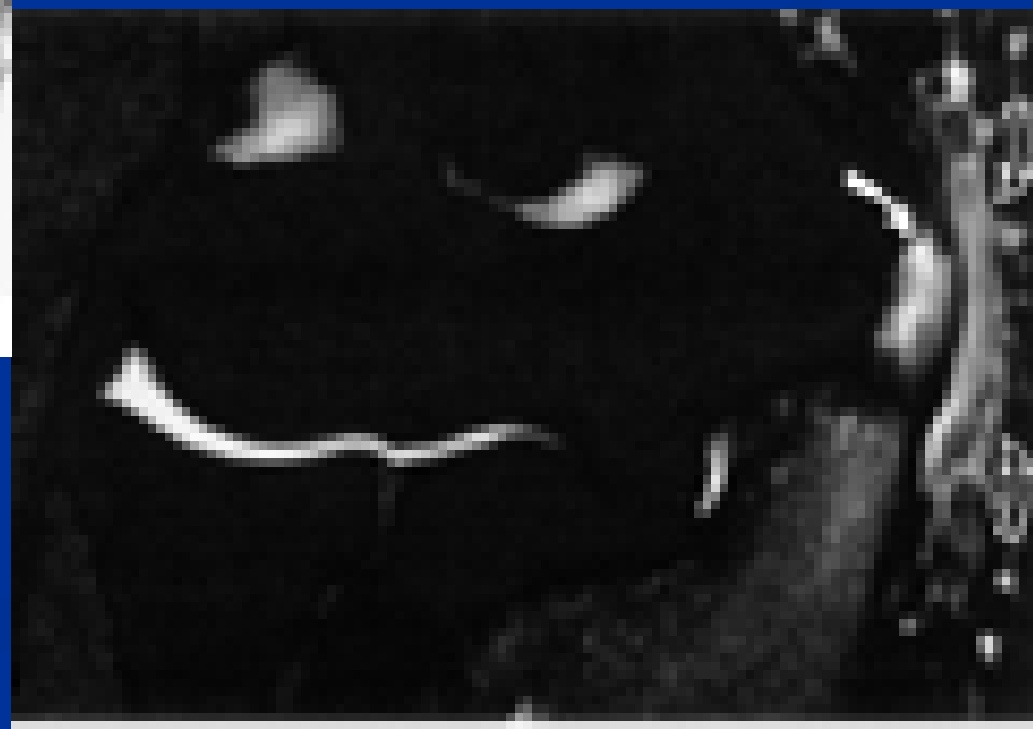




Medial epicondylitis with UCL tear



Med epicondylitis with Common flexor tendon tear



Osteochondral lesions of the capitellum Panner / OCD

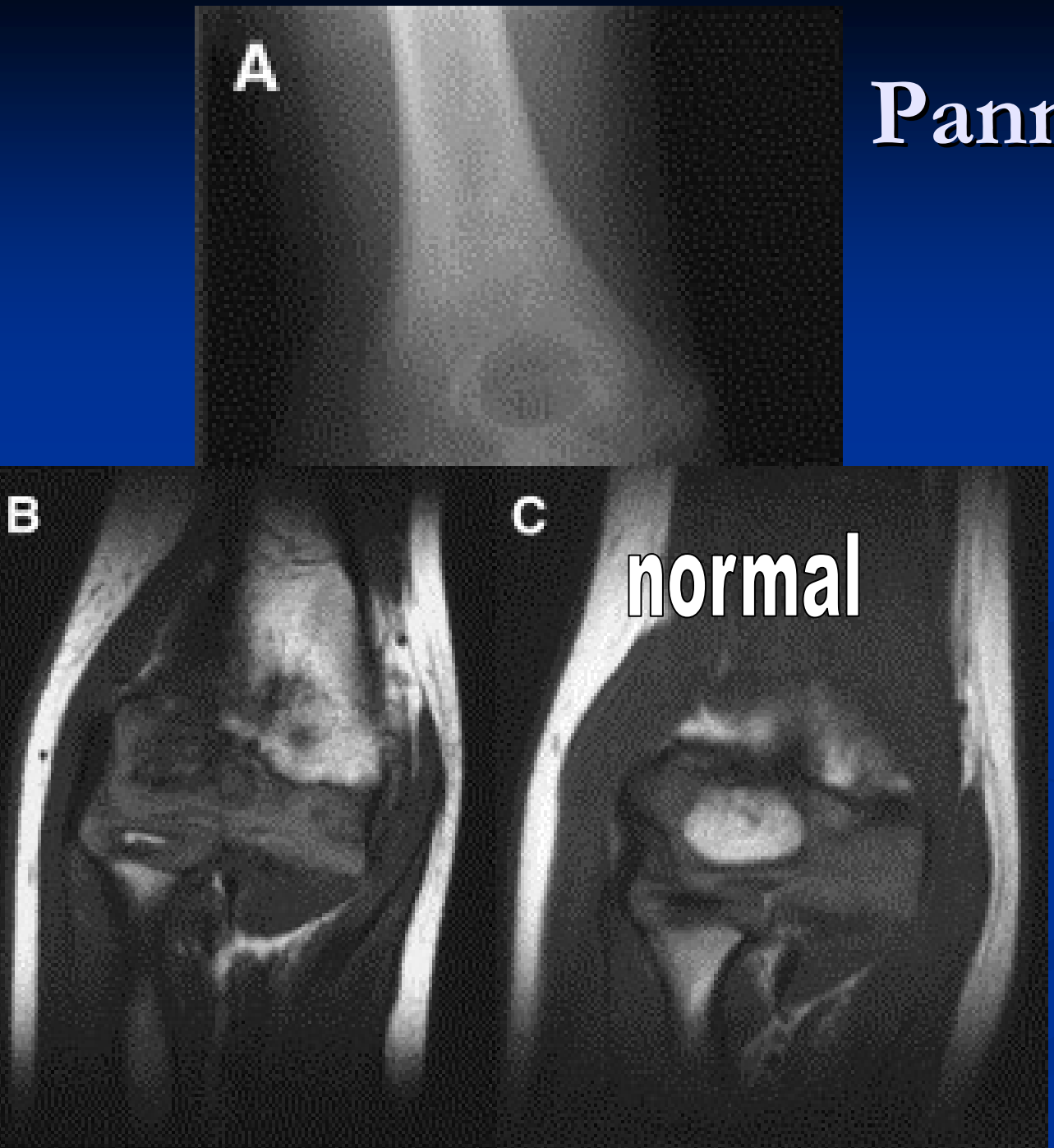
- Baseball pitcher, tennis, gymnasts.
- Valgus stress- lateral compression
  - Adult = UCL tear
  - Child = impaction osteochondral lesion.
    - Child < 12 yo Panner ostochondrosis
    - Adol > 12 yo OCD
- disordered endochondral ossification of capitellum
  - Likely share same cause ? two stages in same process-
  - Different age, different outcom

Panner disease

- Benign, self limiting osteochondrosis/necrosis of capitellum
- 7-12 yo boy
- Dull elbow pain and swelling
- Fragmentation of capitellar ossification w/ sclerosis
- Minimal flattening of capitellar subchondral bone plate

Panner disease

- Healing with conservative management-
  - typically resolves w/o sequela
- MRI **not** indicated- partial complete replacement of fatty marrow with Low T1/ inc T2w
- Cartilage unaffected
- No loose body



Panner disease

- 8-year-old male. abnormal fragmentation and rarefactionof the capitellar ossification center.
- Cor T1 abnormal low signal replacement of fatty marrow as compared with a normal capitellum(*C*).
- Emery Clinics in Sports Med 2006

OCD of capitellum

- 12-15 yo boys
- Anterolat capitellum
- Pain, swelling – late elbow locks
- X Ray- little change early.
- Subchondral flattening (45 degree angle), cystic rarefaction, fragment/loose bodies (Loose bodies often missed)
- If Fragmented – chronic sequela long term pain, osteoarthritis instable radial head/ less of extension
- loss of terminal extension, and chronic instability of the radial head

OCD of capitellum

- 16 yo. T2w focal high signal in the capitellum.

- Kijowski R, De Smet A. Radiography of the elbow for evaluation of patients with OCD of the capitellum. Skeletal Radiol 2005;34:266–71

- End arterioles not connected to metaphyseal vessels.
- Radial head stiffer. Combination of ischemia and articular cartilage may explain why repeated lat compression results in OCD

OCD of capitellum

- US has been used
  - reactive synovitis can limit exam
- MRI - Low T1 at capitellar surface / nl T2
  - Conservative management at this stage
- MRI - Abn T2 peripheral ring around lesion or throughout lesion with cyst/fragment loose
  - Worse prognosis so early Dx key

OCD MRI

- Pros

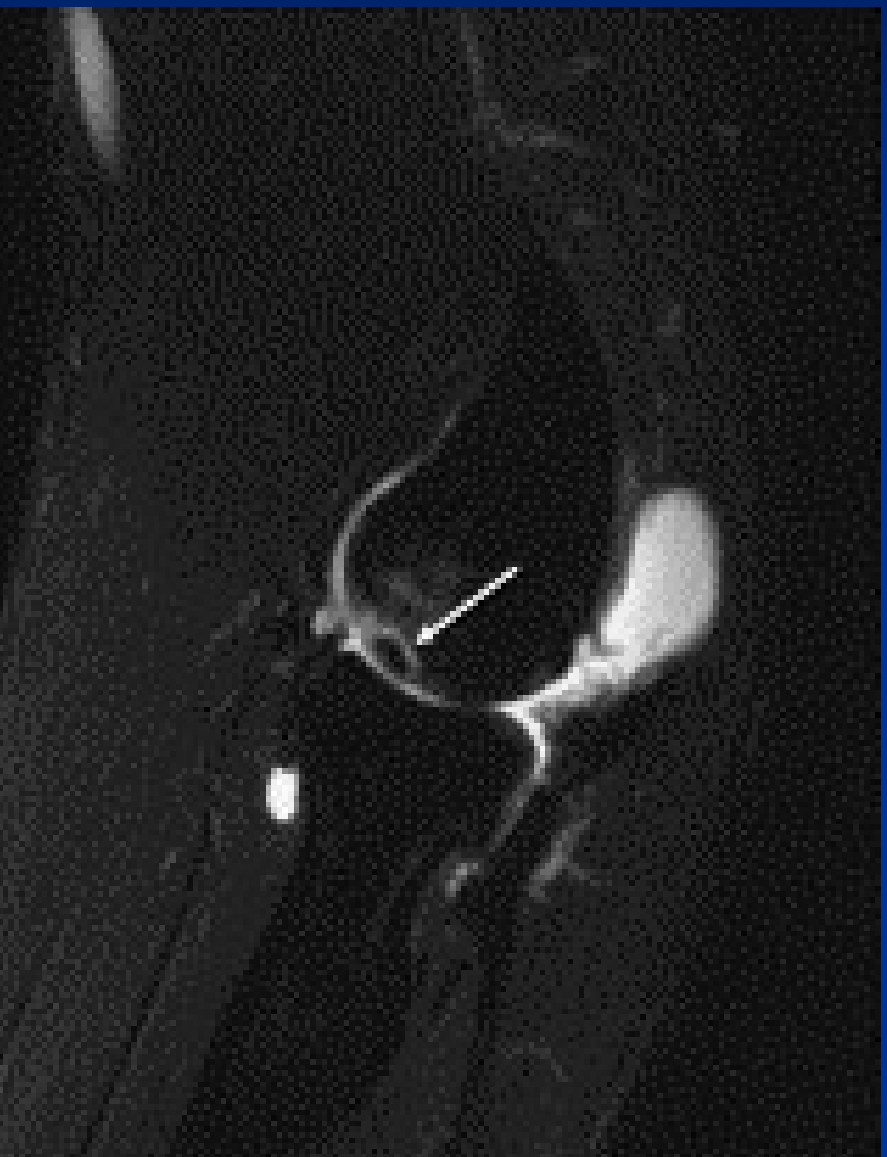
1. May be seen before XR

   Early treatment may prevent chronic symptom
2. Preop planning – size, intergrity of cartilage, chondral bodies
3. Size and viability of fragment
4. Stability – linear high signal alone fragment and capitellum fluid or granulation tissue

OCD of capitellum- MRI problems

- Critical to assess articular cartilage and fragment viability and detect loose fragment
- Articular cartilage challenging
- Pseudodefect of capitellum groove b/w capitellum / lat epicondyle
- Gd - fragment enhancement suggest viability and good blood supply
- Loose bodies difficult – x ray may be better than MR or CT arthrography

Unstable OCD lesion in a 17 yo



- Sagittal T1-w FS image shows linear high signal Gd contrast surrounding the OCD fragment.

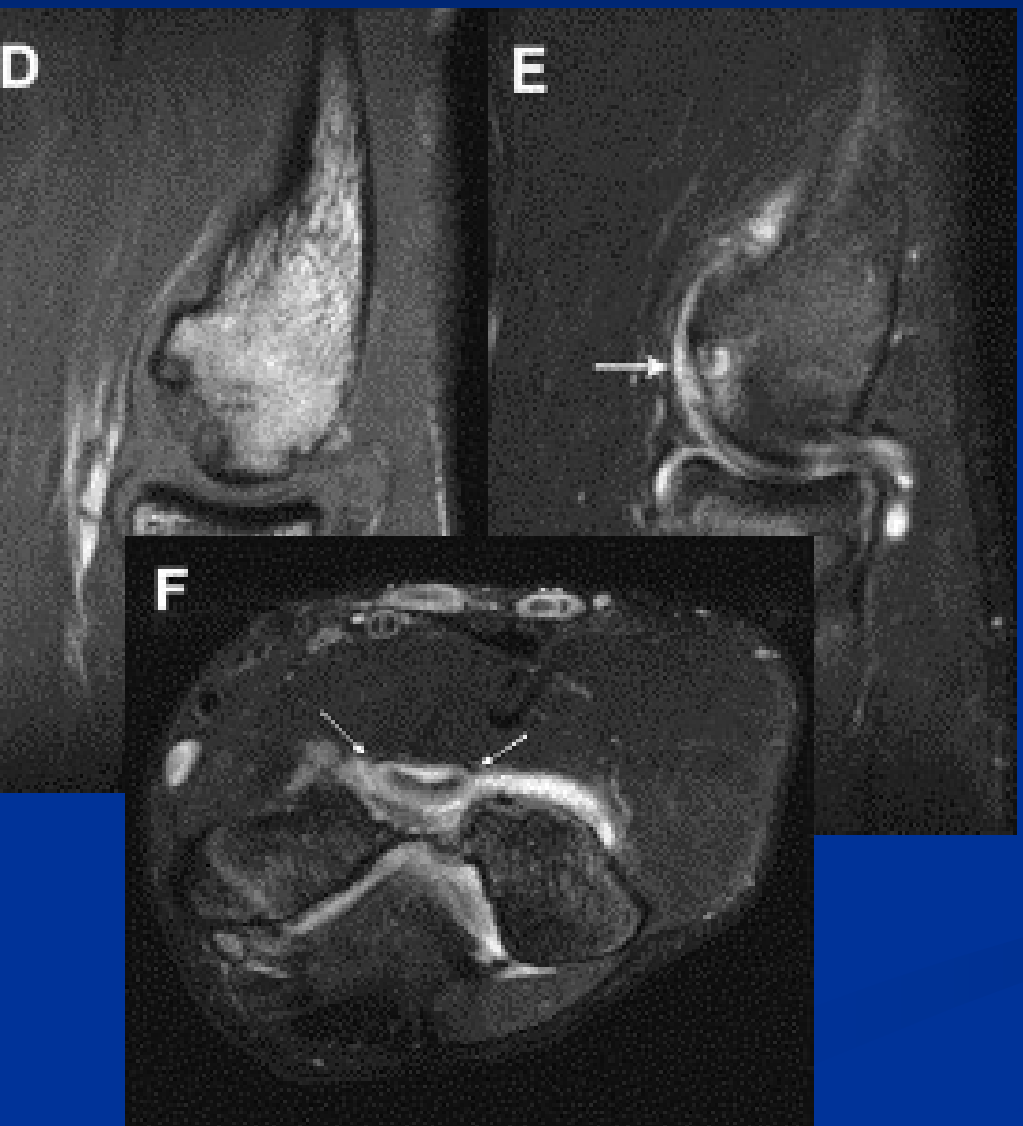
OCD of capitellum

- Intracapsular fat pad and synovial folds can mimic loose body on MR
- Gd - MR sens and spec similar to CT arthography(78/95% vs 87/94%)
- MR arthrography not been studied

Capitellar OCD with progression to loosebody formation.

- 12 yo xray normal
- T1 sagittal MR image shows the scalloped area of abnormal decreased marrow signal in the subchondral bone with intact overlying cartilage on the sagittal gradient echo sequence

Capitellar OCD with progression to loosebody formation



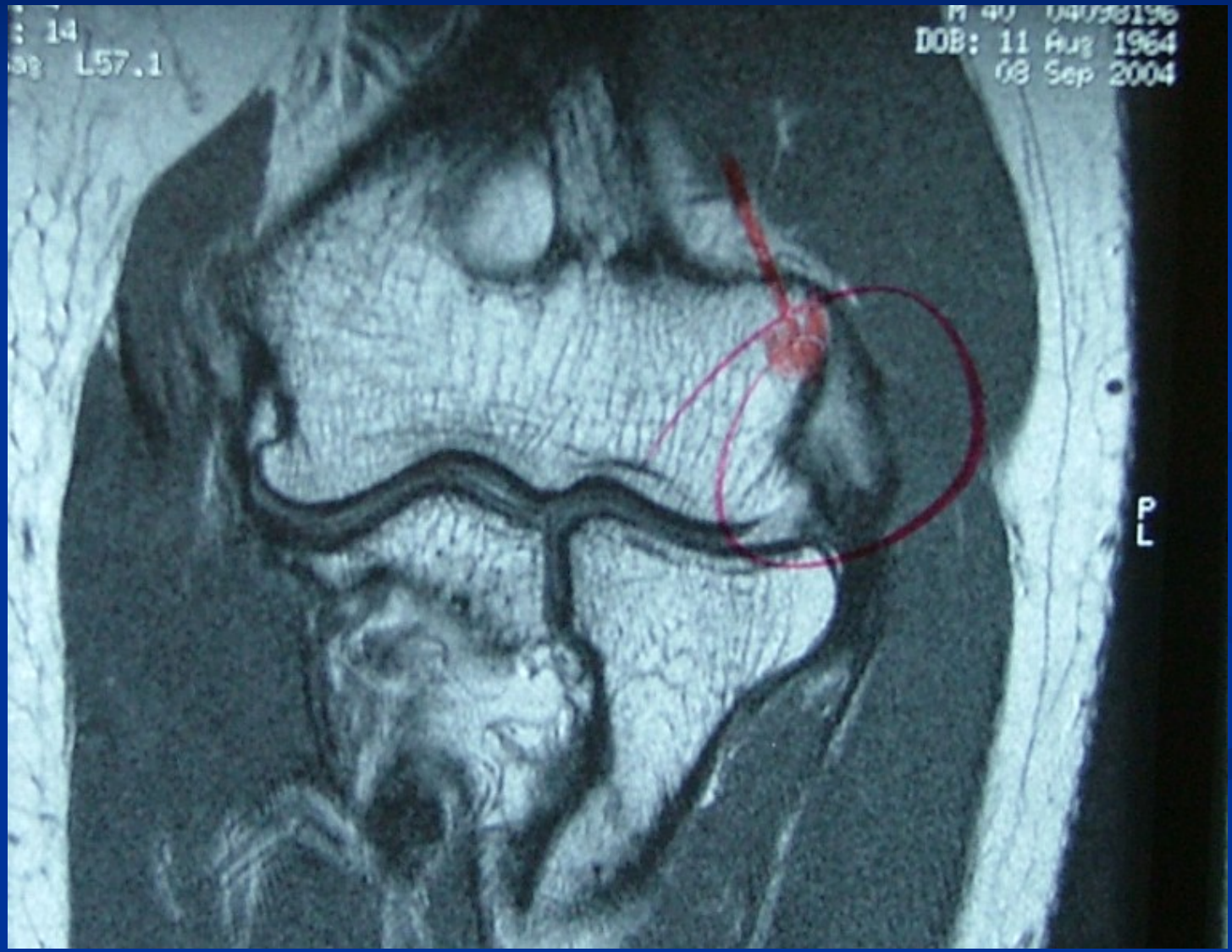
- 2 years later at age 14
- Sagittal T1 image (*D*) at that time shows the progression of the lesion with disrupted overlying articular cartilage (*arrow*) on the sagittalT2 image (*E*),
- axial T2 image (*F*) confirms the intra-articular loose body (*arrows*) in the anteriorjoint space that was removed arthroscopically.

- Emery 2006

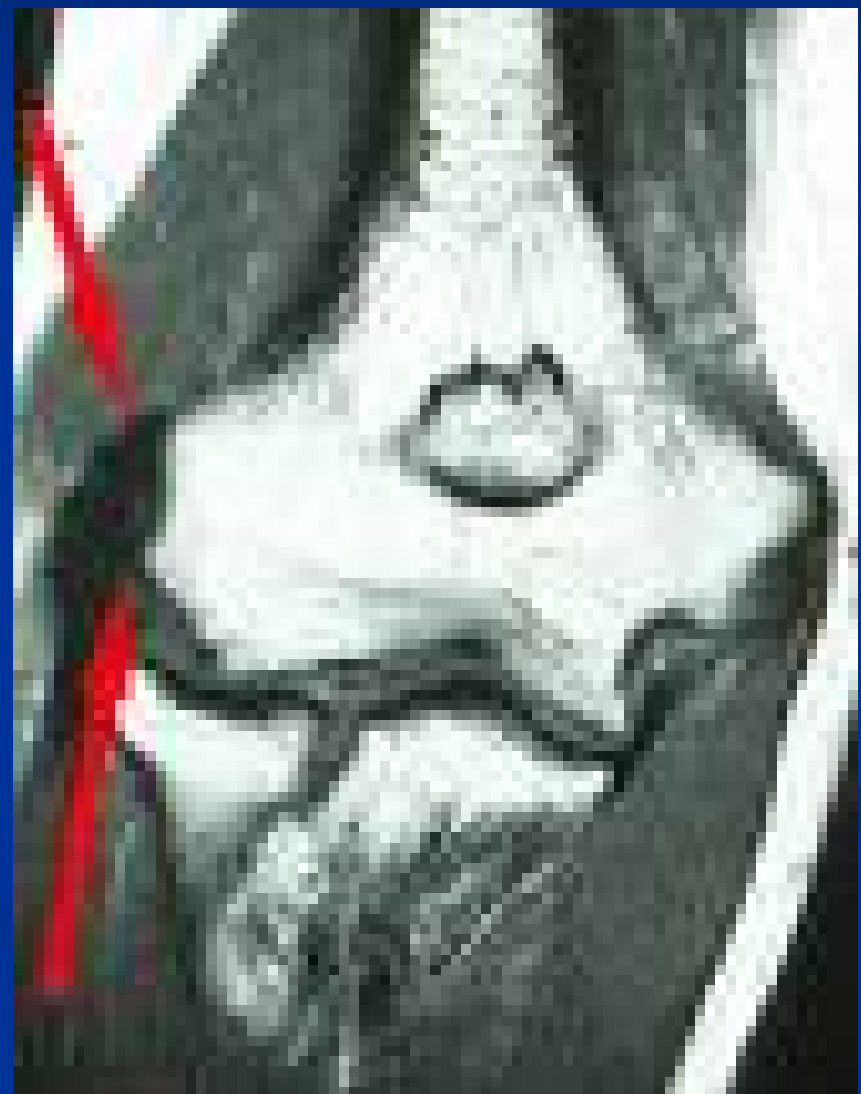
Lateral Epicondylitis "Tennis Elbow"

- Microtrauma repetitive wrist extension- racquet sports
- More common than medial
- More frequent in adults -
  - Xray -widening or fragment of apophysis
- MR not indicated. Will show high signal

Lateral epicondylitis

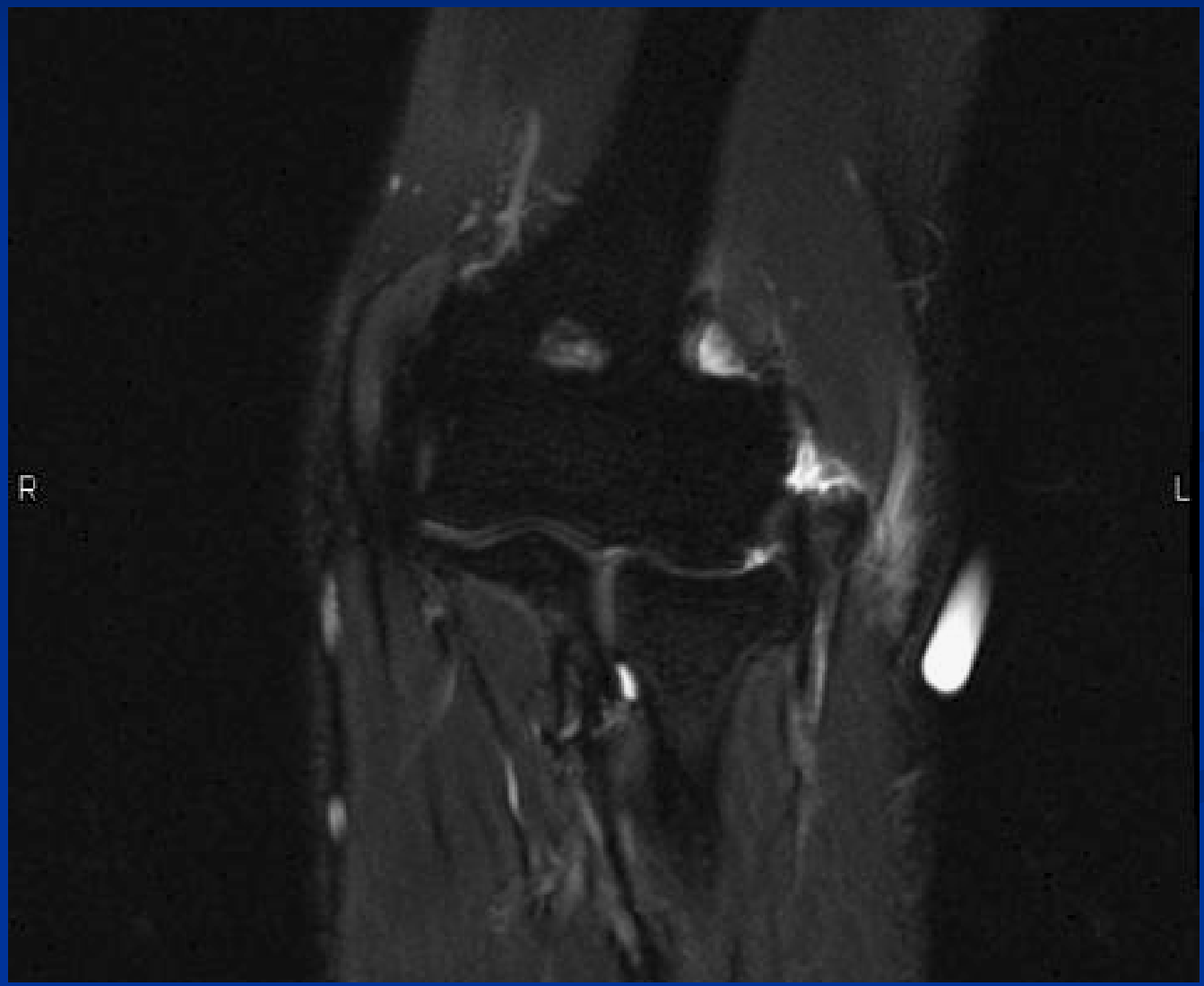


Tennis elbow –Lateral Epicondylitis



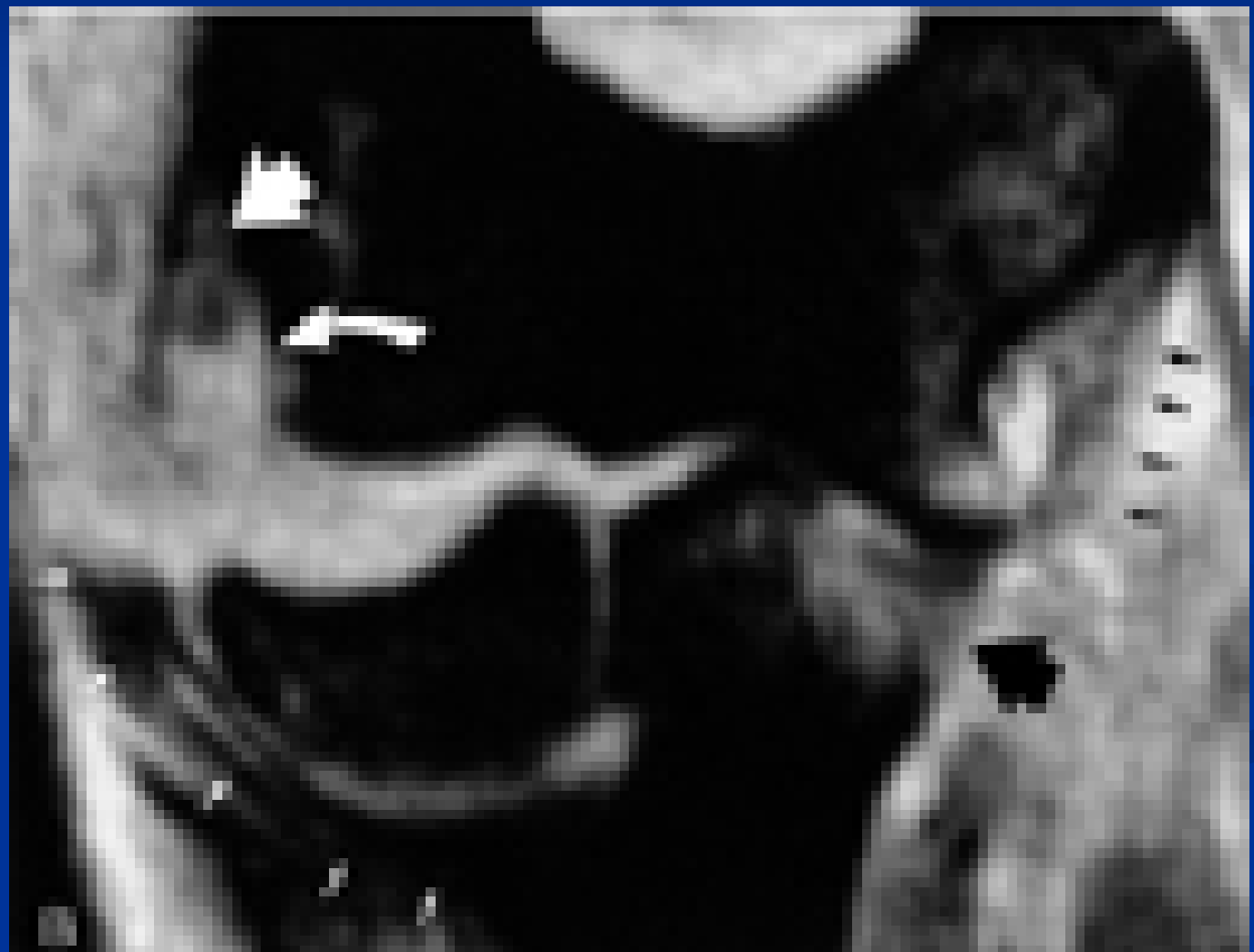
Differential - Lateral common extensor tendinosis

Partial tear of common ext tendon tennis elbow



Case

Rupture lateral collateral lig and common ext tendon and coronoid process



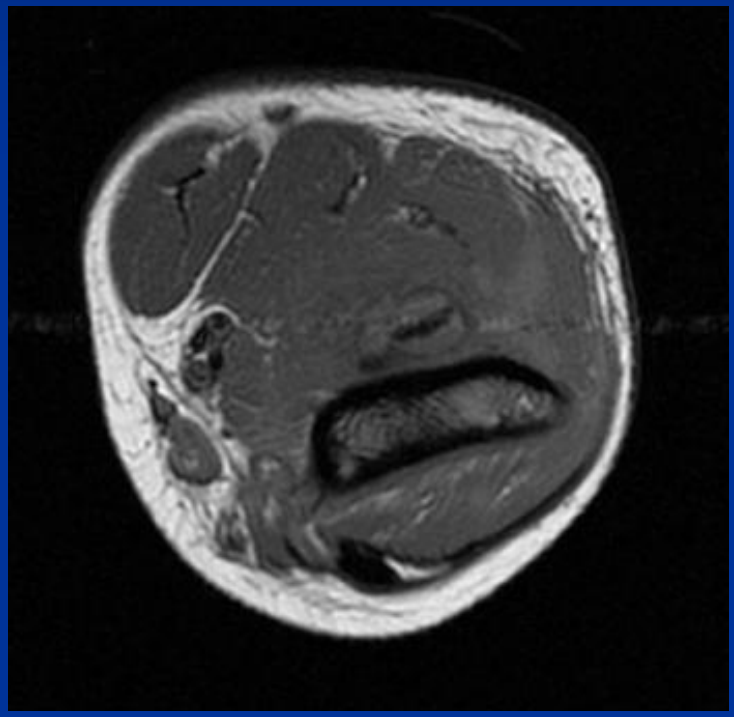
Rupture collateral lig and common ext tendon and coronoid process

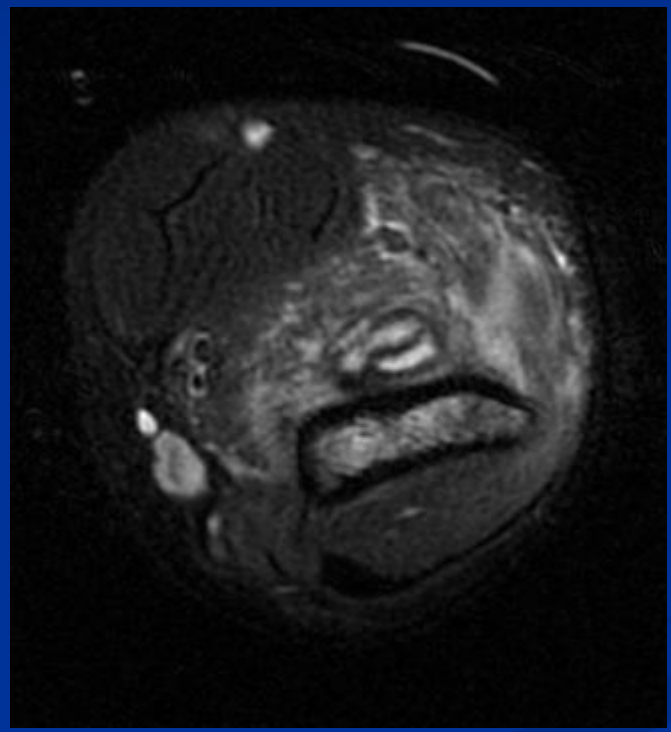
Rupture flexor tendon and MCL wrestling

Elbow

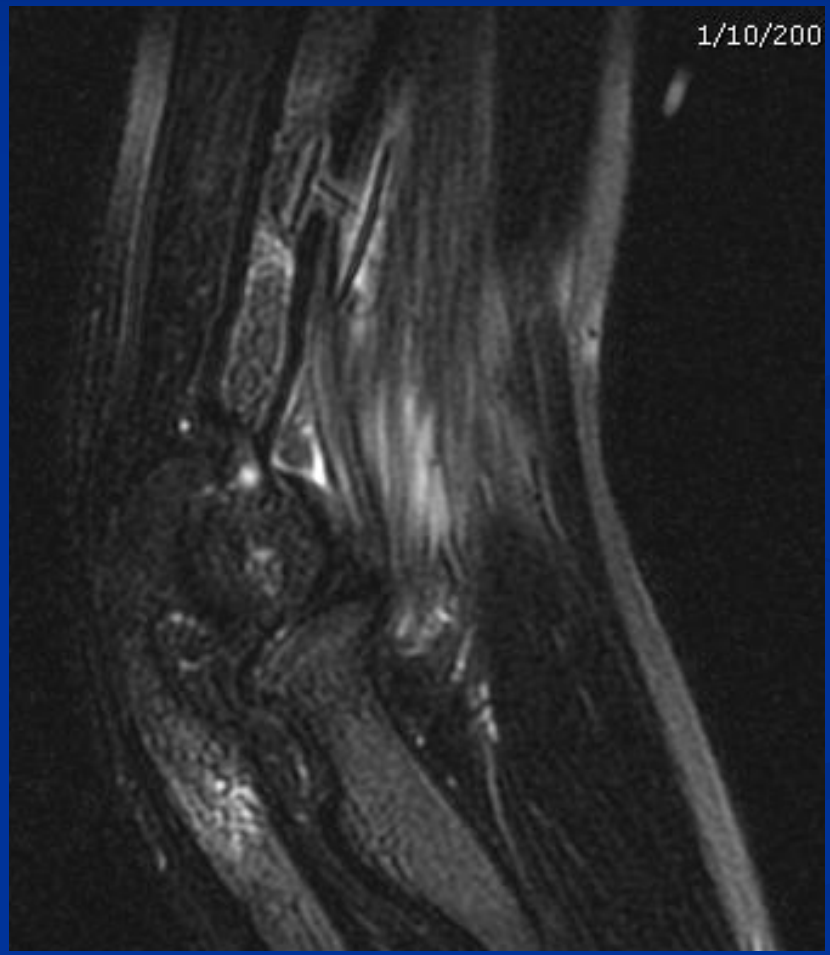
- Infarction
- Infection
- Tumors

Osteomyelitis SSD

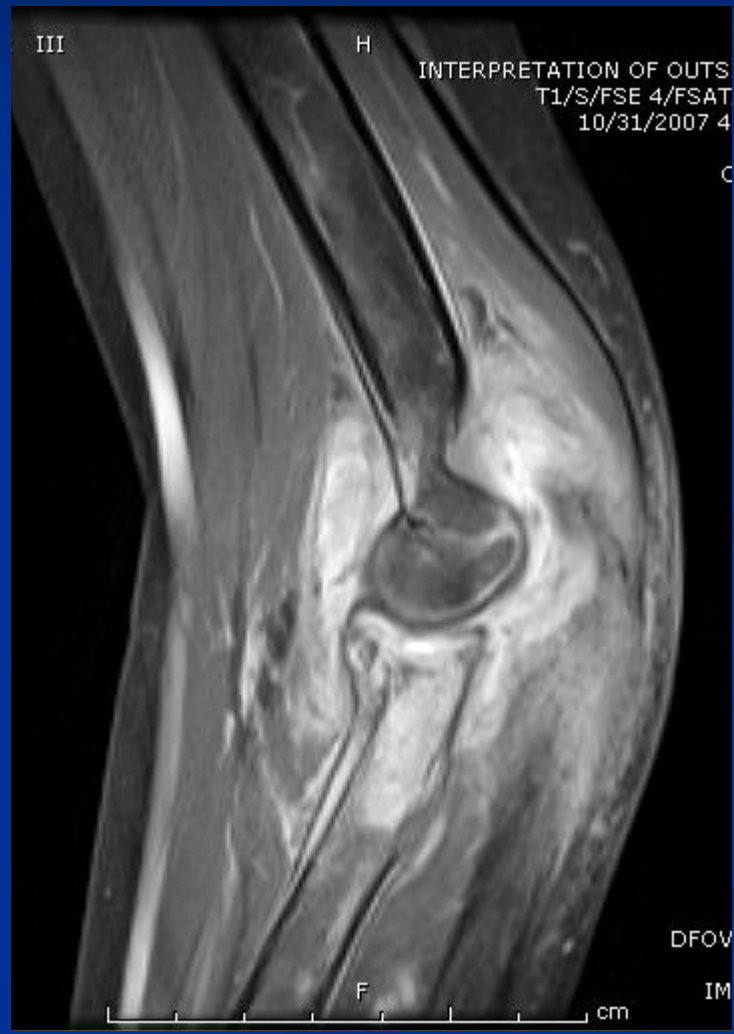




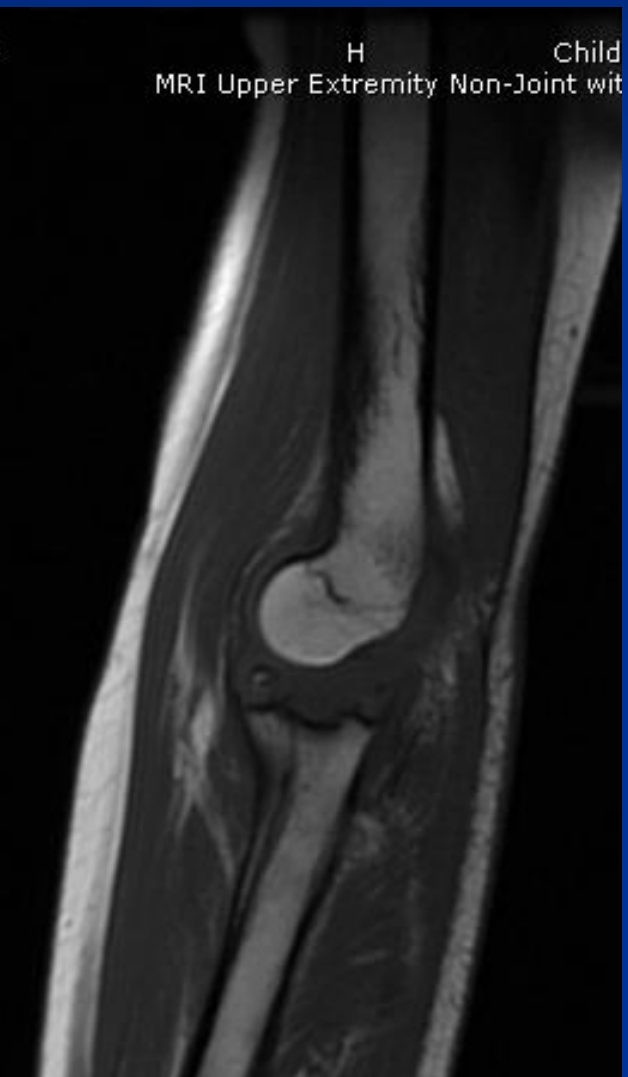
Osteomyelitis – sequestrum SSD

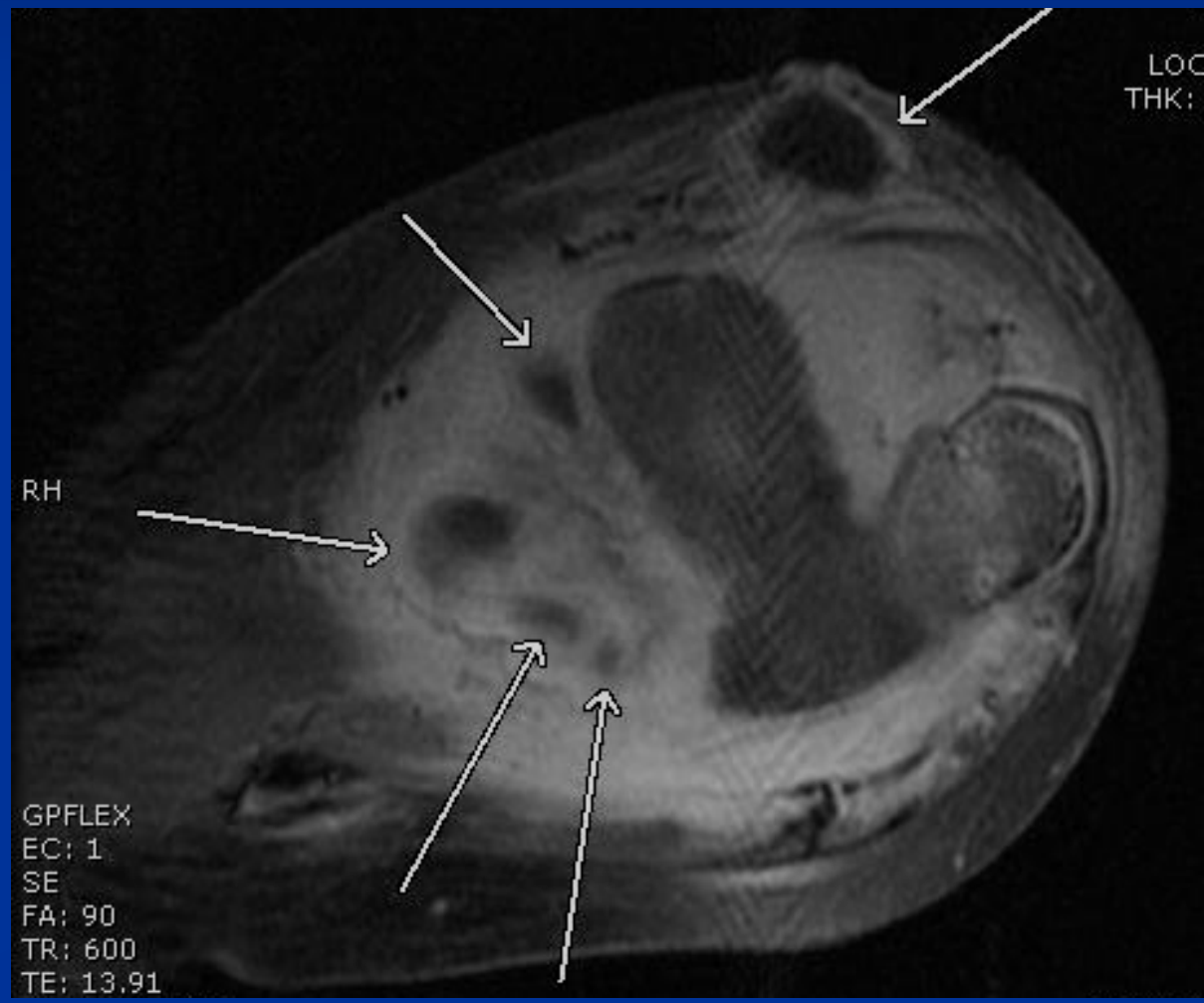


Radial fx and osteomyelitis

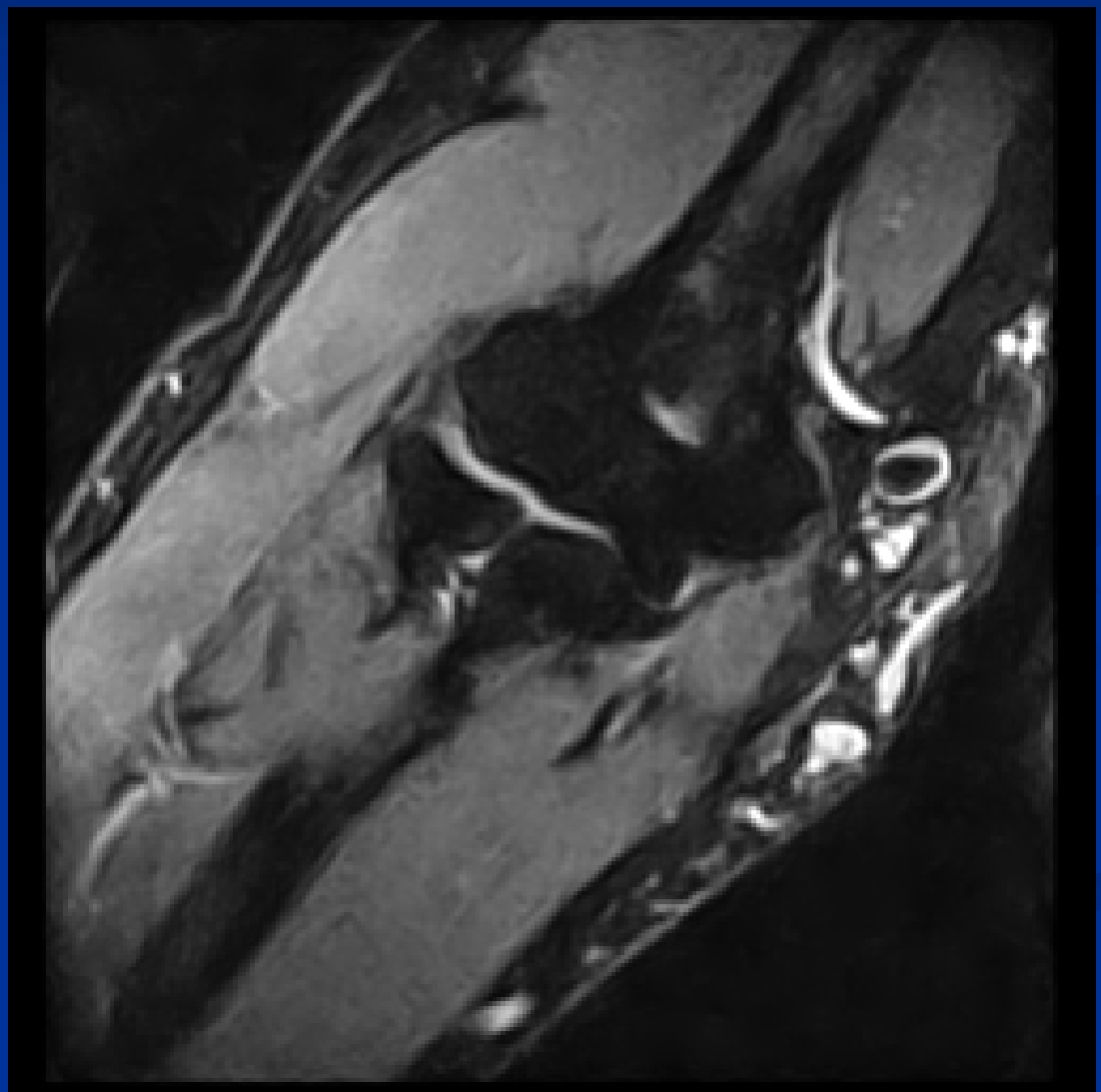


Radial fx and osteomyelitis





AVM



Conclusions

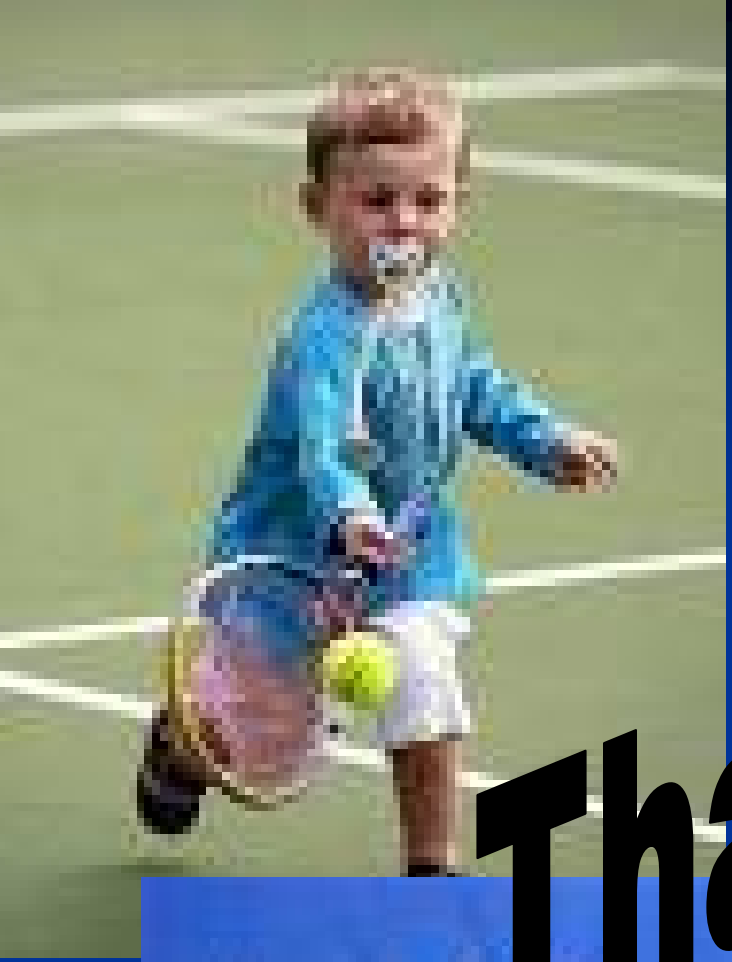
- "Little League"- medial apophyseal growth plate chronic injury - Medial tension and lateral compression.
  - fragmented physiologic response to repetitive traction stress
  - Conservative management - NO MRI needed
- Lateral epicondylitis "tennis elbow" more common than medial in older pts.
  - partial tears of extensor group
- Medial epicondylitis "golfer elbow"
  - Chronic overload of pronator group

Conclusions

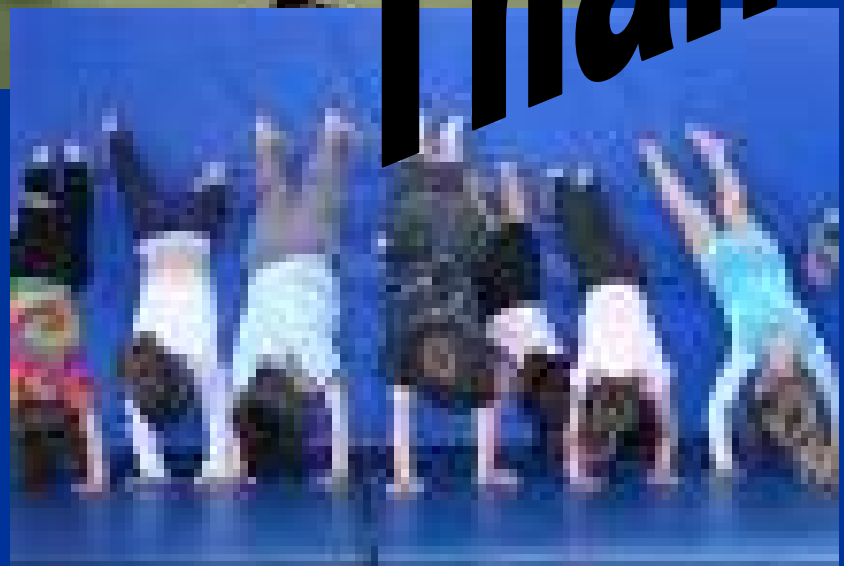
- UCL/MCL primary structure that maintains stability in valgus stress. Anterior band most important
- LCL les common result of chronic trauma associated with “tennis elbow”

Conclusions

- Panner – Osteochondrosis 5-11 yo whole capitellum, no sequela
- OCD anterior capitellum 12-16 yo – edema
  - Unstable if fluid between fragment and bone
- Pitfall pseudodefect of posterior capitellum – no marrow edema



Thank you!!



Accessory Muscles of the Elbow

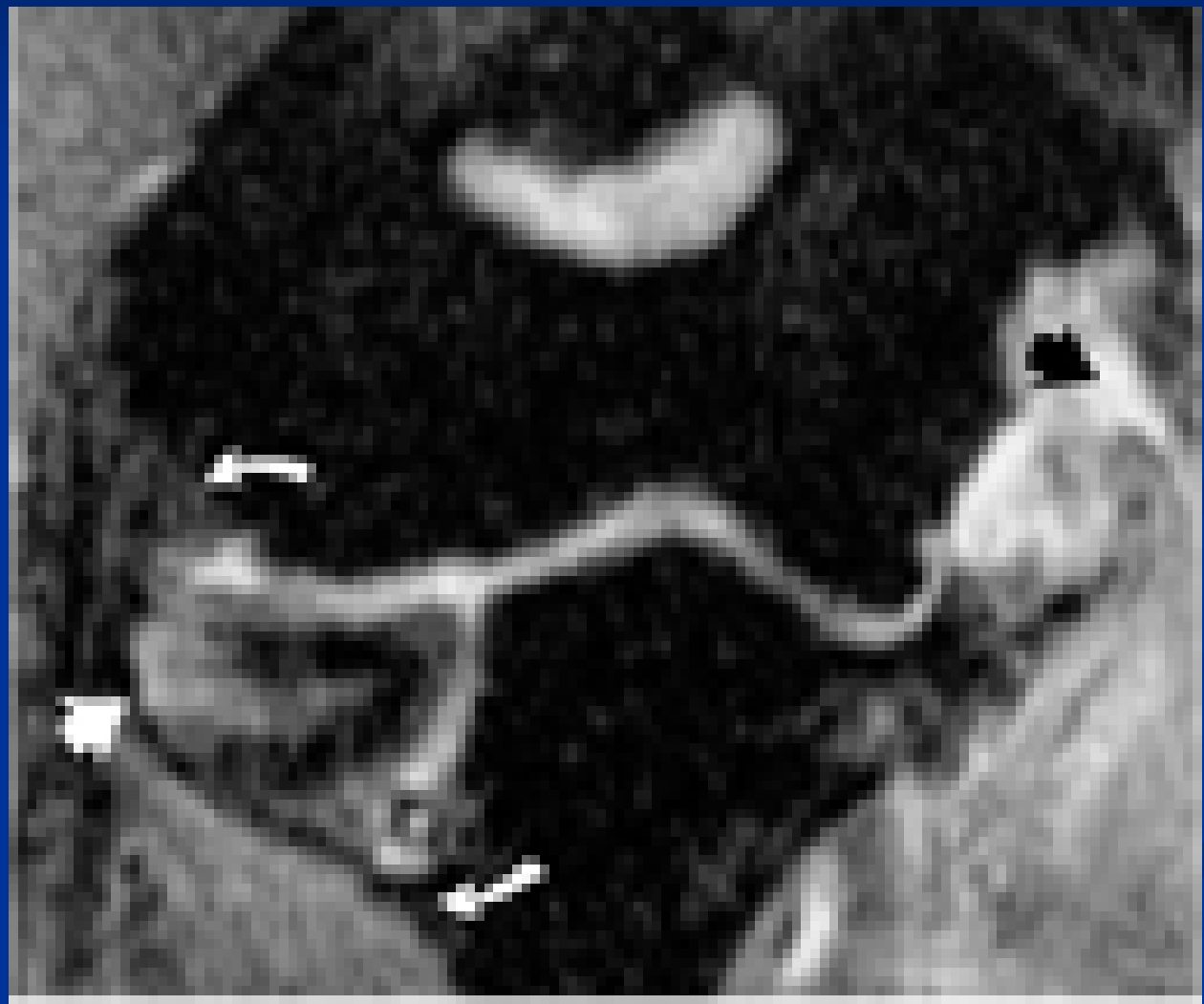
Accessory head of flexor pollicis longus Mus

- Ant radius, inf to anterior oblique line and sup to pronator quadratus
- Passes to flexor retinaculum insets at bases of thumb
- 45-66%

Accessory Brachialis

- Brachialis from ant lower humerus and inserts into ulna tuberosity and coronoid process
- Accessory originates from med humerus with distal insertion into common tendon of antebrachial flexor compartment
- Medial to elbow and crosses median NN and brachial
- Distal tendon can compress the median NN

MCL graft rupture



Technique- routine

- Localizer
  - Axial fat-suppressed T2-weighted images
  - Sagittal fat-suppressed T2-weighted images
  - Coronal fat-suppressed proton density weighted images

- for loose body, capitellum osteochondritis dissecans (OCD), nerve impingement, biceps and triceps tear:
- • Axial T1-weighted images
  • Sagittal T1-weighted images

- For MCL tear or epicondylitis:
- • Axial FS proton density weighted images
  • Coronal T1-weighted images
  • Coronal inversion recovery (STIR) images

- MRI arthrography can be helpful in the athlete with a suspected partial tear of the MCL or a loose body

Tendinous abnormalies

- Lateral epicondylitis
- Medial epicondylitis
- Biceps tendon injury

- Troclea and capitellum rotate 30 degree ant to humerus
- Synovial recesses
- Olecranon recess
- Anterior humeral recess
- Anular recess
- Ulnar collateral lig recess
- Radial collateral lig recess
- Synovial folds