KNEE MRI From physical therapy point of view

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First of All

The aim of the lecture

1-learn to read MRI in different knee cases

2-Decided if the case truly need PT or not ?

3- And if it need PT how this different lesions even in same area can affect our rehab protocol ?

OUR items Today

- 1- MRI accuracy
- 2- Meniscus
- 3- ligament
- 4- Tendons
- 5-patella

MRI

- Non invasive and accurate
- Reliable tool in the detection of knee injuries(menisci and cruciate ligaments) it can be diagnosed with a high degree of sensitivity and specificity
- Accuracy of MRI decreases in patients with multiple injuries & fragment lesion (meniscal fragments) must be actively searched for in the common locations of displacement

Arthroscopy?

- Diagnostic arthroscopy of ACL, PCL, and medial and lateral meniscus injuries is more valid than MRI and clinical examination.
- Although arthroscopy has been considered the Gold Standard in diagnosis of meniscal and ligament injuries, MRI remains a reliable, non-invasive modality, which can reduce the use of diagnostic arthroscopy

NB

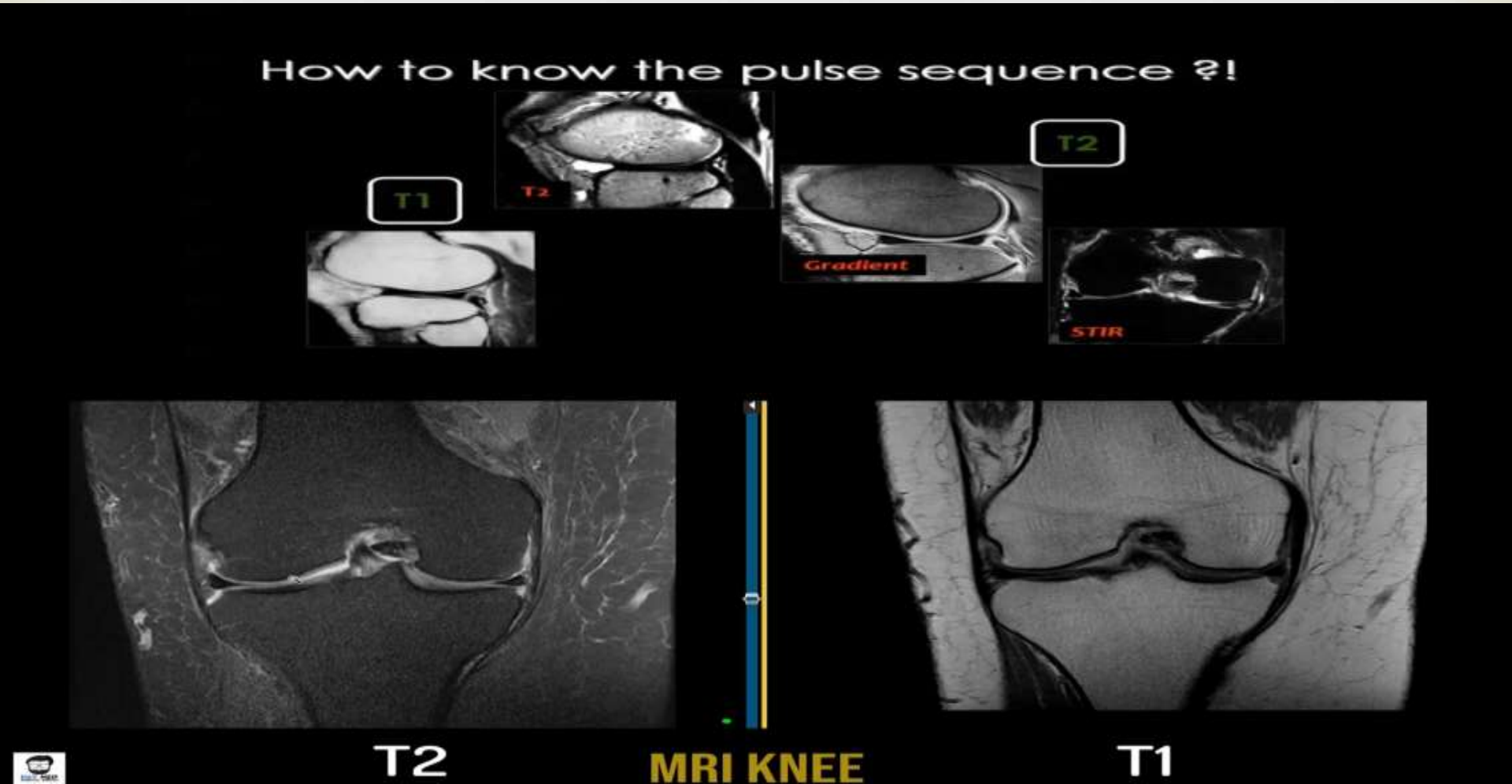
- **Remember MRI is one of many factors which will be considered in operation decision**
- 1- functional state of the patient
- 2-His job & daily routine
- 3- Age & health problems

MRI

Anatomy

- T1 ….. Fat (bone marrow) white, water black
- T2…Fat black, water white
- Sagittal view~~ For Diagnosis of Meniscus ,ACL ,PCL , Tendons
- Coronal view~~For diagnosis of collaterals ,ACL,PCL
- Axial view for reticulum patella
- **Black in T1&T2 (Meniscus, Ligament, Calcification , Muscle tendons)**

T1-T2


How to know the pulse sequence ?!
T1
T2
T2
Gradient
STIR
T2
MRI KNEE
T1

1-Meniscus

- How to define medial meniscus from lateral meniscus?

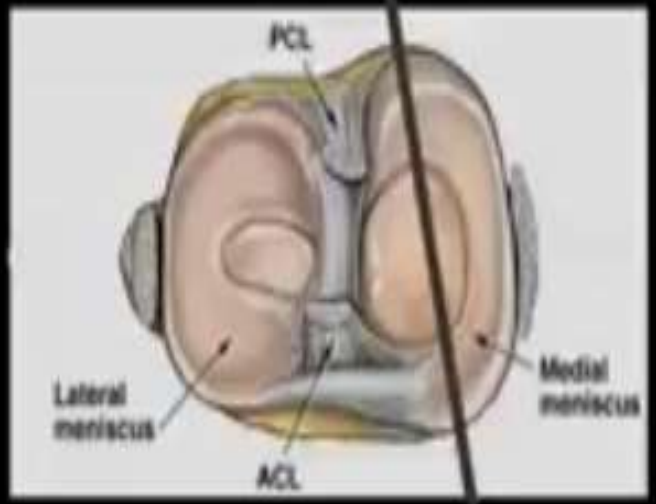
1-In lateral meniscus ~~ AH= PH, In Medial meniscus ~~ AH < PH

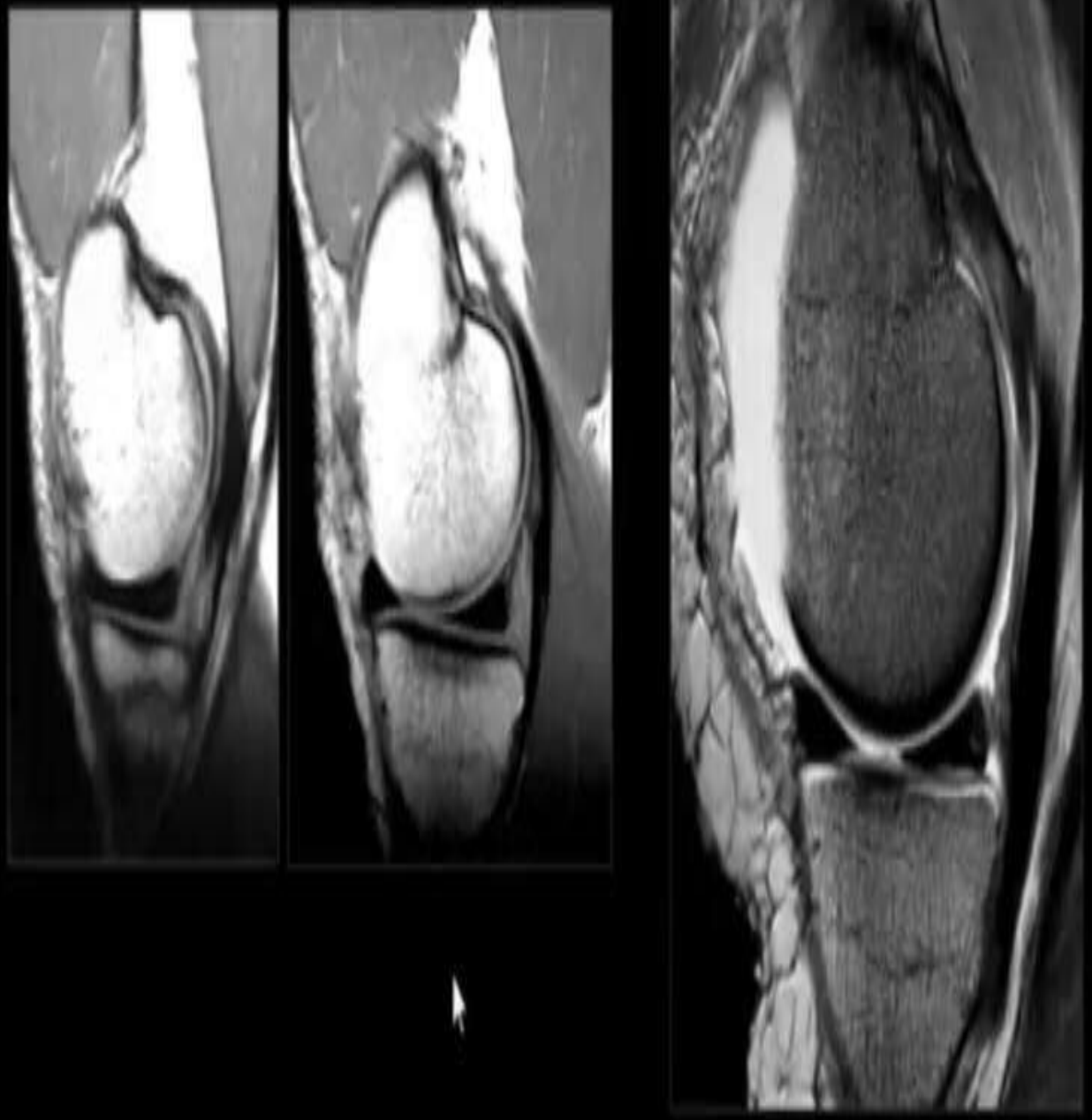
2-shape of tibia

3-postion of fibula

Medial meniscus

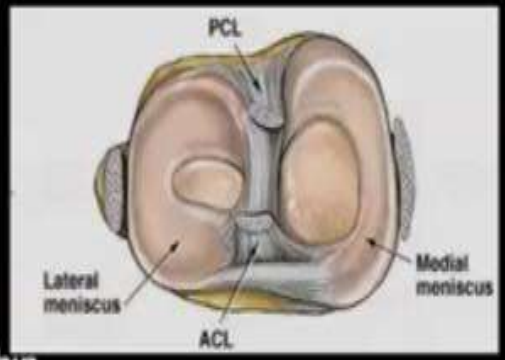
- Banana-shaped
- Posterior horn wider, longer, than anterior horn
- Posterior horn tightly attached to the capsule
- Grade II degeneration more common

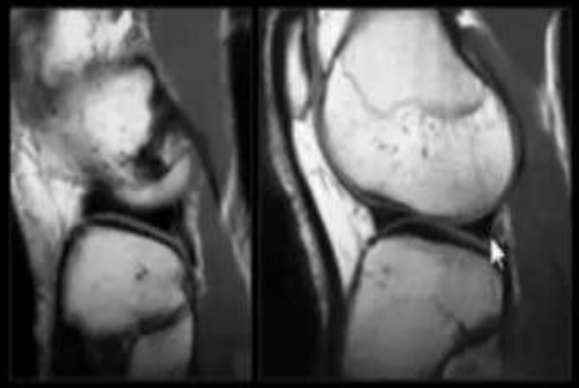


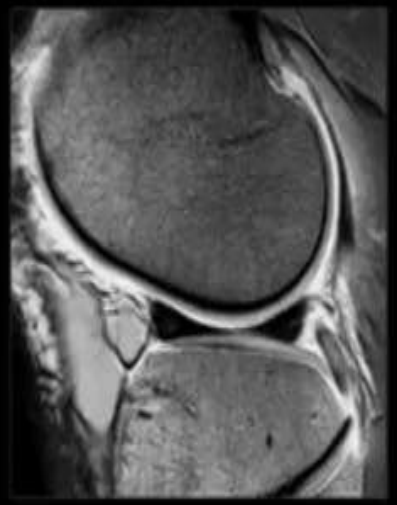


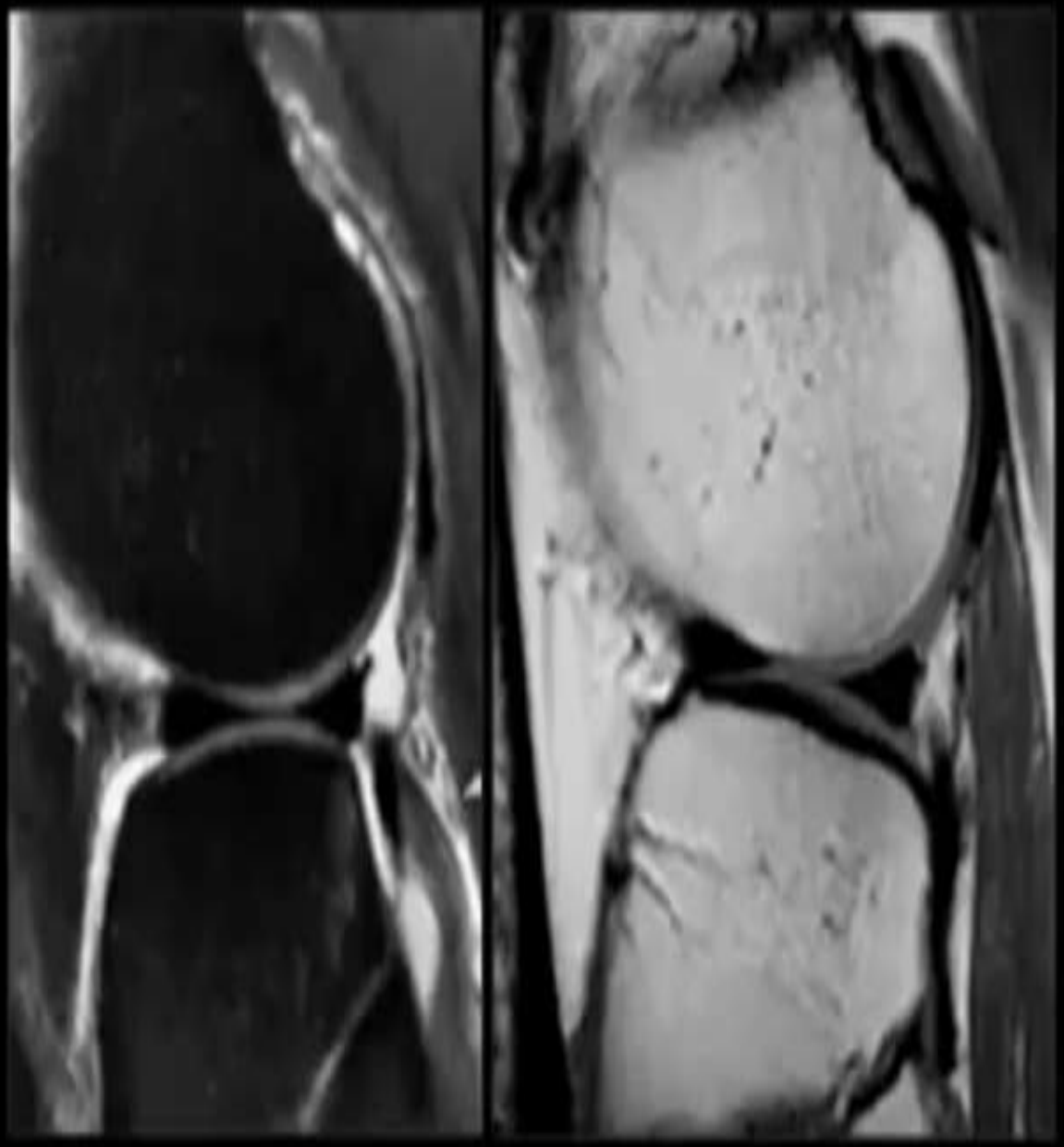
Lateral meniscus

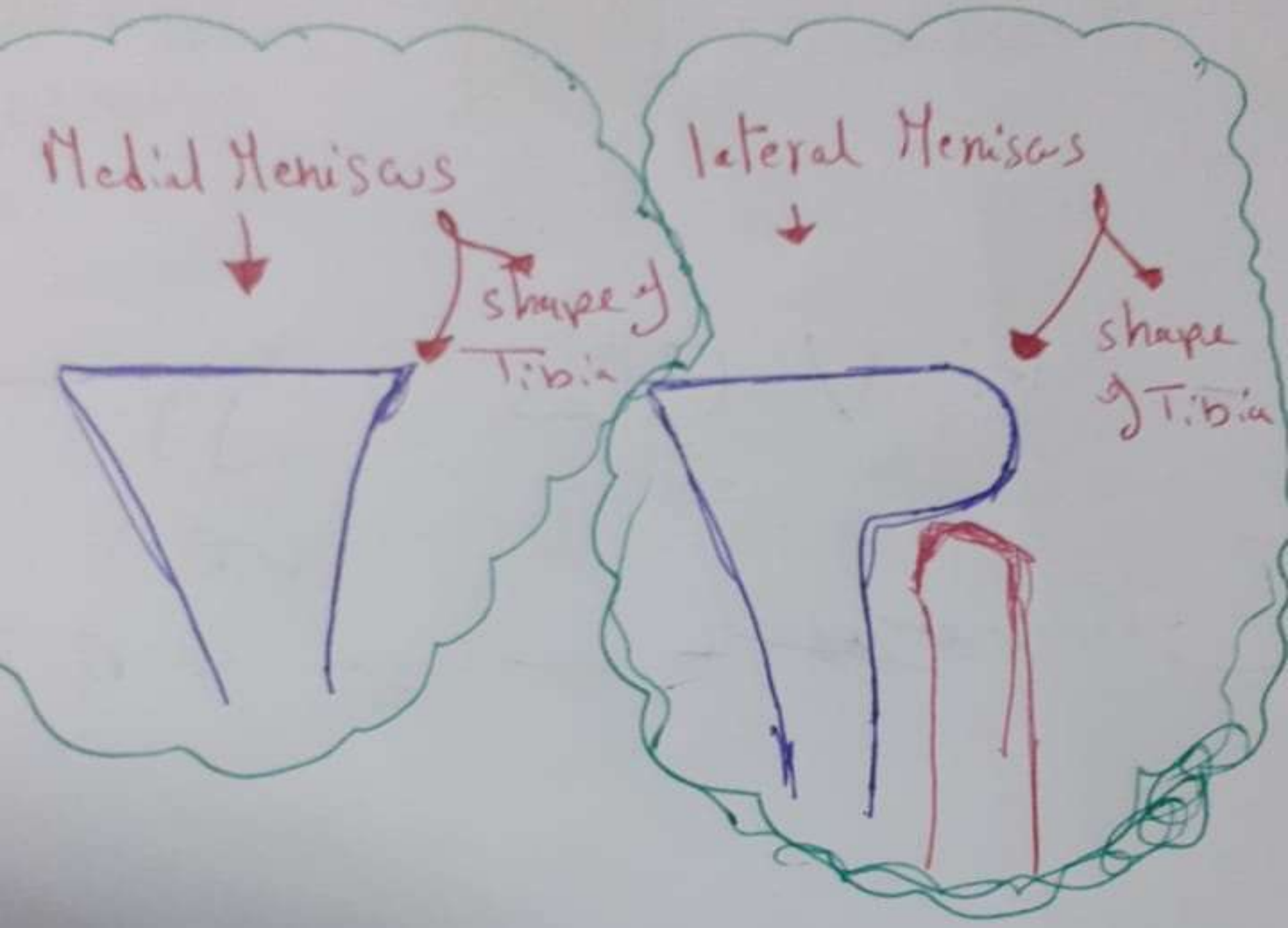
- C- shape
- Posterior and anterior horns are symmetric
- Anterior horn may be hypo plastic, extremely thin
- Discoid meniscus and meniscal cysts more common

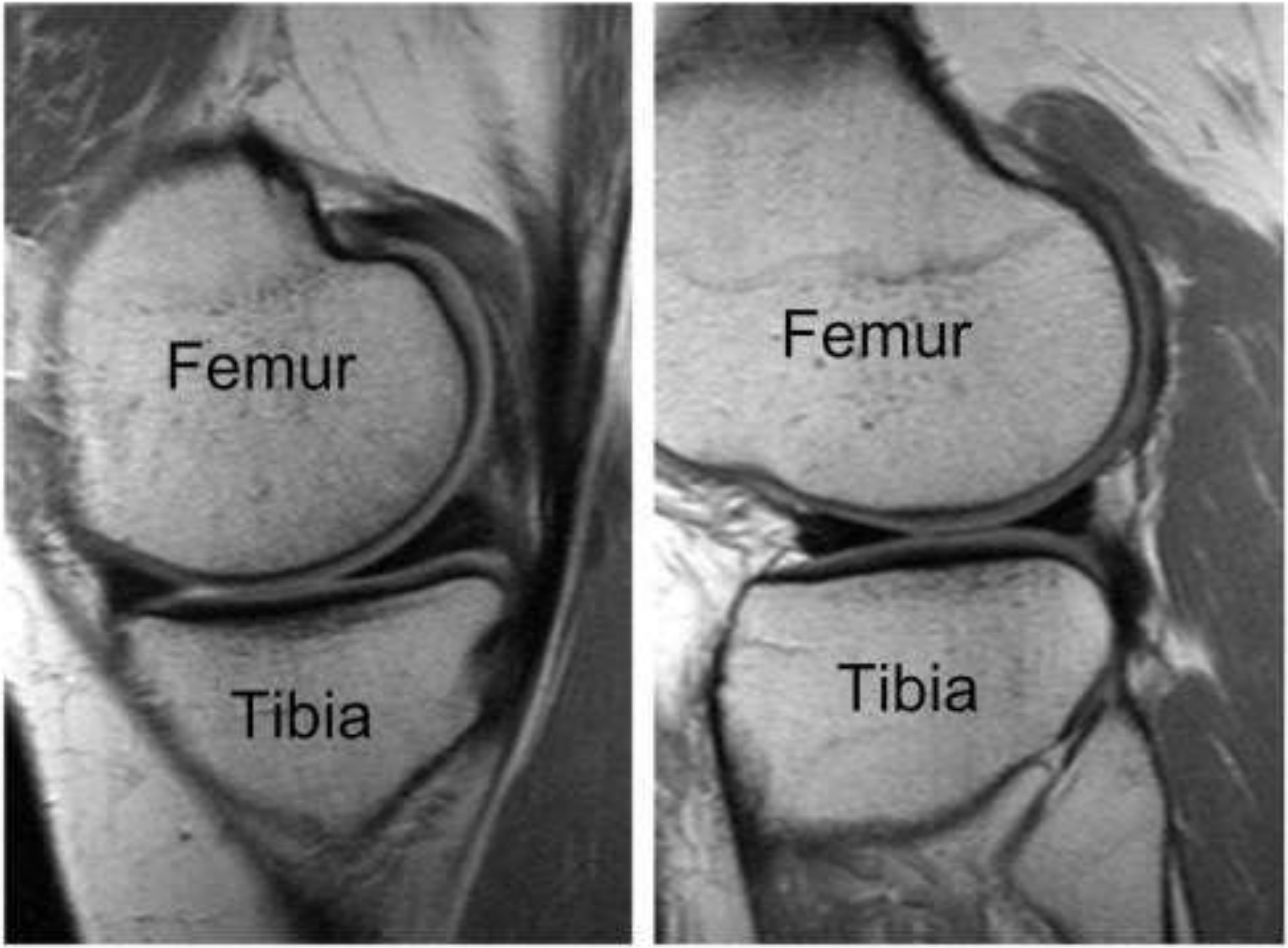




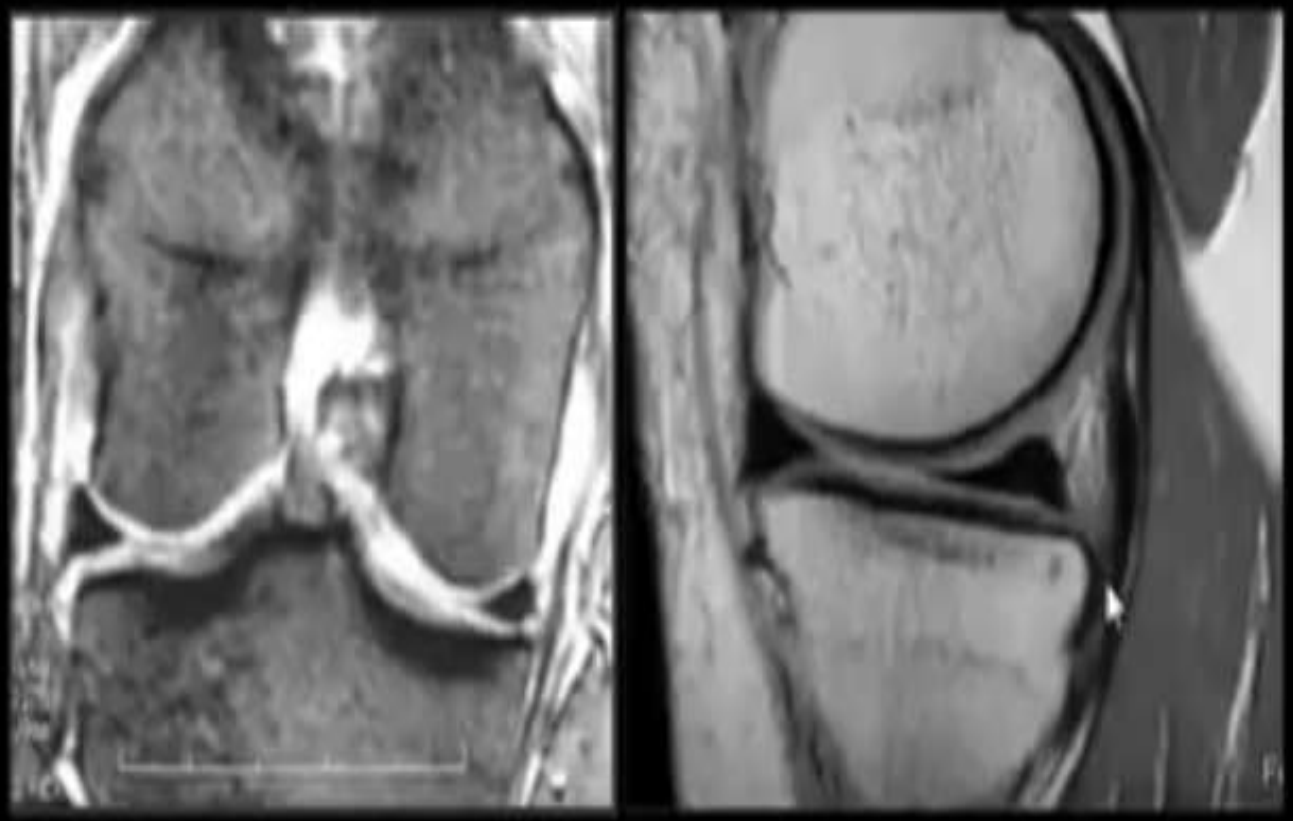





Medial Hemisacus
shape of Tibia
lateral Hemisacus
shape of Tibia

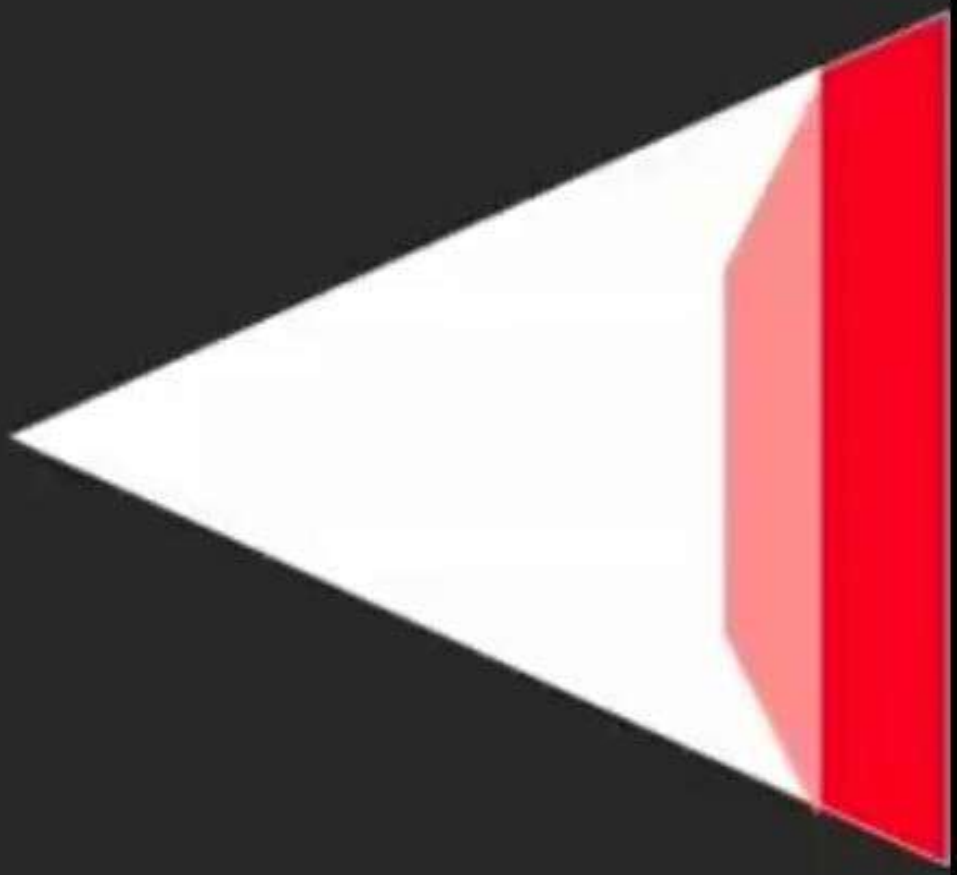

Femur
Tibia
Femur
Tibia

Meniscal horns, coronal & sagittal images

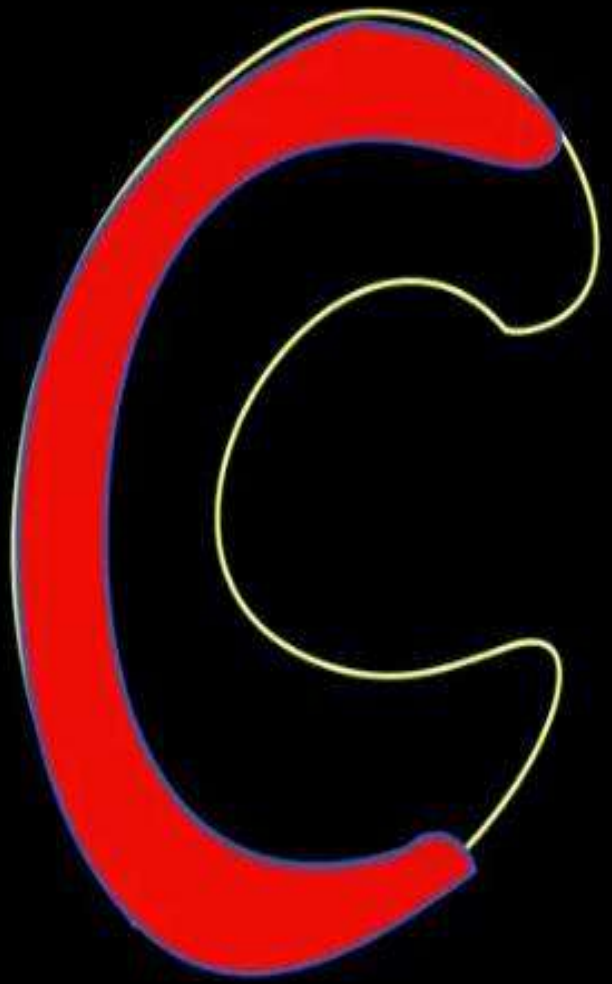


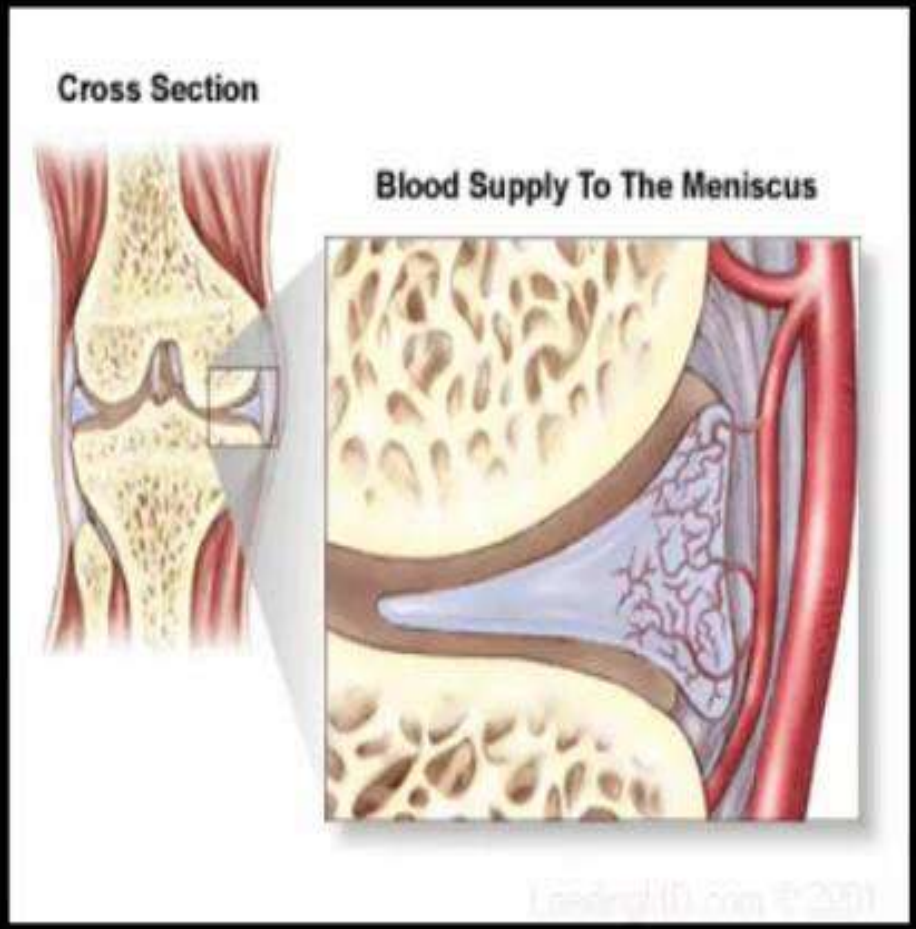
Meniscal Vascularity

- Majority of meniscus is avascular in adults
- Tears in red zone have the best chance to heal
- White zone lacks ability to heal
- Red zone MM: 10-30%
- Red zone LM: 10-25%
- Pink zone of borderline vascularity

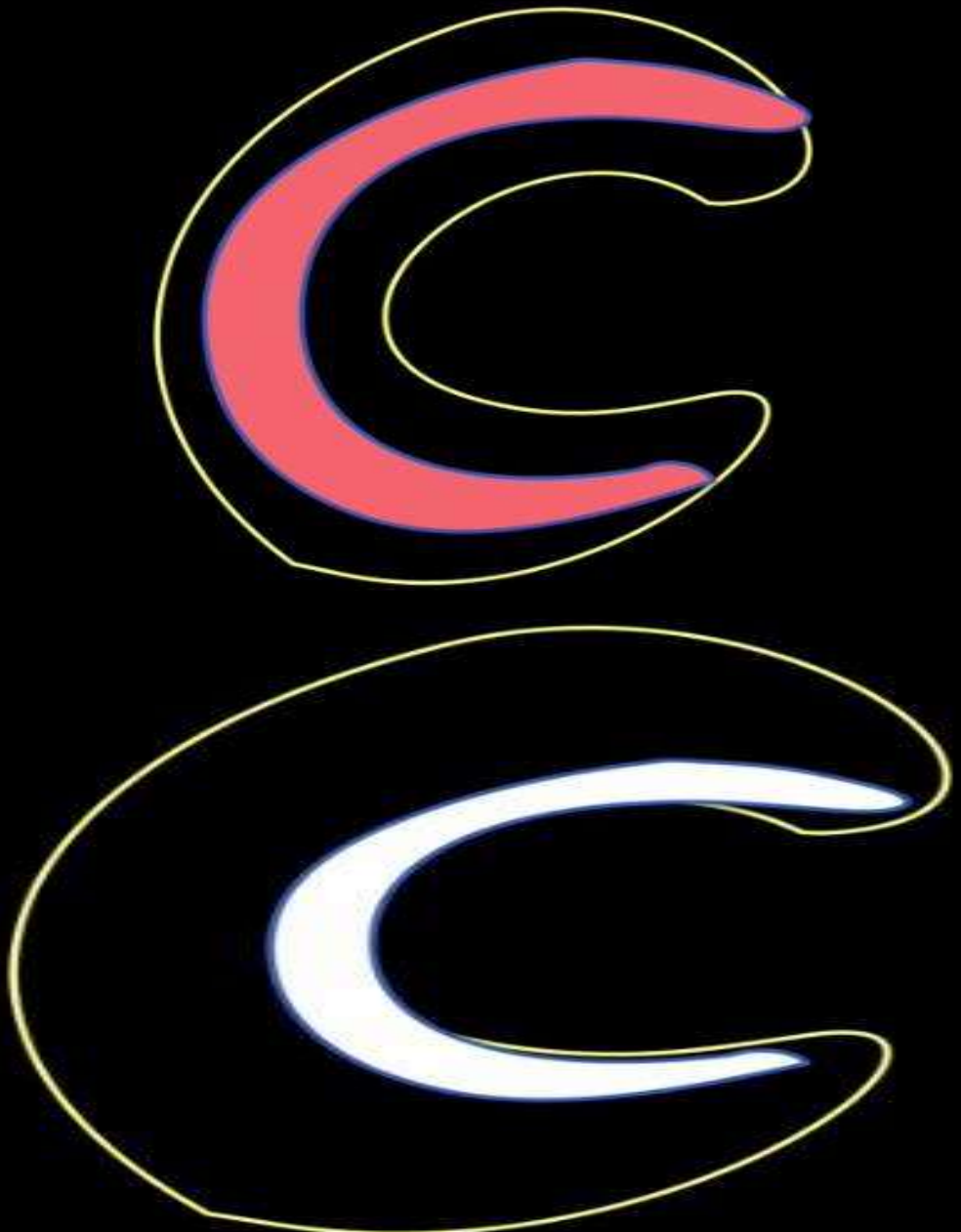


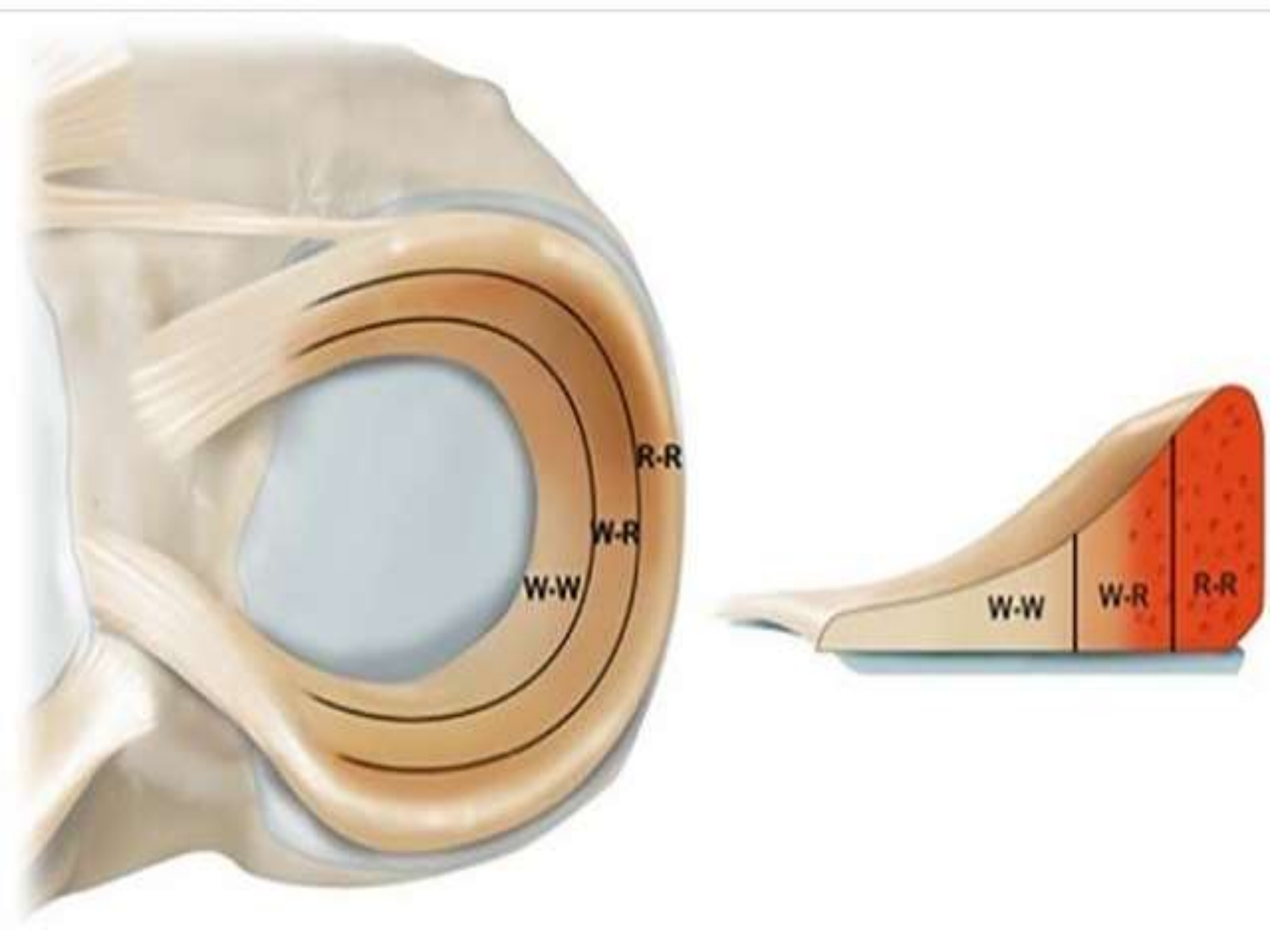
Red Zone Popliteal artery - > geniculate arteries

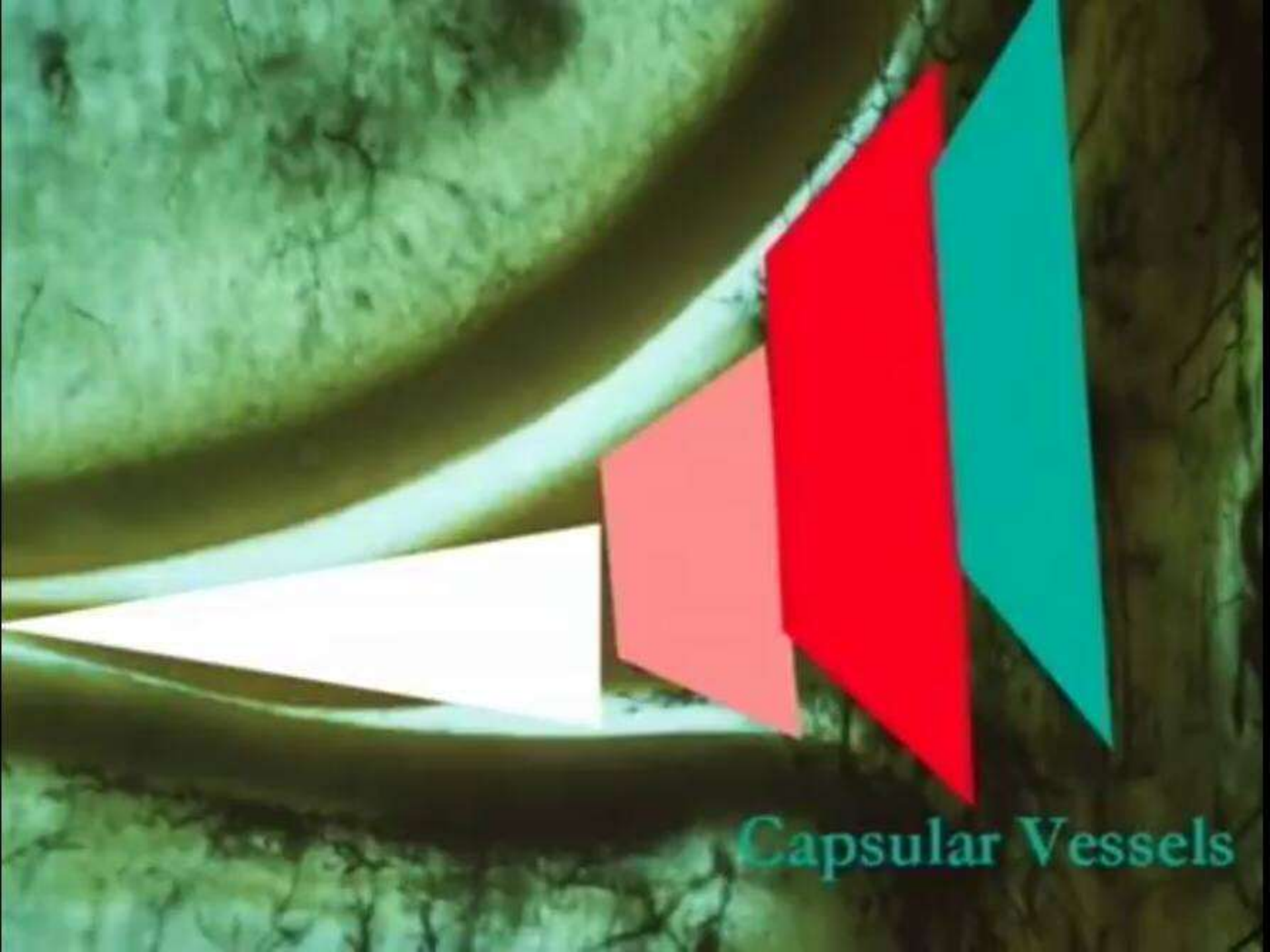




Red-white zone

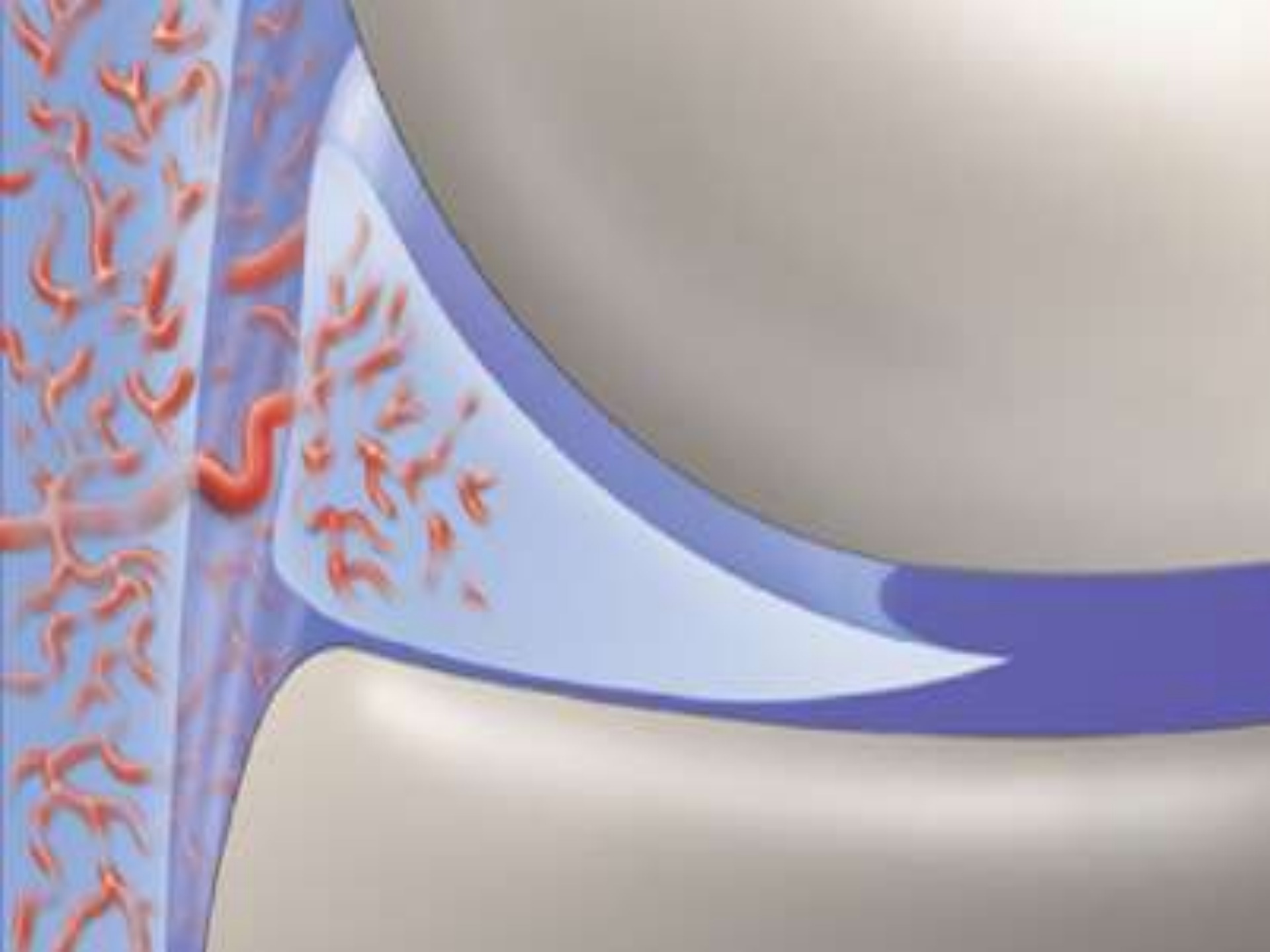



R-R
W-R
W-W
W-W
W-R
R-R


Capsular Vessels


PCP
1
2
3
F
R R R W W W
T


PCP
F
T



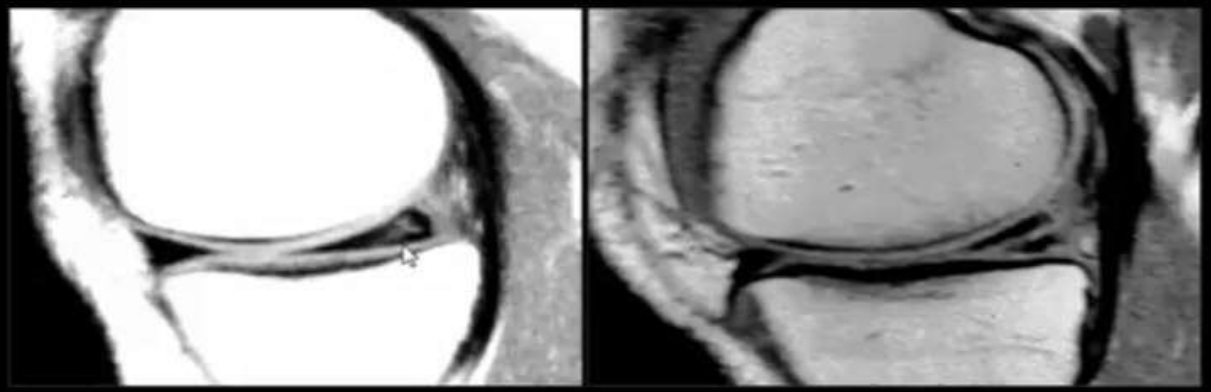
Meniscus problems

- 1-Degeneration (I,II)
- 2-Tear (simple =H,V,R),(complex=flap, B.handle, M.c separation)
- 3-Discoid (congenital)
- 4-Contusion
- 5-Extrusion

- First of All the big difference between degeneration and tear

Degeneration no touch with triangle lines

Tear touch triangle lines



1- Degeneration types

- Grade 1 ~~~ just a point
- Grade 2 ~~ line

Type I

Grade I meniscal degeneration

2-Tear types

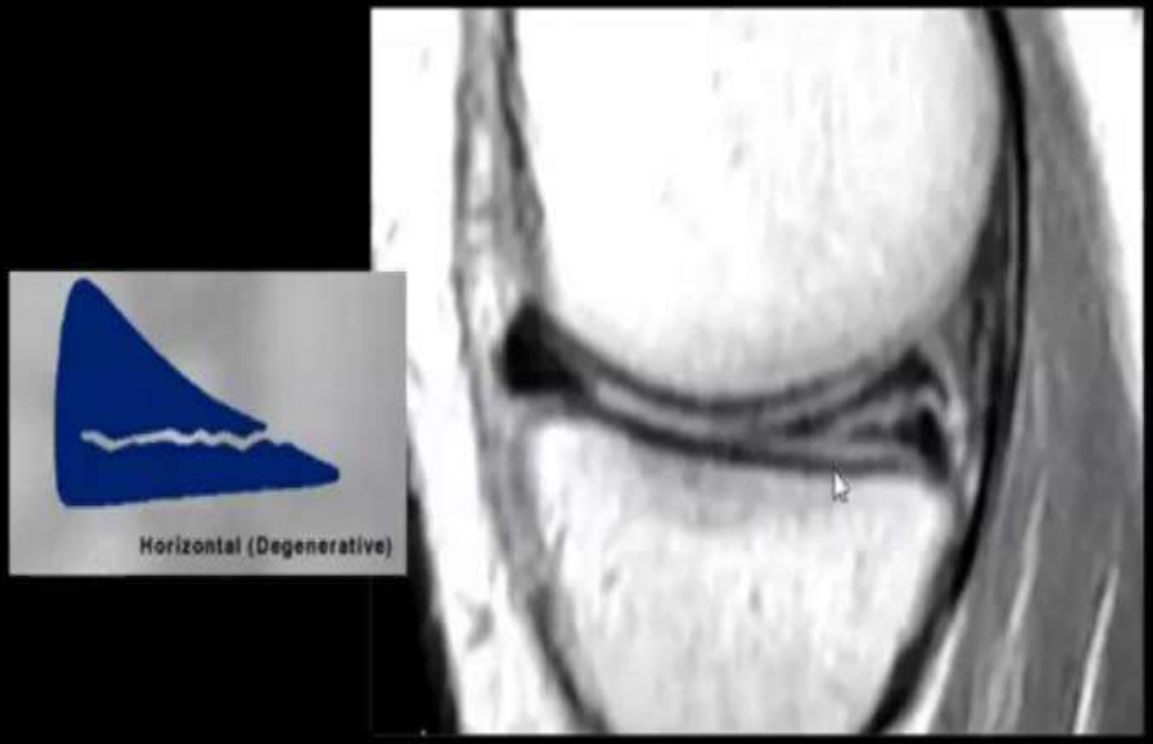
-simple tear

- Horizontal (degenerative tear) secondary to type 2 degeneration divides the meniscus in half and runs parallel to the tibial plateau

- Vertical (post traumatic) oriented perpendicularly to the tibial plateau. It may be longitudinal (follow the long axis of the meniscus)

- Radial (Root) perpendicular to the long axis of the meniscus

Horizontal degenerative tear



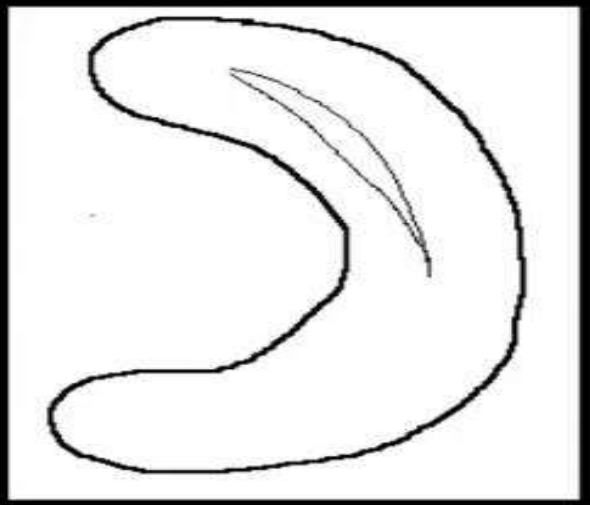
Horizontal (degenerative tear)treatment

- According to site of lesion

Vertical(traumatic tear)

Longitudinal-Vertical

- Inner and outer segments
- Younger patients with trauma
- Highly associated with ACL tears



Causes?

- **Mechanism:** The menisci follow the tibial condyles during flexion and extension, but during rotation they follow the femur and move on the tibia; consequently, the medial meniscus becomes distorted.

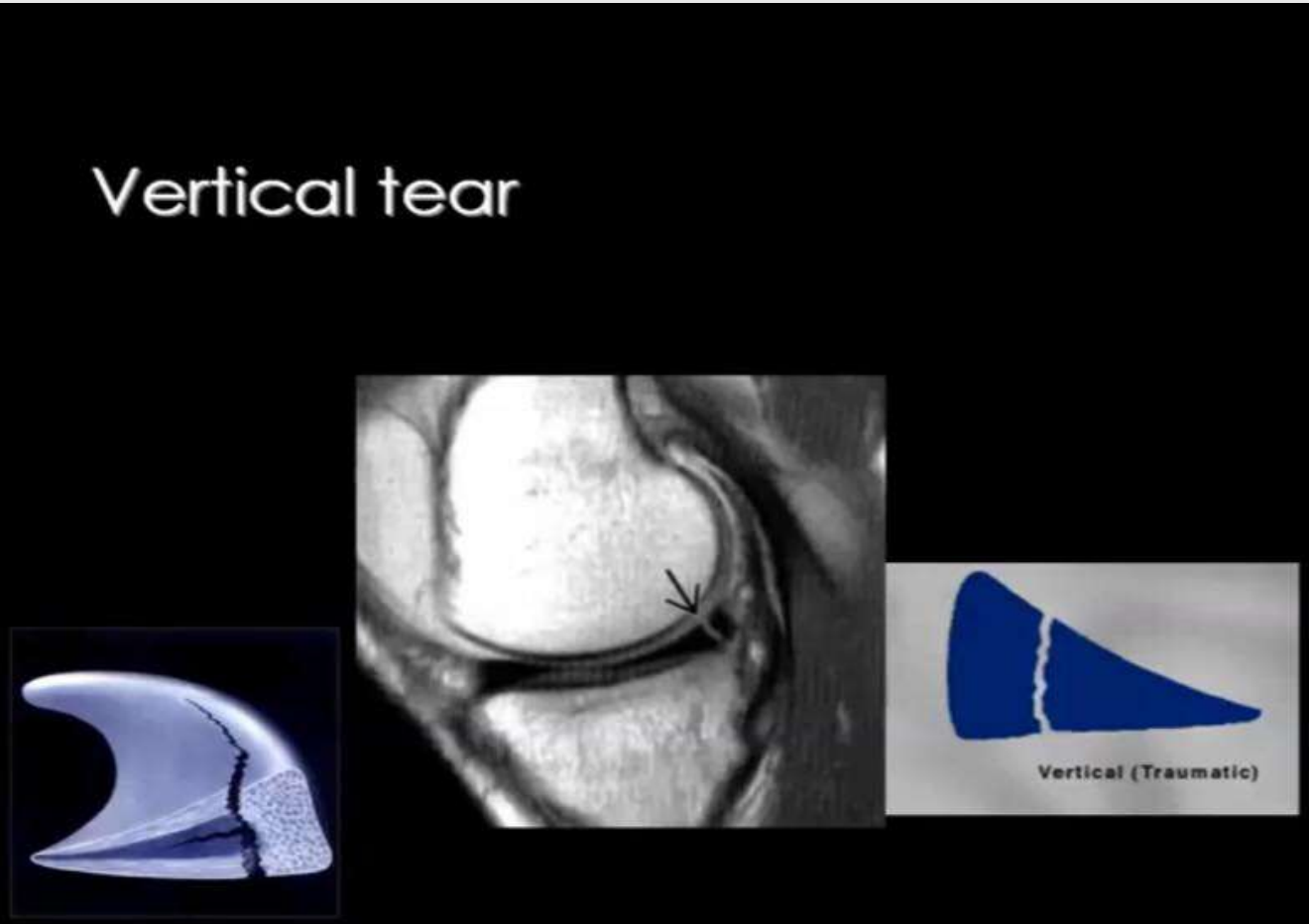
- During vigorous internal rotation of the femur on the tibia with the knee in flexion, the femur tends to force the medial meniscus posteriorly and toward the center of the joint
- The posterior part of the meniscus is forced toward the center of the joint, is caught between the femur and the tibia, and is torn longitudinally when the joint is suddenly extended.
- **Most common location**: posterior horn of meniscus
- **Most common type**: longitudinal

Vertical(traumatic tear)

Vertical tear commen with ACL tear


RONALDO
7

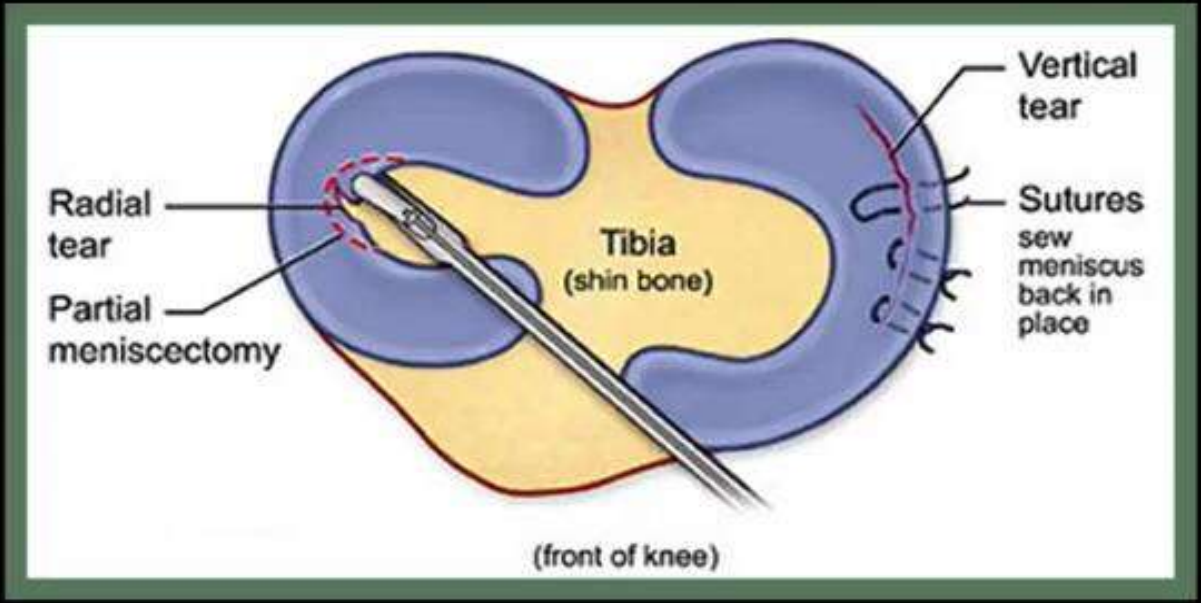
Vertical(traumatic tear) MRI



Vertical(traumatic tear) treatment

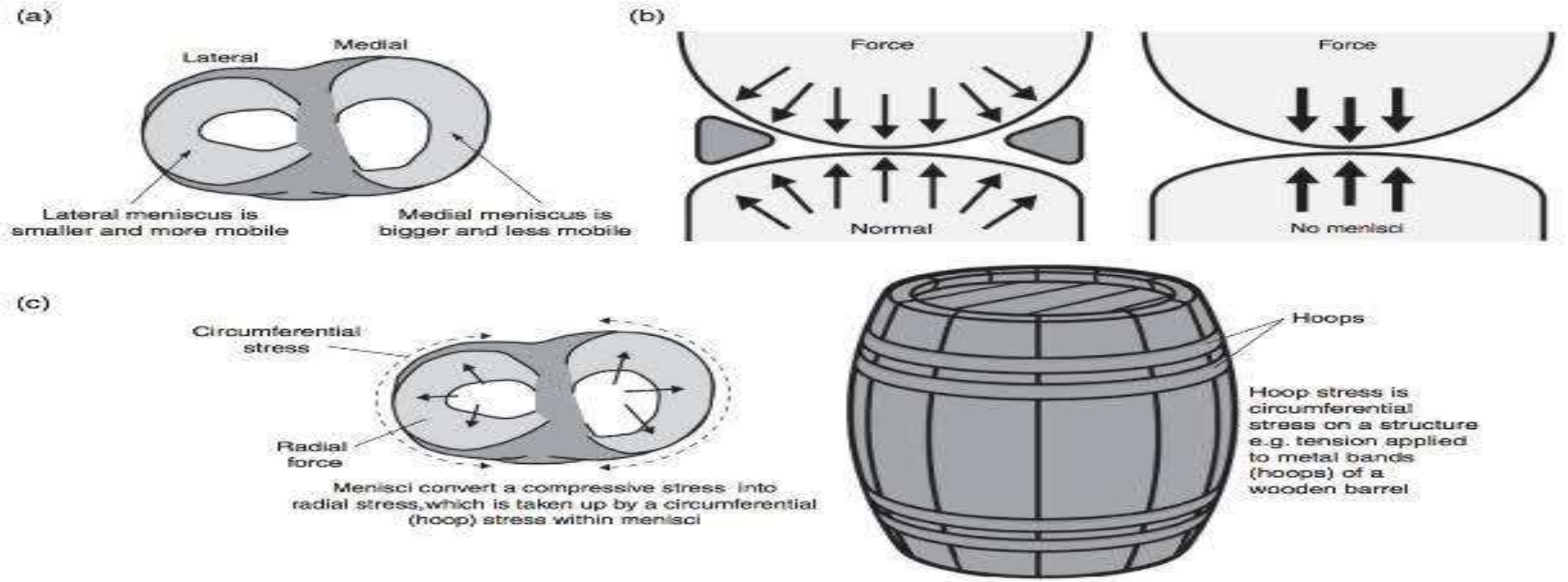
Repair (R number 2)

- Posttraumatic vertical peripheral tears at or near the joint capsule in patient < 40



Radial tear

- perpendicular to the long axis of the meniscus

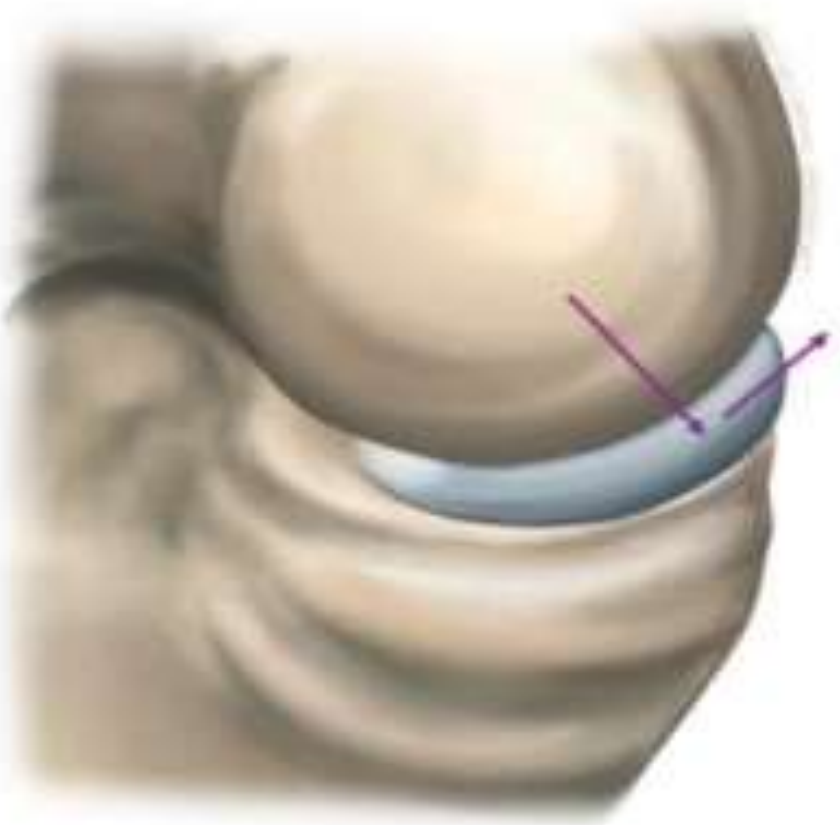


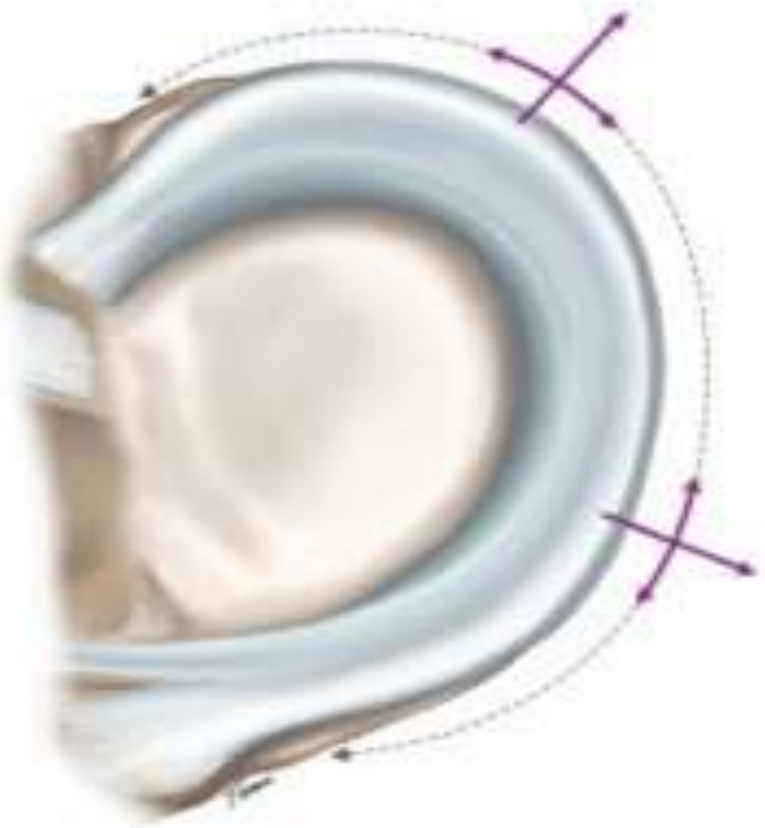
Compression to radial to be contained by the Menx

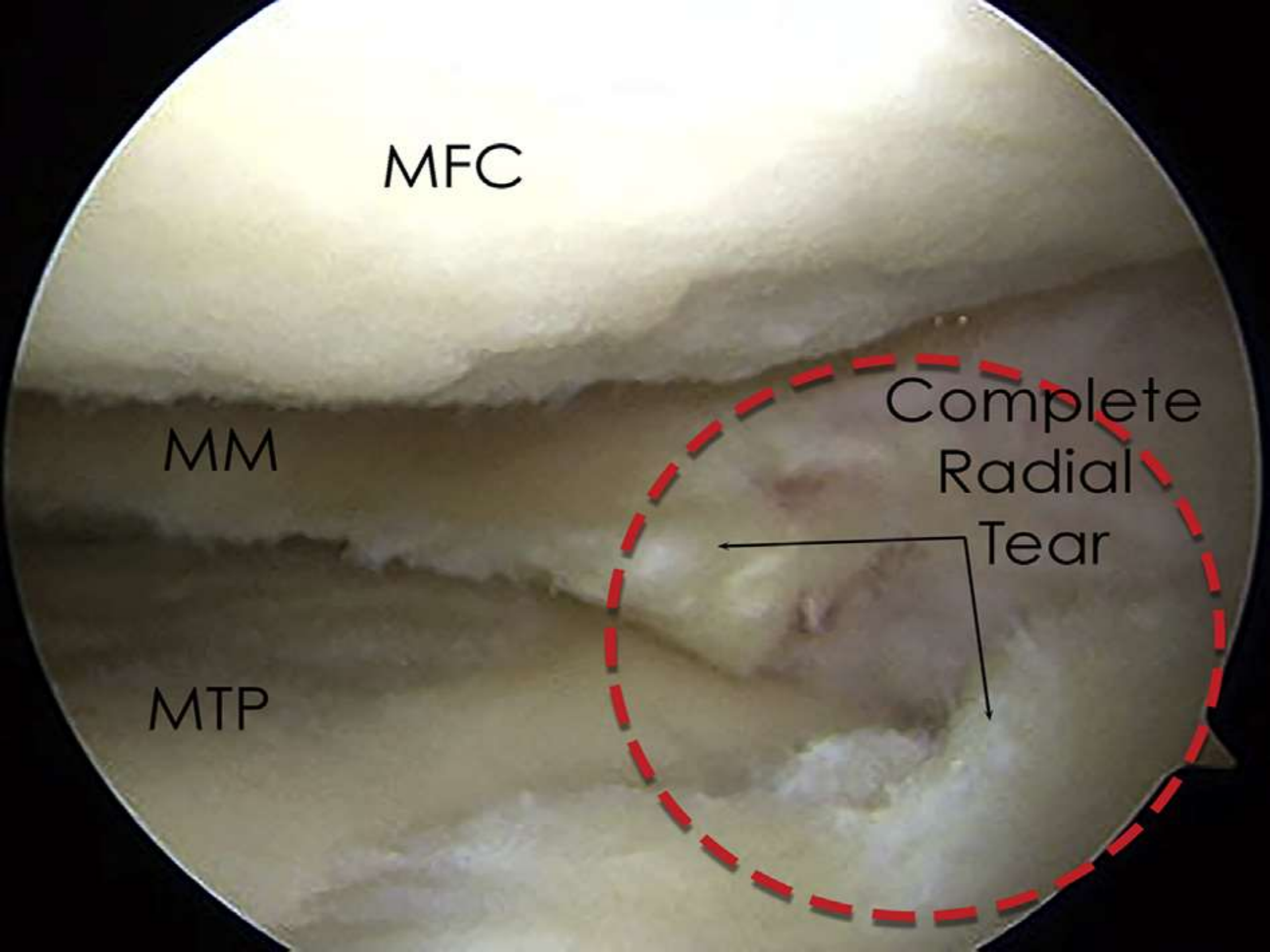
NB

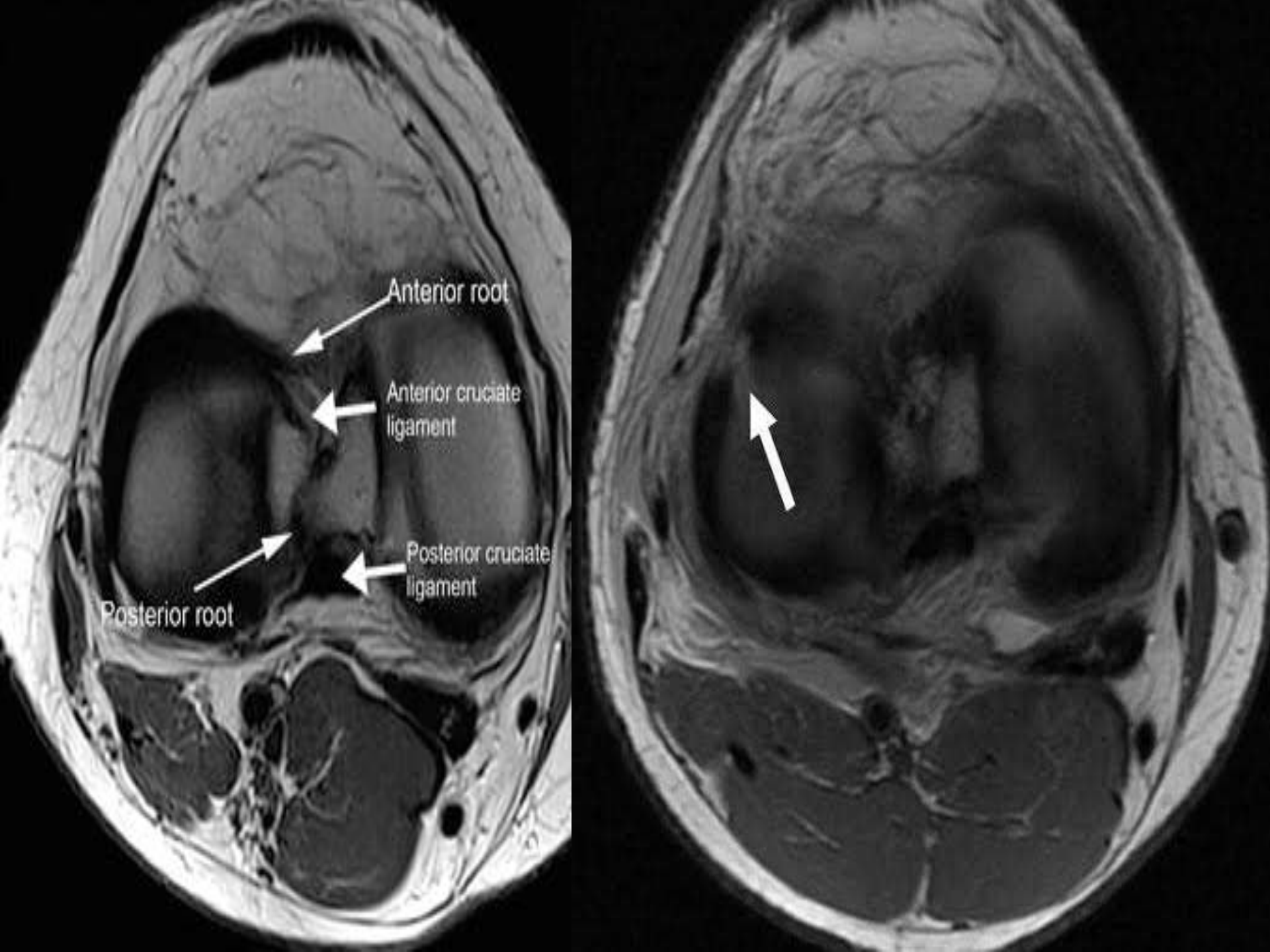
- The most important function for the prevention of arthritis in the knee is the maintenance of this ‘hoop tension’ in the meniscus
- The medial meniscus transmits approximately 90% load on the medial side and the lateral meniscus is approximately 70%·Therefore, the menisci will spare the cartilage from bearing 100% of the bodyweight

Hoop stress






MFC
MM
MTP
Complete
Radial
Tear


Anterior root
Anterior cruciate ligament
Posterior cruciate ligament
Posterior root

Root tear

- Meniscal root injuries can be considered as a catastrophic injury to the meniscus in the athlete, as damage to the root will significantly alter the ability of the meniscus to absorb and distribute load due to loss the ‘hoop stress’ mechanism.
- **It is one of the difficult injuries to diagnose on clinical examination; therefore specific MRI features are usually needed to diagnose the injury prior to a knee arthroscopic investigation**

Root tear causes

- In deep squats from 90 degrees onwards, the posterior horns of the medial and lateral menisci transmit more load than the anterior horns (the posterior root of the medial meniscus has the least mobility of all the meniscus roots), and studies have reported that the stress placed upon the posterior medial root results in a higher incidence of tears compared with the other roots

Root tear

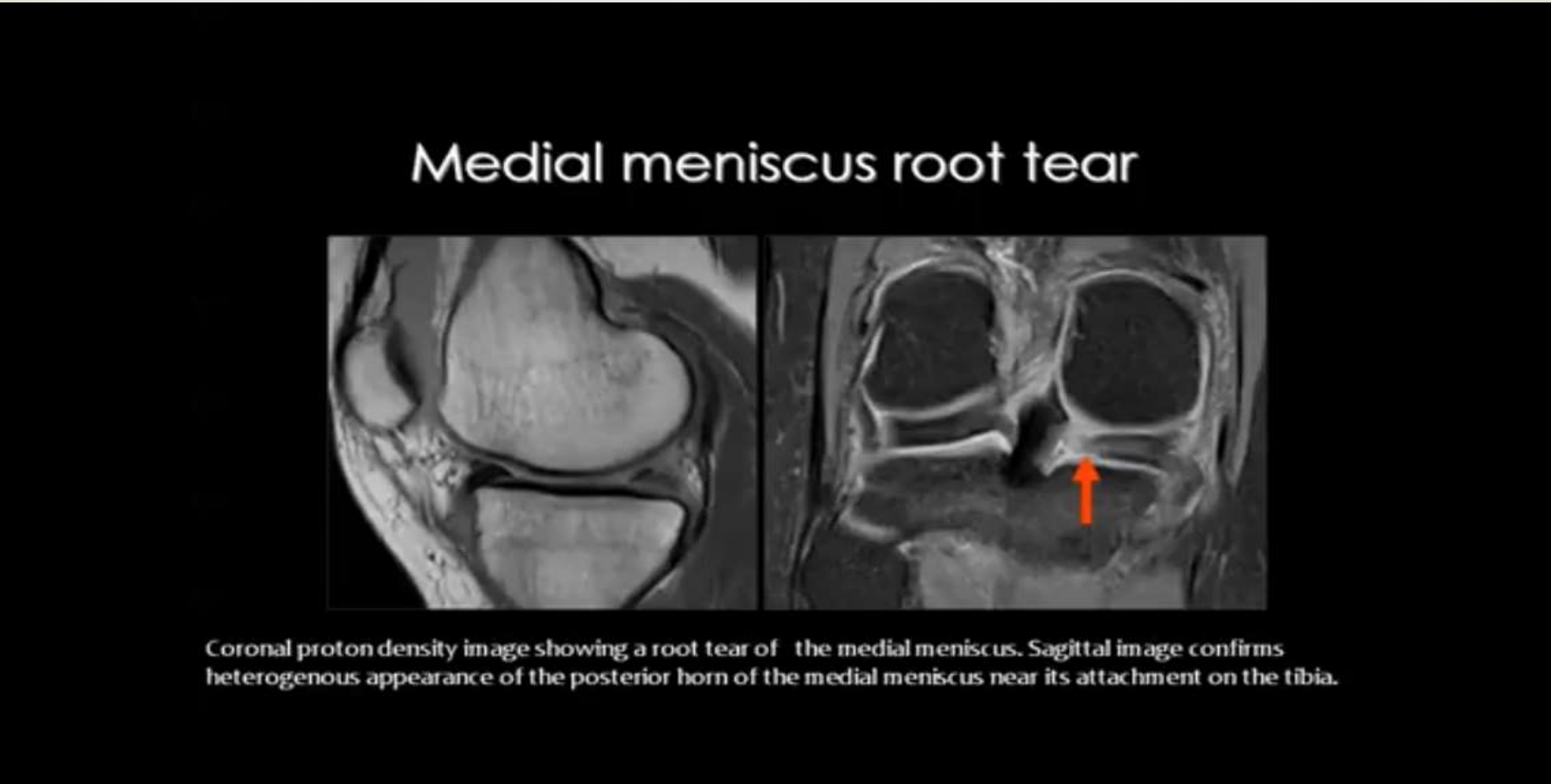

Tampa B

Root tear


Vertical tear of the free edge of the meniscus [Root tear]
Ghost meniscus

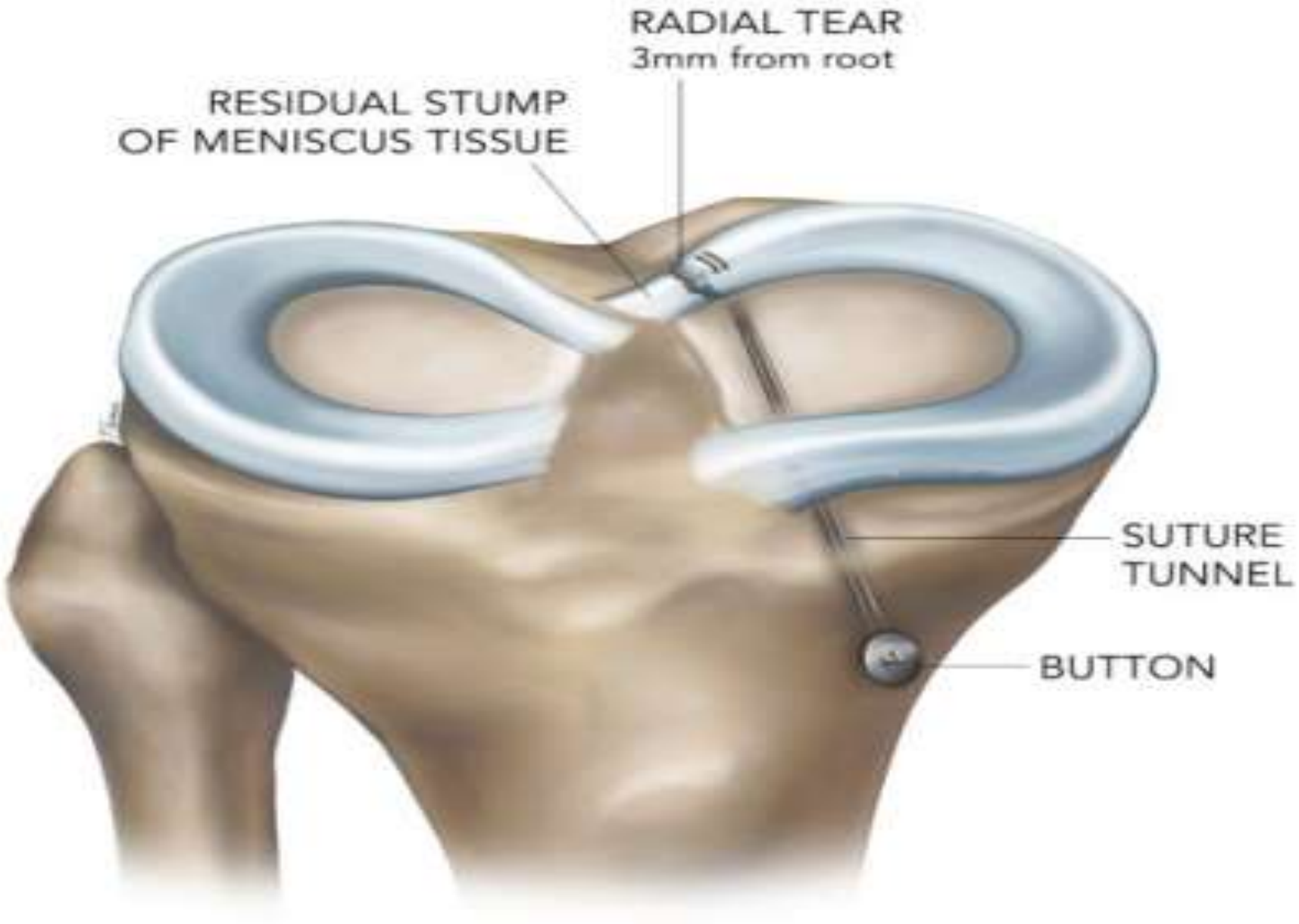
Root tear MRI

Root tear MRI



Root tear treatment

- *In a recent study, it was reported that 35% of patients who received meniscectomy required revision surgery using total knee arthroplasty , however in those who received meniscal repair none required revision surgery*
- ***The arthroscopic pull-out repair** provides better clinical and radiographic outcomes in the long-term than partial meniscectomy (has a higher potential to completely heal the meniscus that facilitates the ability of the meniscus to convert axial load into hoop stress)*

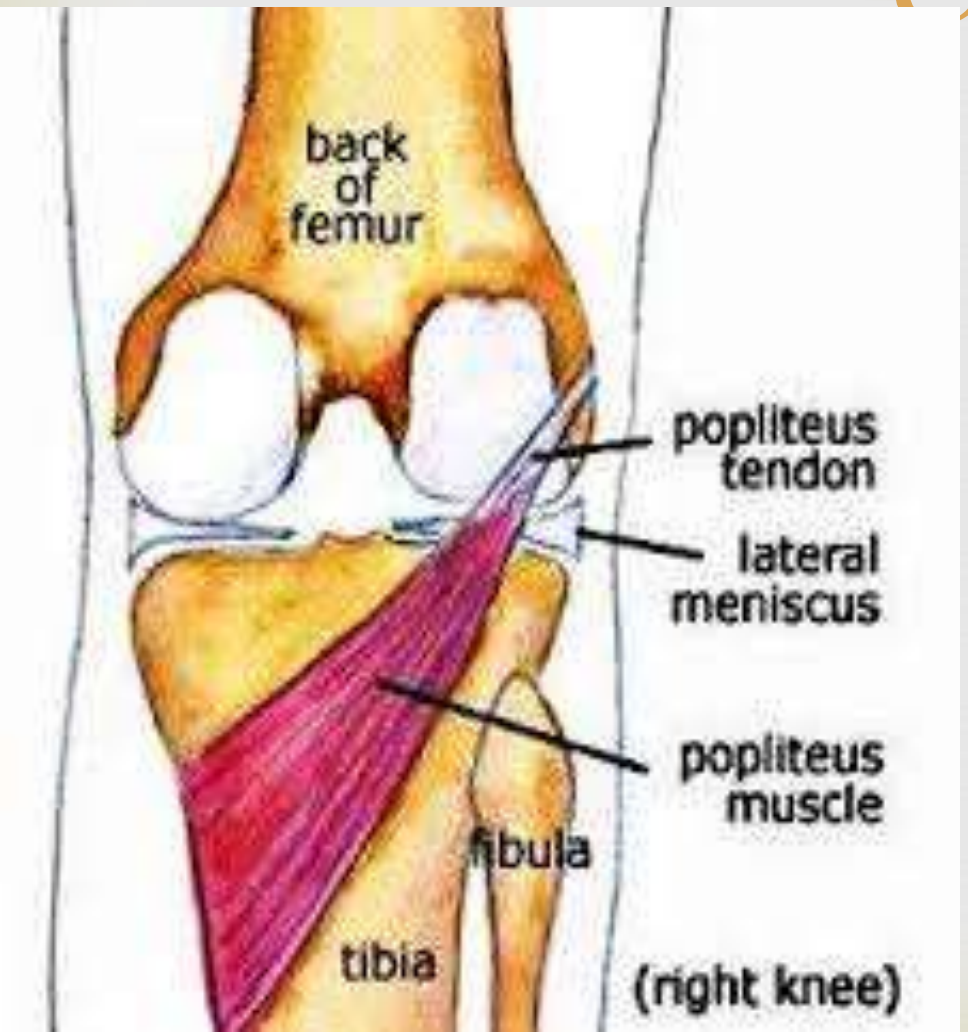

RADIAL TEAR
3mm from root
RESIDUAL STUMP
OF MENISCUS TISSUE
SUTURE
TUNNEL
BUTTON

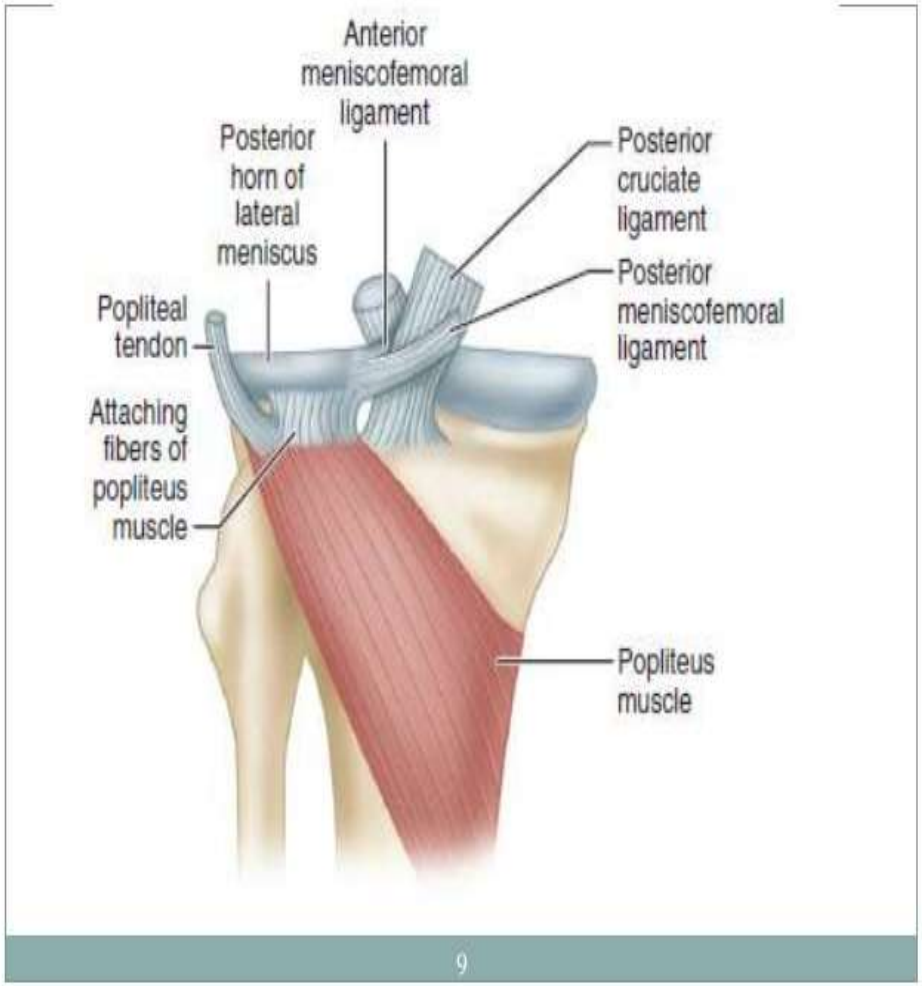
Root tear rehab tricks

1-Avoid cyclic loading that may loosen the root repair for 6 w to reduce risk of meniscal extrusion

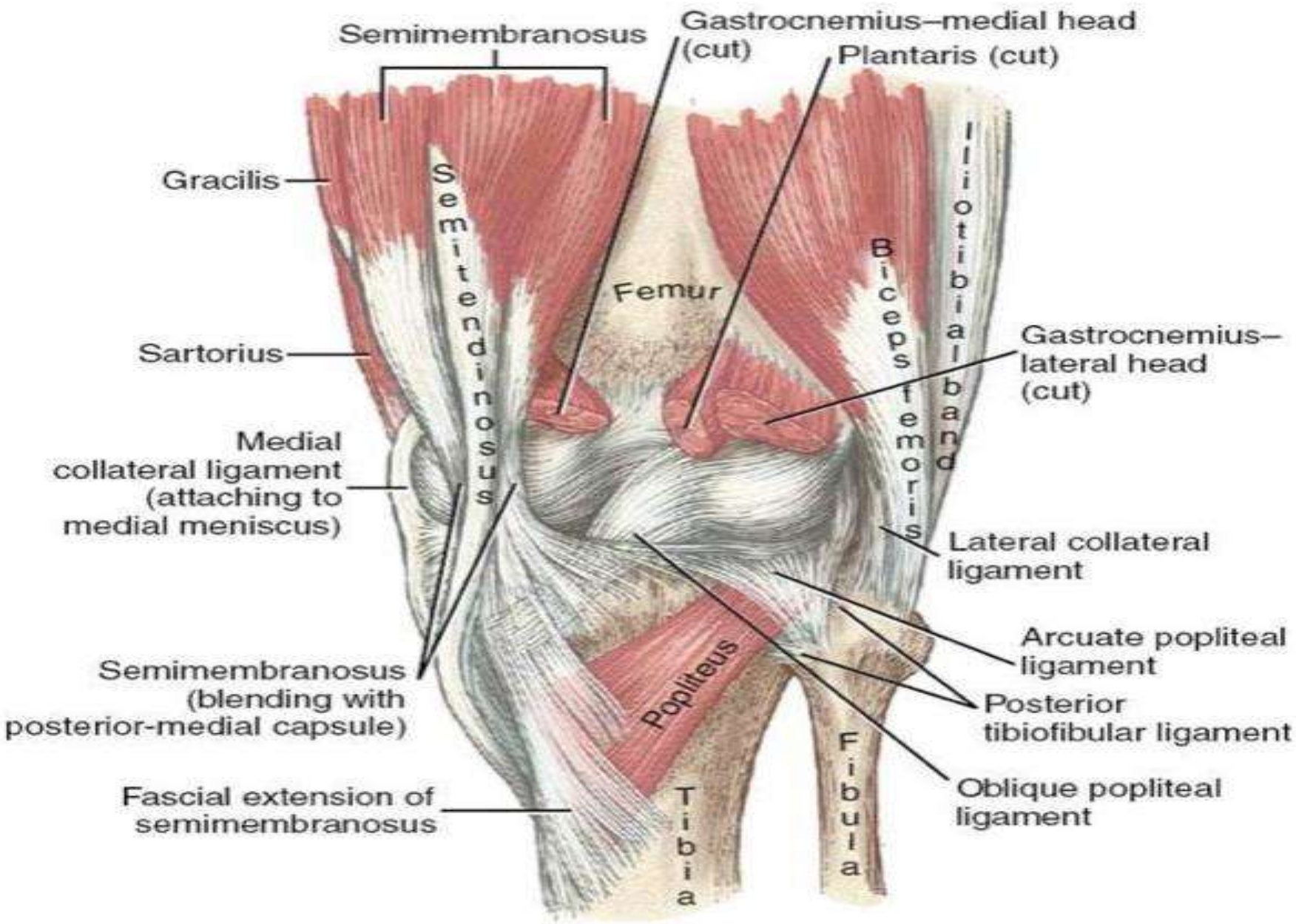
2-wear a straight-leg brace for six weeks to provide protection in the event of a fall, and to prevent them from holding their knee in flexion during gait (which would activate the hamstrings and popliteus , and potentially impart stress to the meniscal root).

- Popliteus attach to lateral meniscus via Aponeurosis
- Semimembenosis attach indirectly to medial meniscus via capsule





Posterior view



Root tear rehab tricks

- *It is important to avoid any active knee flexion ranging in the first six weeks to avoid the hamstring and popliteus pulling on the meniscus (due to their attachment onto the meniscus)*

Complex tear

- Flap (horizontal & vertical)
- Bucket handle

Bucket handle tear

The torn part inter intercondylar notch if it is loose body

How to diagnose it in MRI?

1-In medial meniscus (commen) PH = or < AH

2- by Double Pcl sign

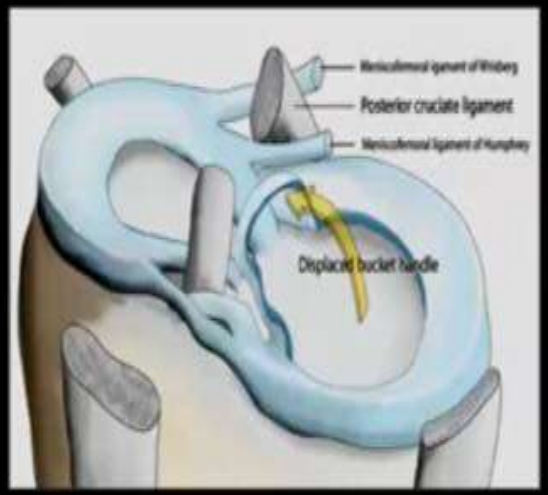
In Lateral Meniscus are rare and we called it flipped meniscus (double delta sign)

Because at it pH run anterior to AH as it is not attach to capsule firmly like MM

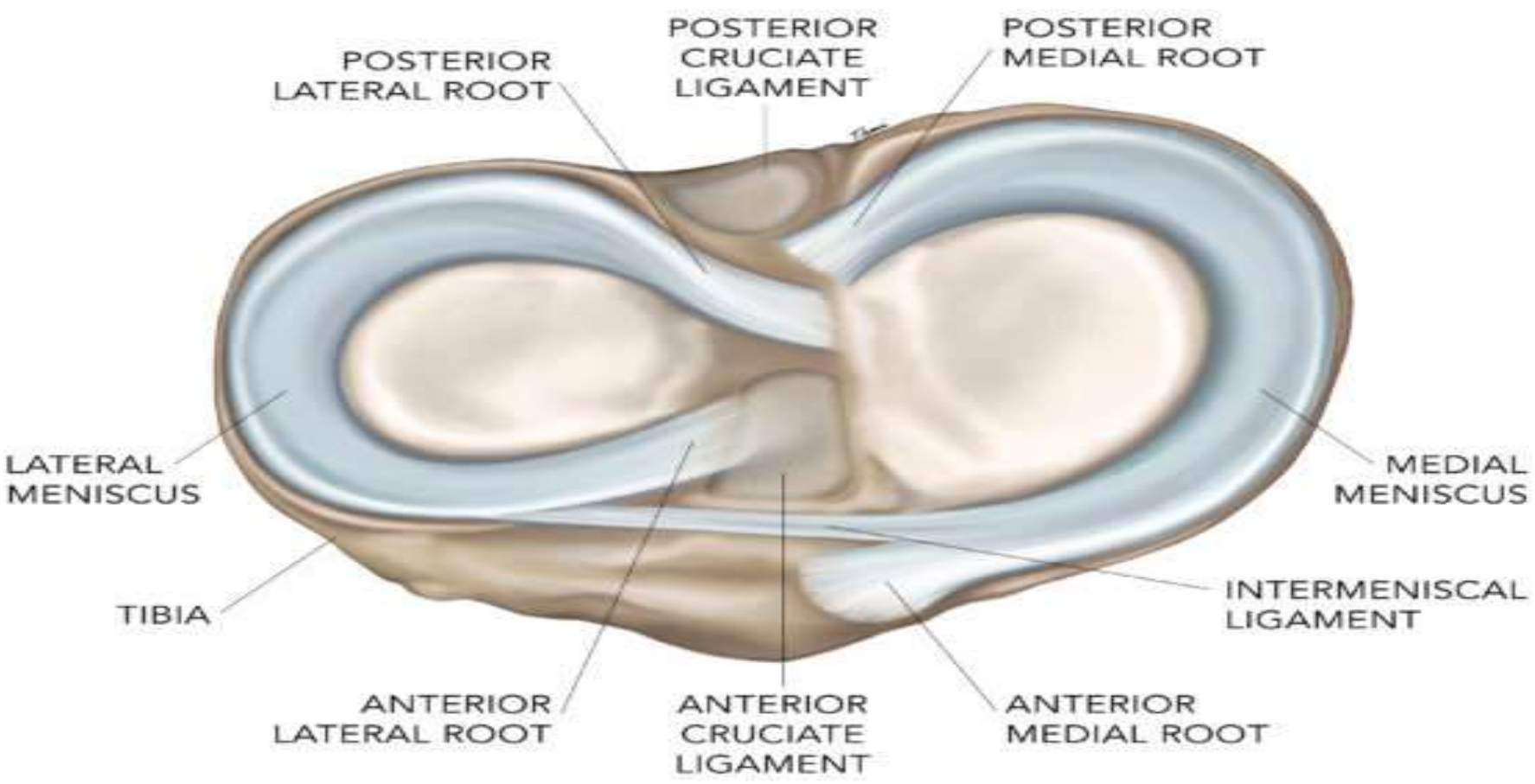
The most differential sign ??

- Lock of the knee as the torn part if involved medially specially if it is torn will enter intercondylar notch lead to distribution of normal flexion & extension mechanics

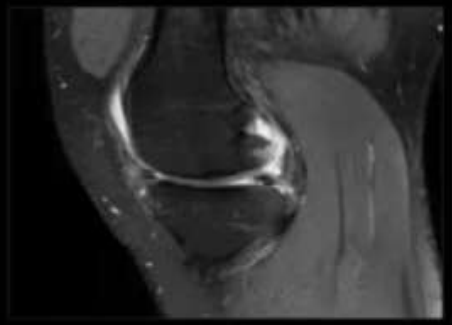
Bucket handle tear

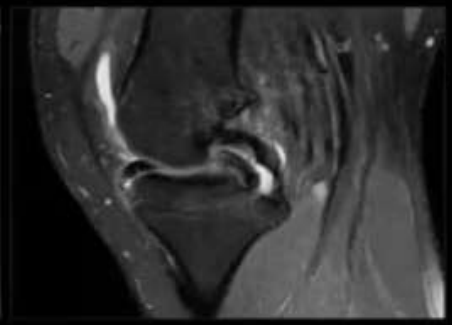


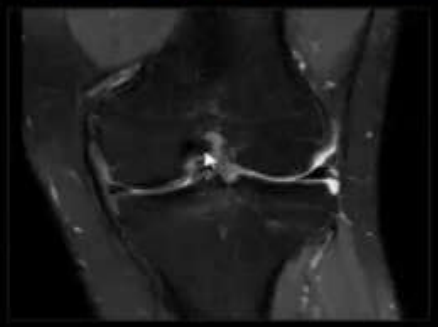
Meniscus fragments must be actively searched for in the common locations of displacement



Bucket Handle Tear

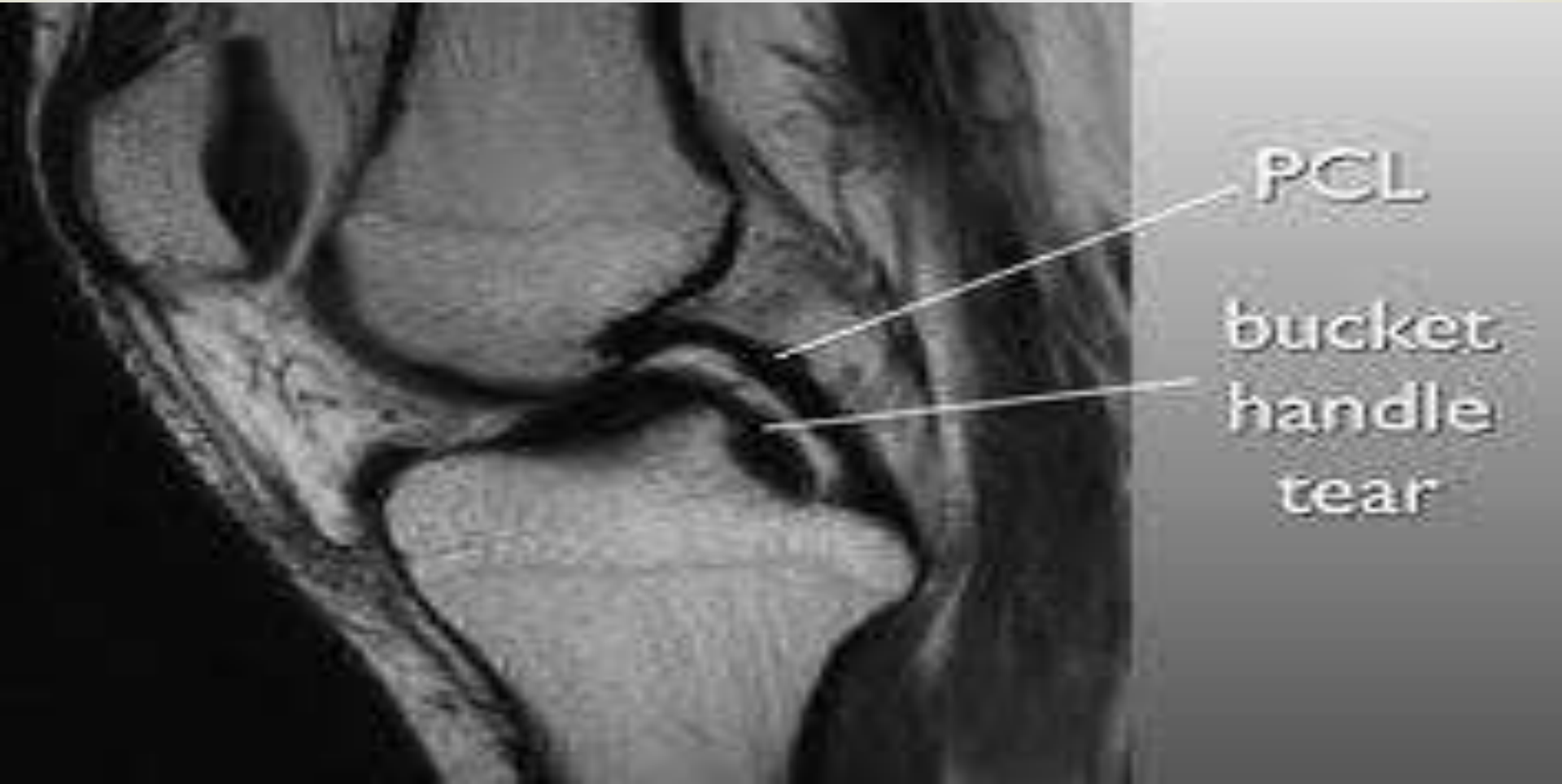




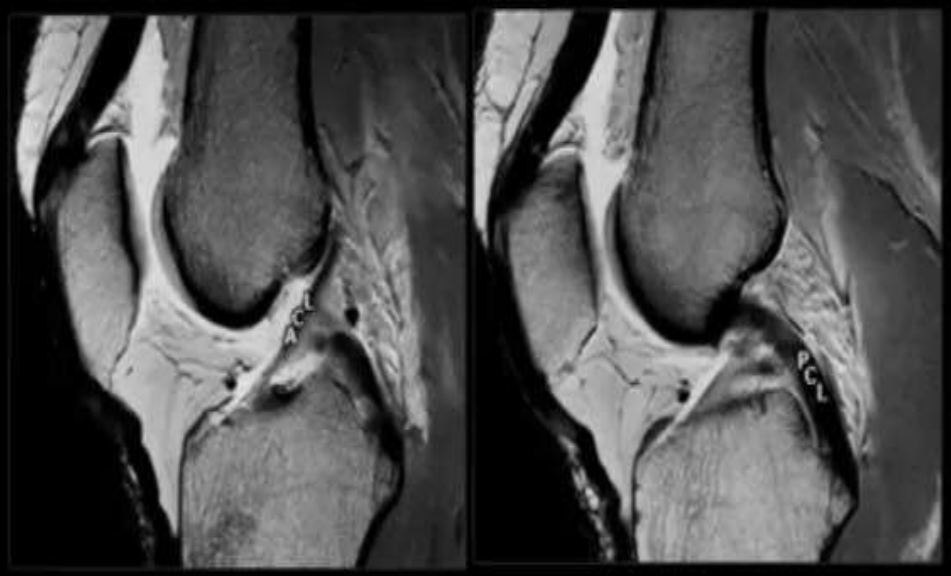


Bucket handle tear

Bucket handle MM



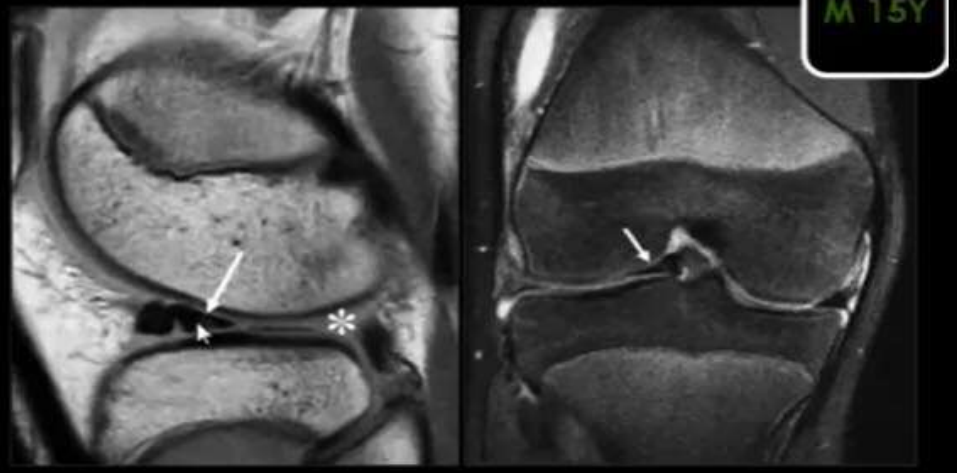
Cruciate ligaments, ACL & PCL



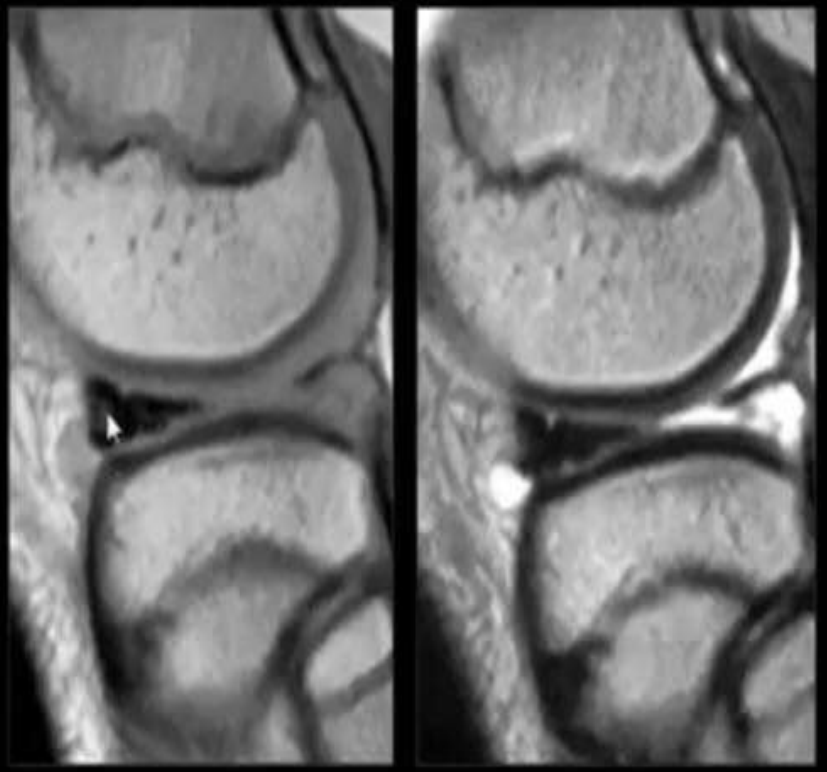
Bucket handle LM

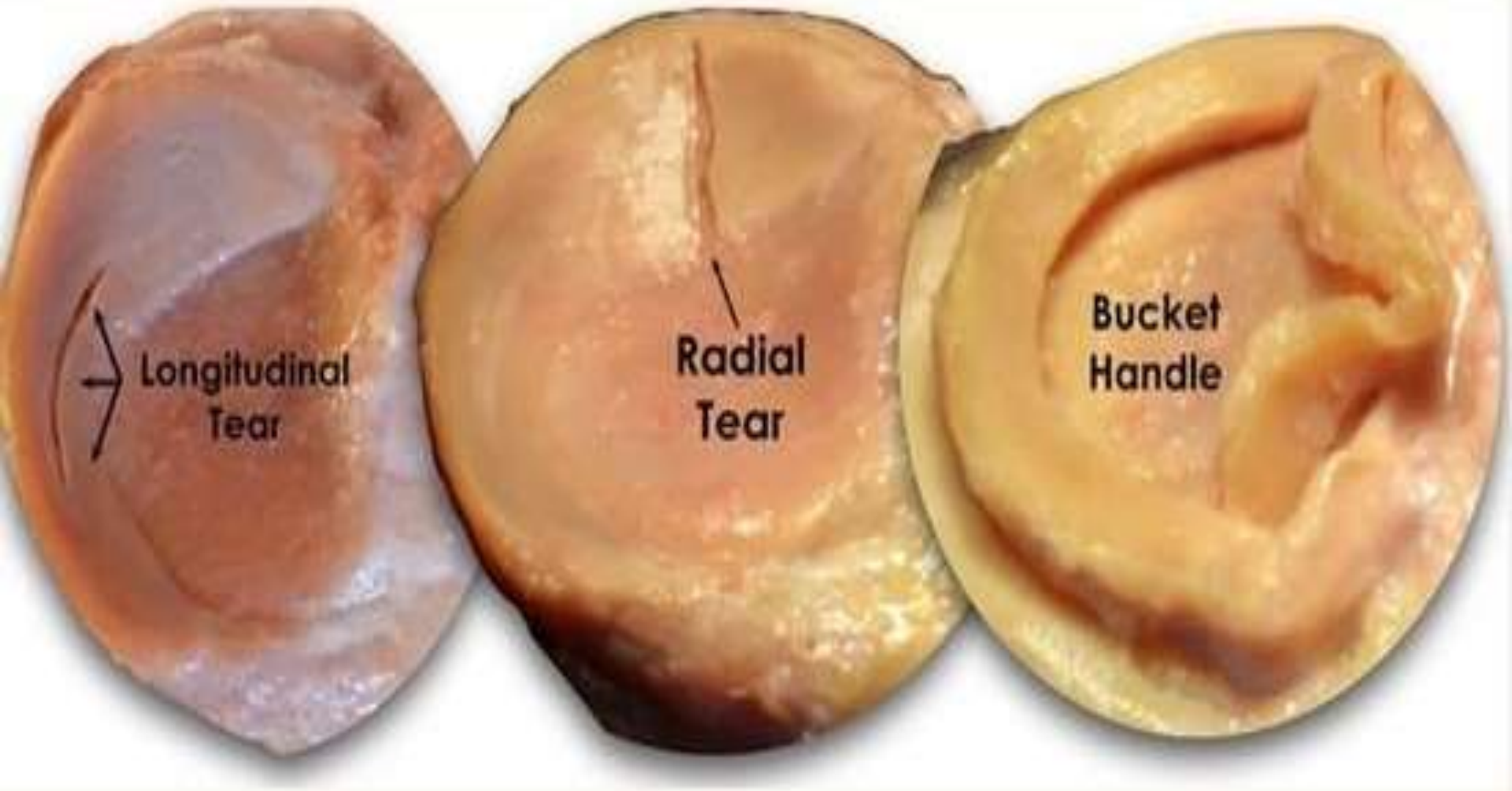
Flipped meniscus

Coronal fat suppressed PD-WI shows medially displaced lateral meniscal fragment . On the sagittal image the posterior horn of the lateral meniscus is missing seen just behind the anterior horn of the meniscus (flipped meniscus).



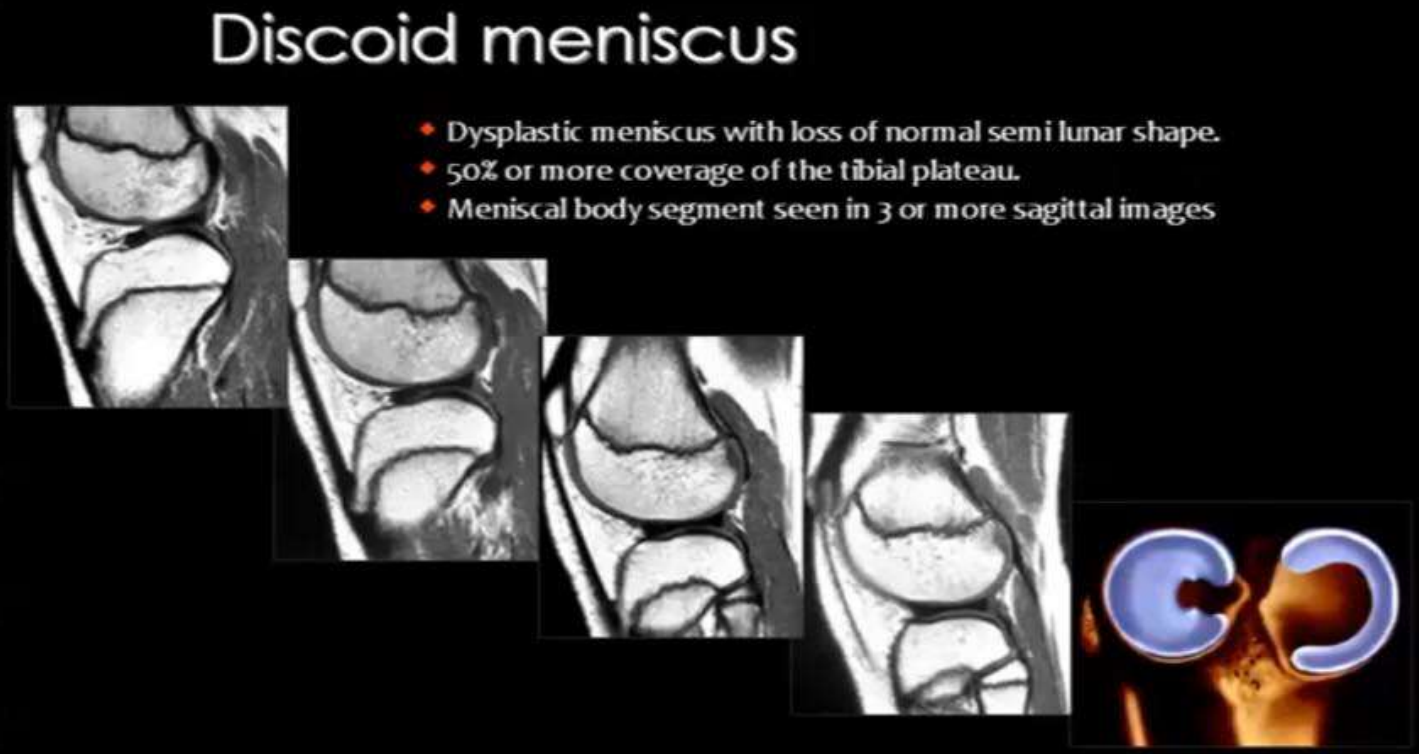
Bucket handle tear , lateral meniscus



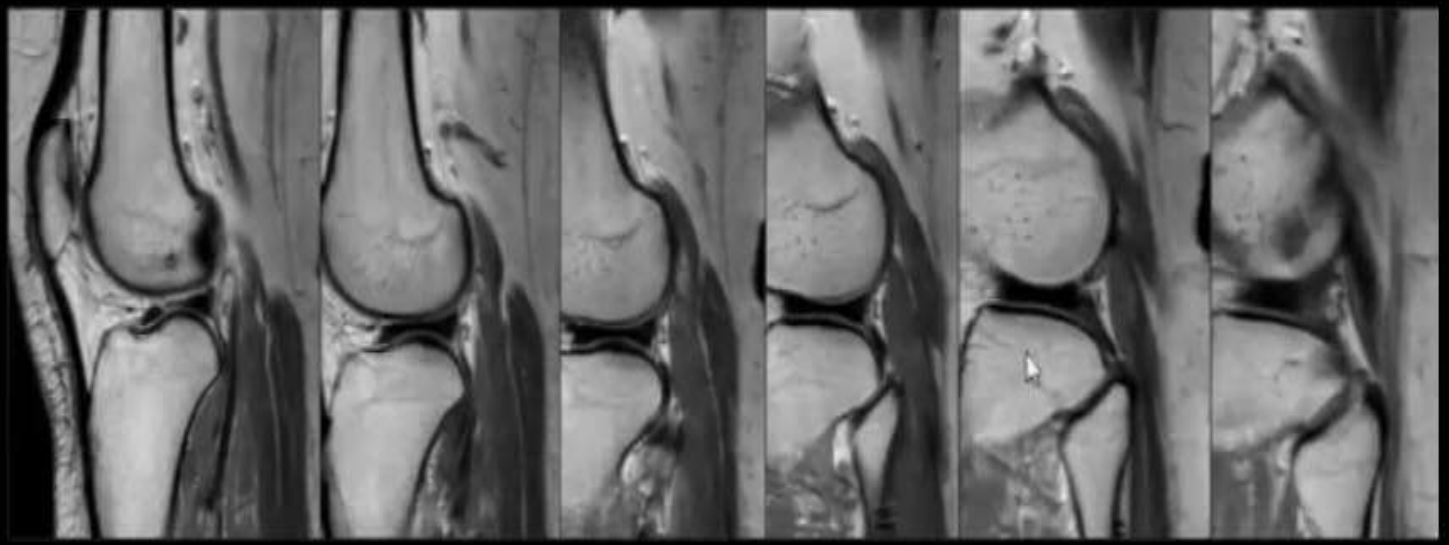

Longitudinal Tear
Radial Tear
Bucket Handle

3-Descoid meniscus

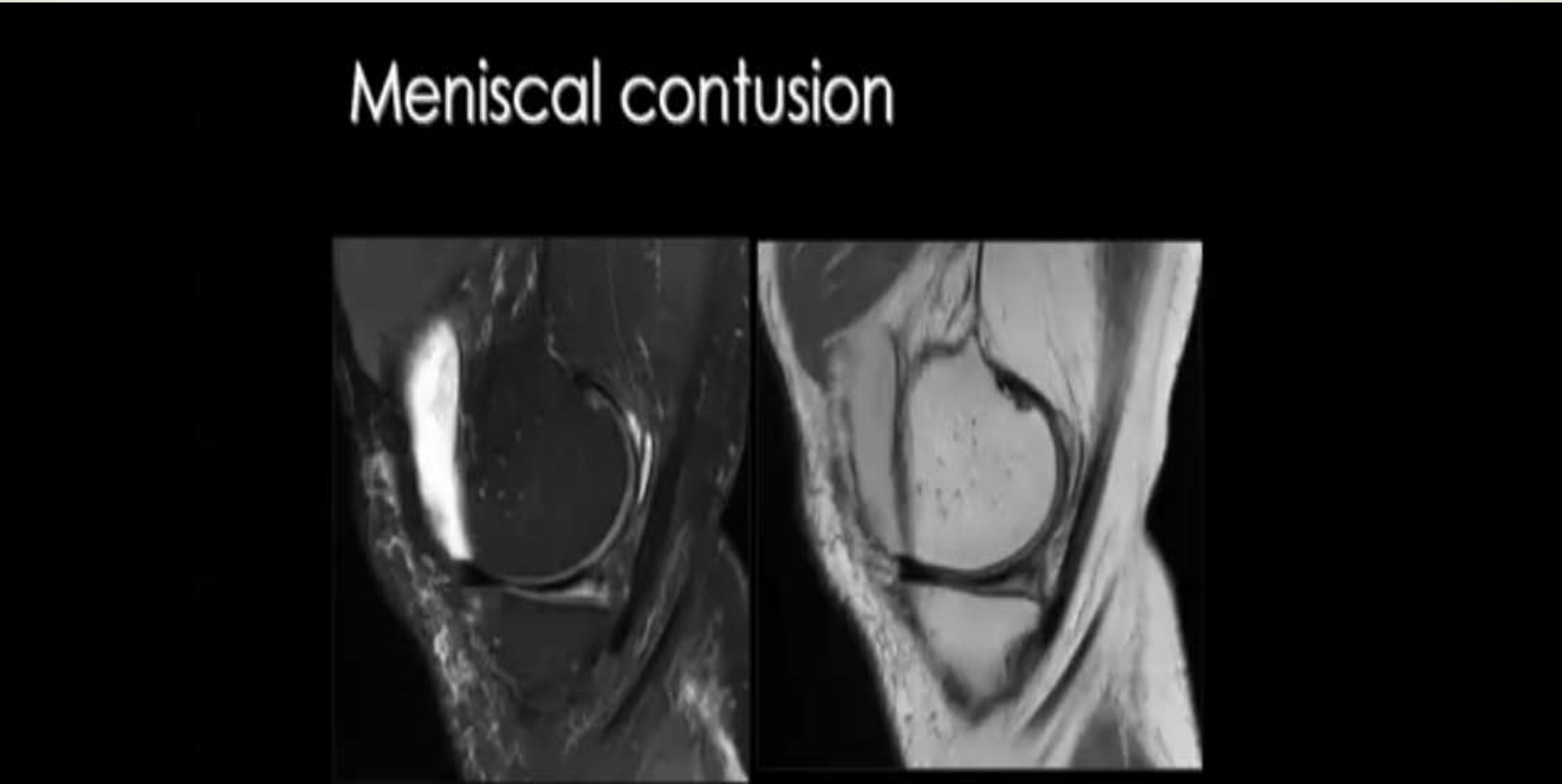
- It is like Disc (body enlarged and look like that of spine)



Discoid lateral meniscus

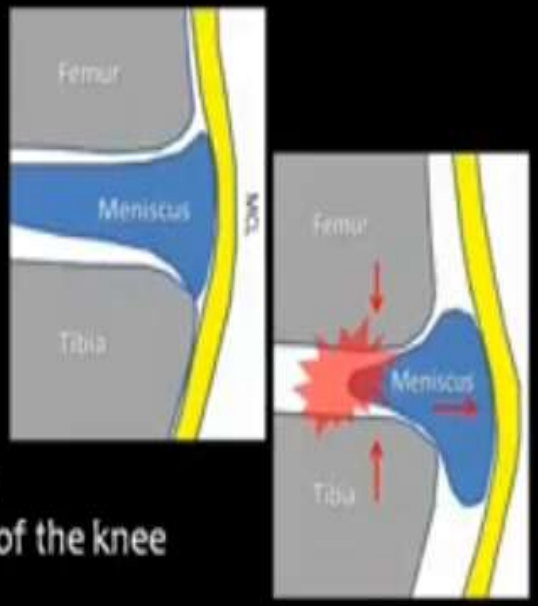


4-Menisucs contusion



5-Meniscus extrusion

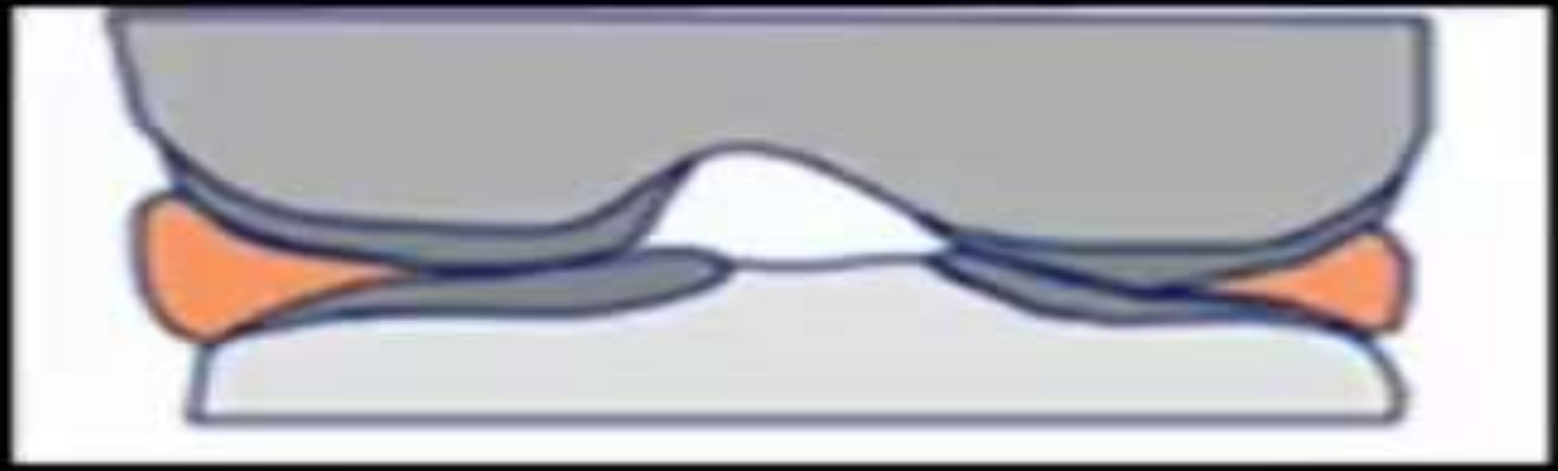
Meniscus extrusion



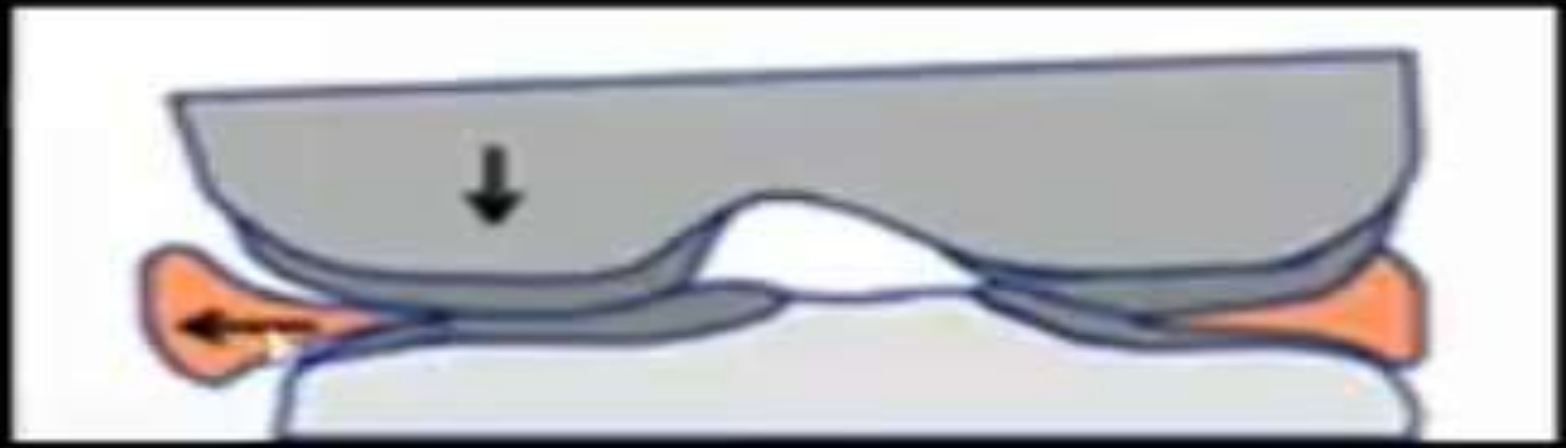
- Meniscus extrusion is a common cause of knee pain
- Can be associated with knee arthritis
- The meniscus subluxates out of the tibiofemoral joint
- Extrusion occurs more frequently on the medial side of the knee
- Radiographs show narrowing of the joint space
- Patients are often managed with medications and physical therapy/exercise
- Meniscus extrusion is measured in millimeters :
  - In the midline of the joint
  - From the medial aspect of the tibial plateau without osteophytes
  - To the peripheral edge of the extruded meniscus

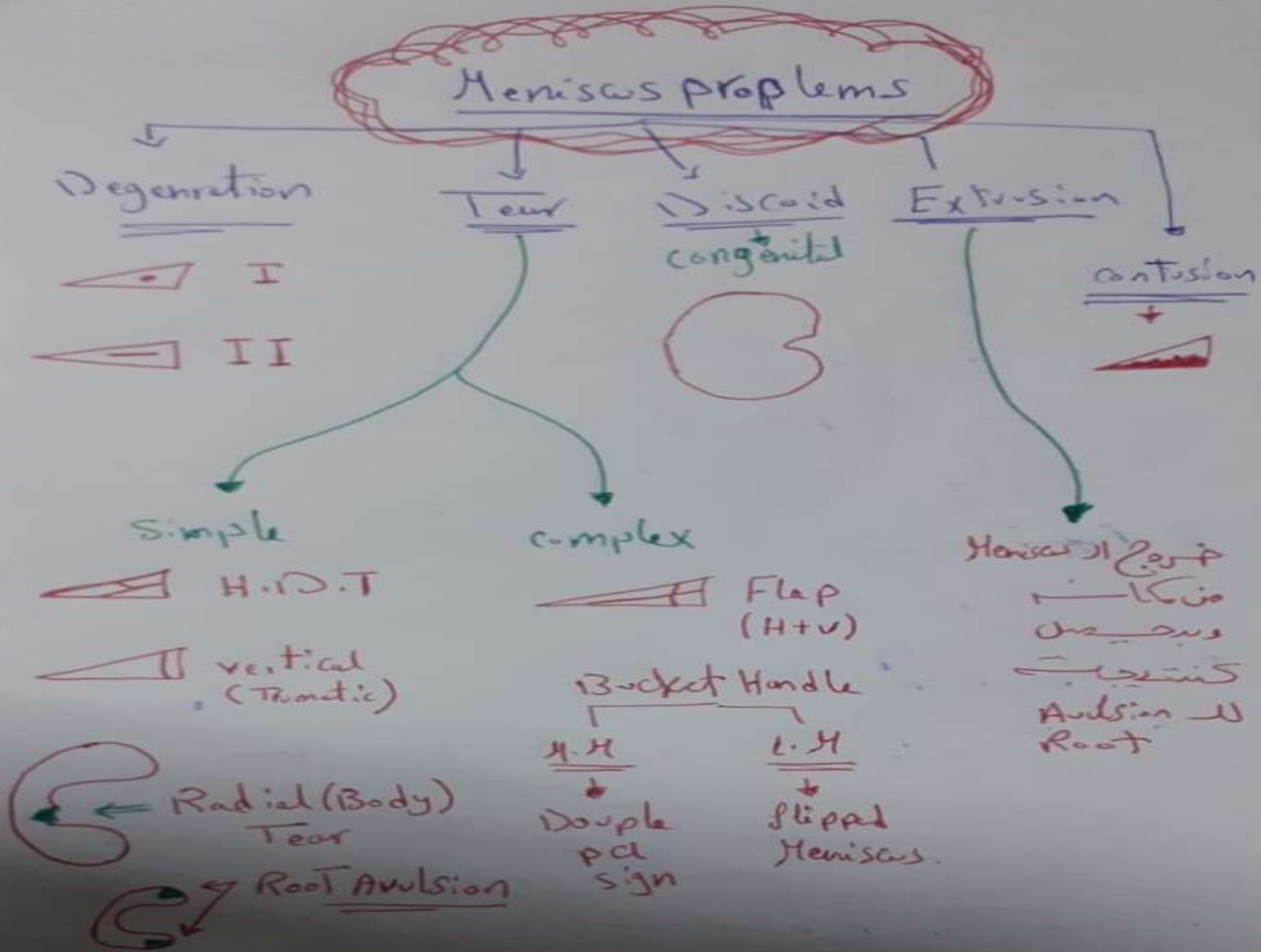
Meniscus extrusion

A coronal image from a patient with a medial meniscal root tear demonstrates associated severe medial subluxation of the meniscal body.



m is significantly associated with :



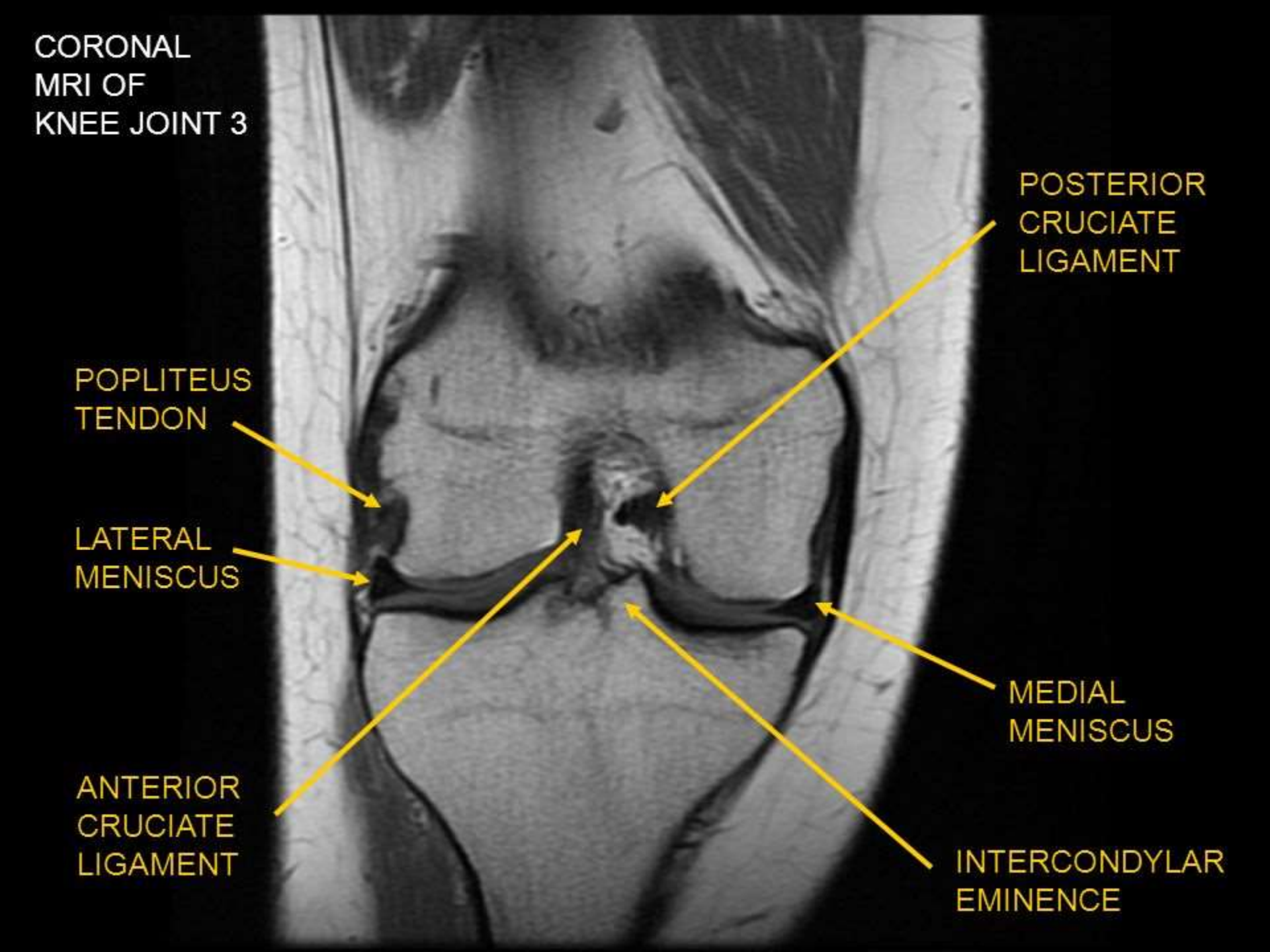

Meniscus proplems
Degenration
I
II
Tear
Discoid
congenital
Extrusion
contusion
Simple
complex
H.D.T
vertical
(Traumatic)
Flap
(H+V)
Bucket Handle
M.M
L.M
Douple
pcl
sign
Slipped
Meniscus.
Radial (Body)
Tear
Root Avulsion
خروج ال Meniscus
من مكانه
وبيحصل
كنتيجة
Avulsion لل
Root

Conclusions

- Degeneration type I&II = conservative
- Horizontal degenerative tear = according to site of tear (partial meniscectomy + repair)
- Vertical tear = common in periphery = repair
- Radial (if body)=Menisectomy
- Radial (root)=repair (tunnel)
- Bucket handle = remove loose part + repair

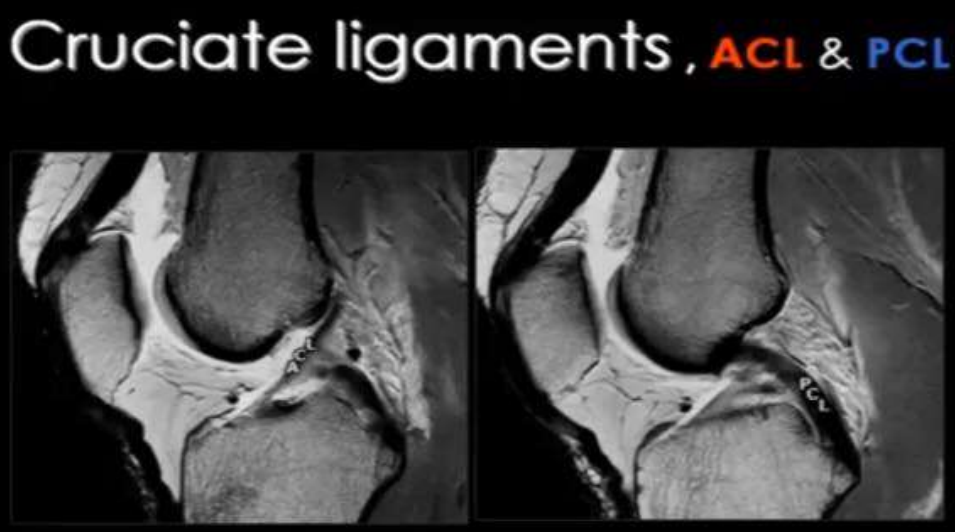
Root Tear repair	Meniscus repair	Menisectomy
First 4w passive flexion 90	From day 1 to w2passive ROM 90	1-2 w restore complete ROM
4-6w continue passive ROM as tolerated	W4 toW6 120 -135 flexion passive	At 2 w hamstring curl
4w begin wall slide less than 90	4 to 6 w Mini squat less than 90	4-6 w run straight
NO Active flexion in first 6 weeks	At 3 to 4 w begin isometric hamstring	**protocol can be aggressive, because in the knee joint anatomical structure should not be protected during the healing phase.**
7- 11 full ROM flexion	12w run straight	**They found that muscle strength returns equal to preoperative state only 4-6 weeks after surgery**

2-ligament of the knee


CORONAL
MRI OF
KNEE JOINT 3
POSTERIOR
CRUCIATE
LIGAMENT
POPLITEUS
TENDON
LATERAL
MENISCUS
MEDIAL
MENISCUS
ANTERIOR
CRUCIATE
LIGAMENT
INTERCONDYLAR
EMINENCE

Major Ligaments of the Knee

Cruciate ligament



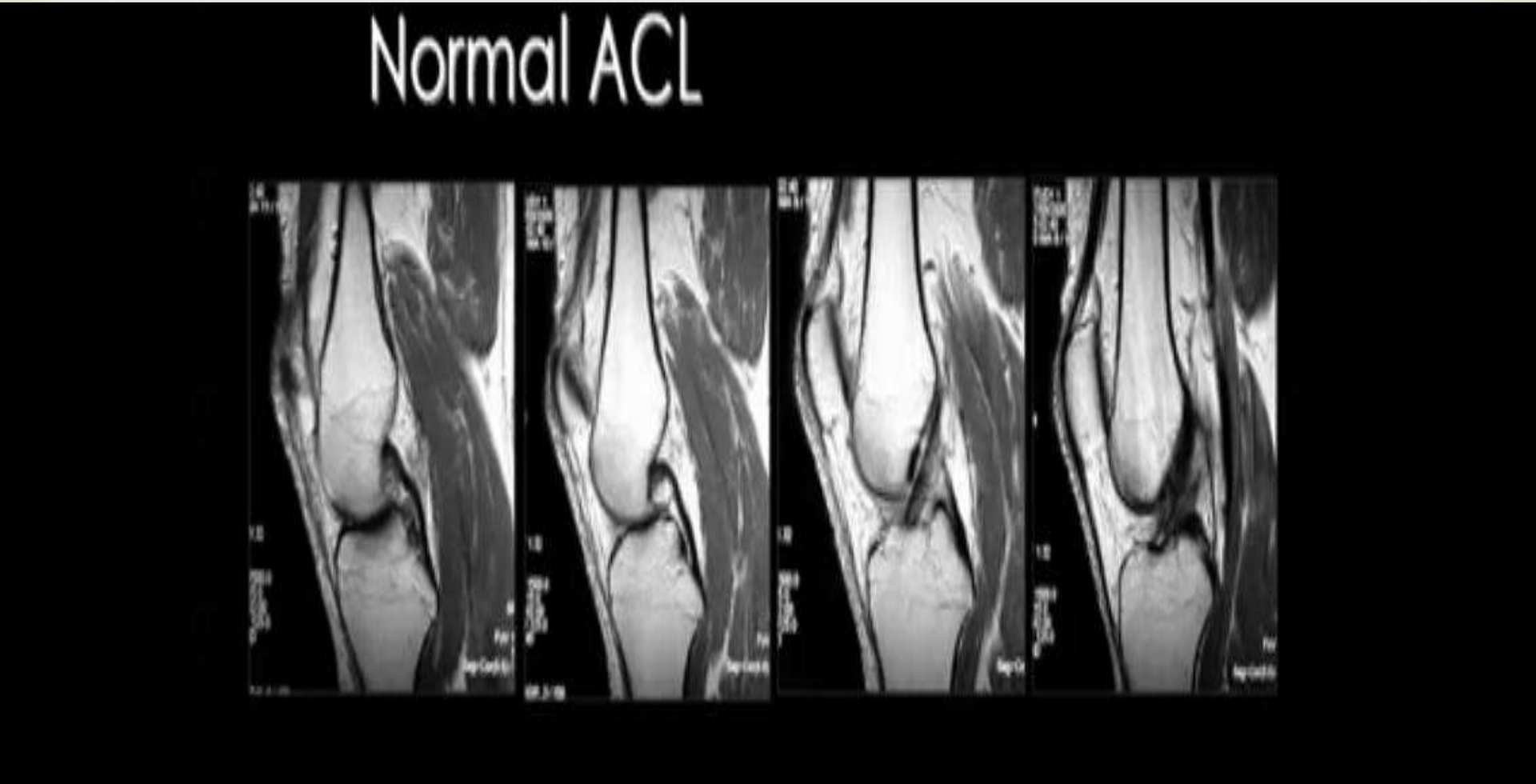
NB

- Remember that Acl is more lateral than Pcl
- Acl is related to lateral femoral condyle
- Pcl is related to medial femoral condyle
- Both appear in sagittal & coronal
- Both appear in (black)

ACL

Normal ACL

ACL



ACL ANATOMY

FRONT SIDE BACK

Pathology

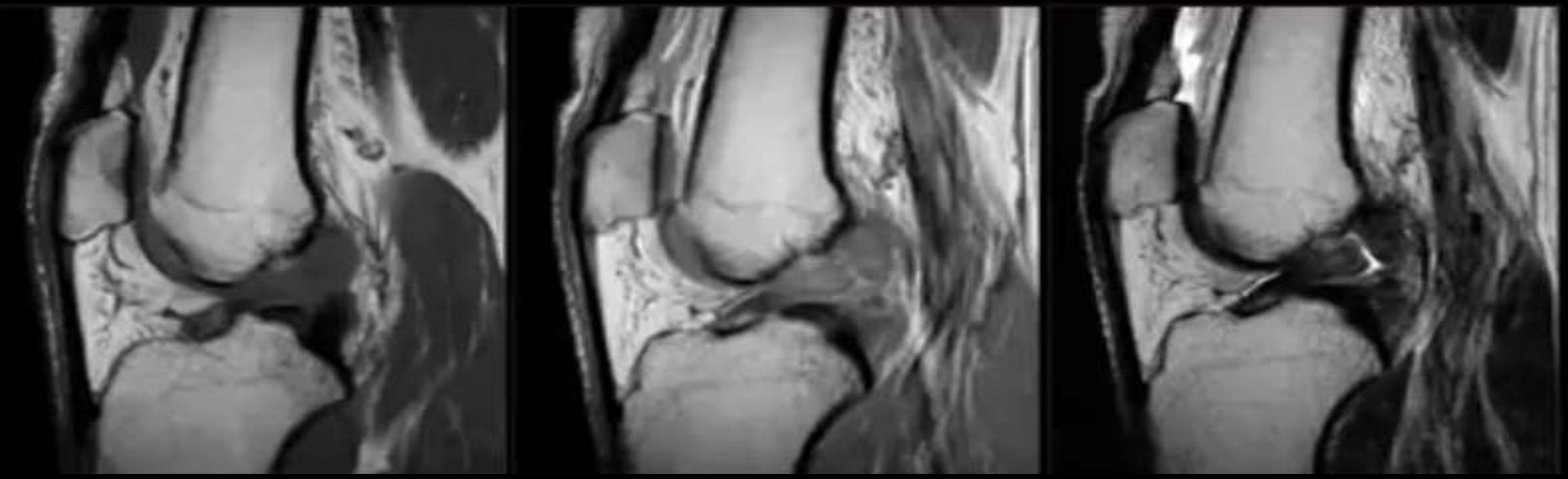
- 1- complete tear(total discontinuity)
- 2-lax or sprained
- 3-partial
- 4-Graft failure

Complete tear(total discontinuity

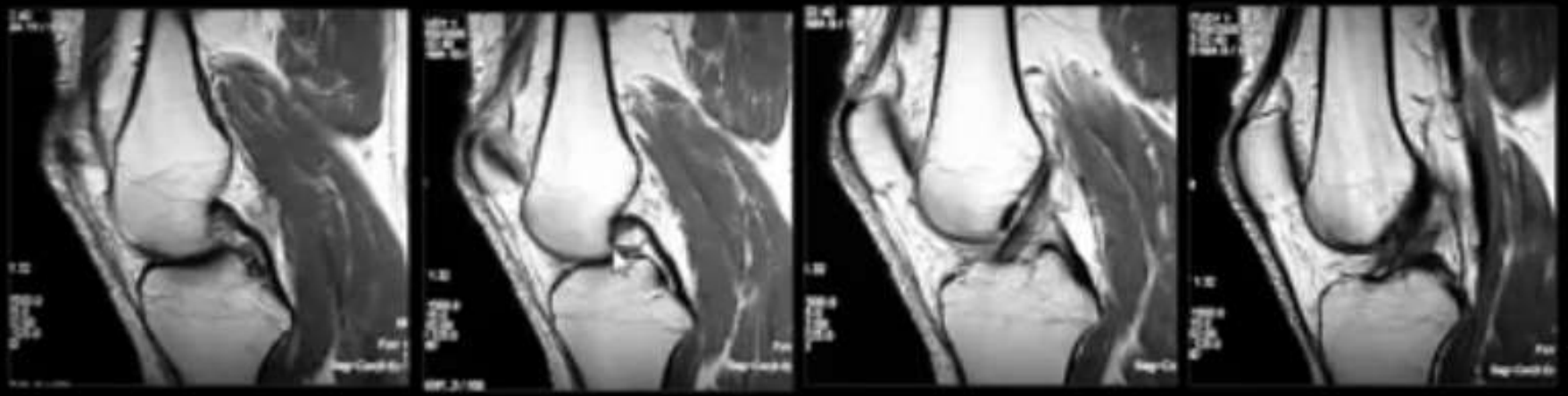
- 1-in sagittal view = no more black , water cut the continuity
- 2- in coronal view = empty notch sign + contusion in lateral femoral & tibial condyles
- 3- in sagittal view = translocation of tibia anterior to femur

ACL tears

Total discontinuity

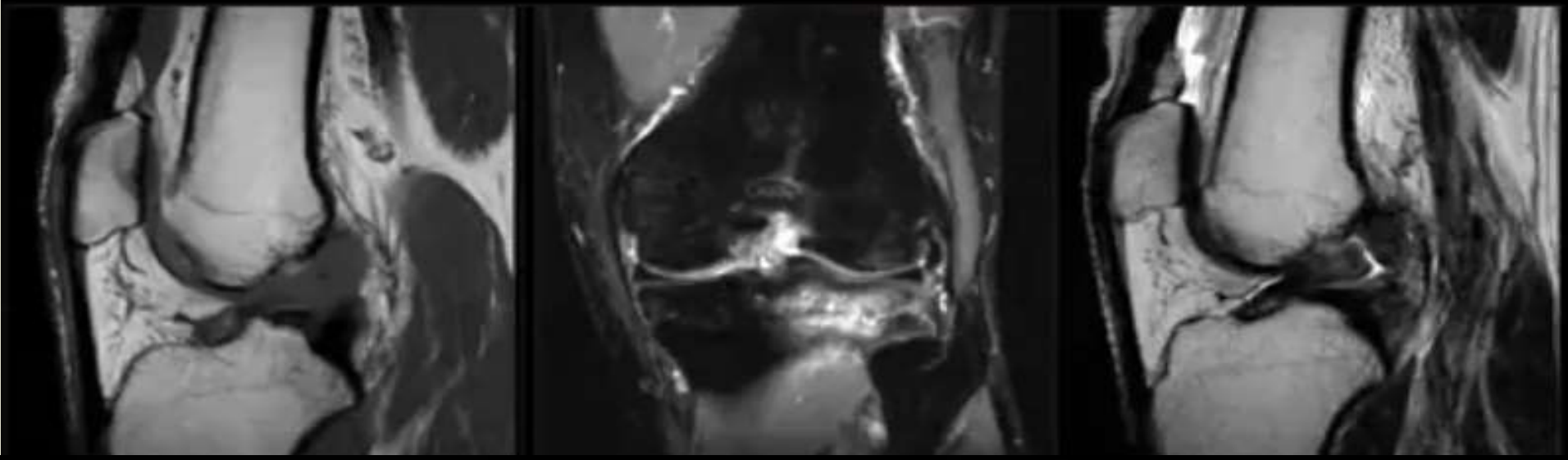


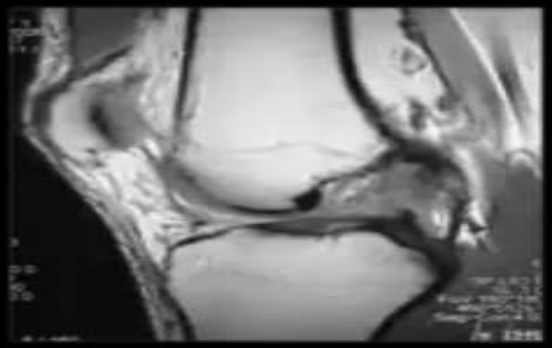
Normal ACL

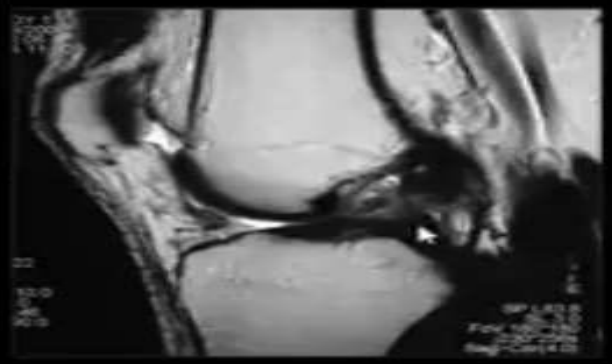


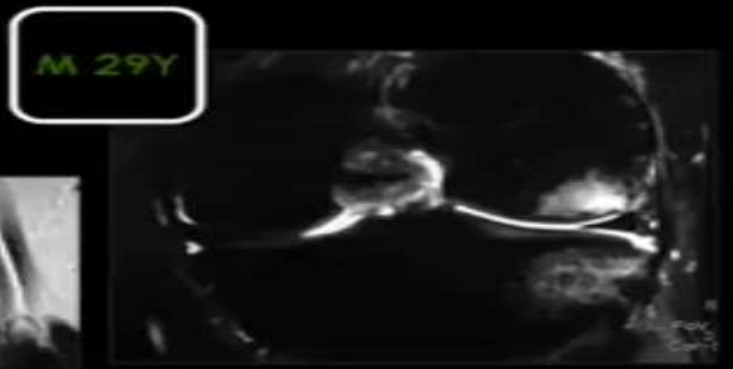
ACL tears

Total discontinuity





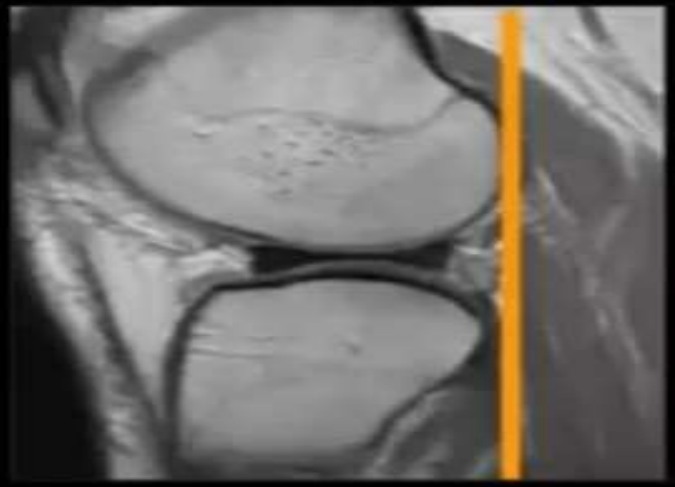


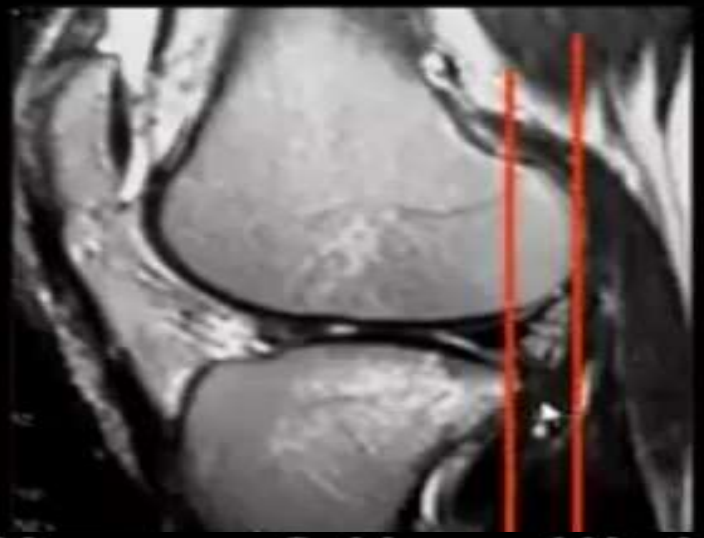


Total discontinuity

Anterior translocation of the tibia

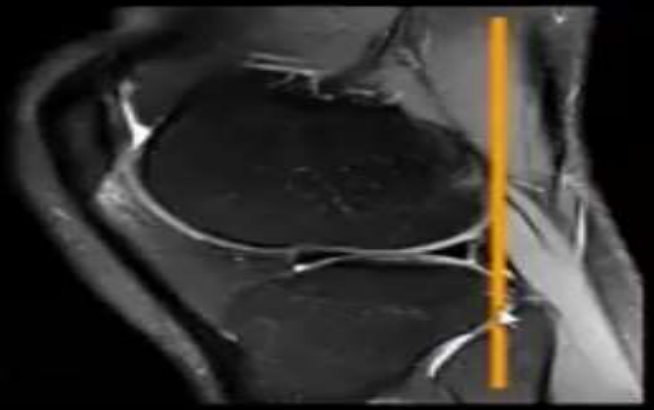
- Forward displacement of the tibia relative to the femer
- A translocation distance more than 5mm is supportive of ACL tear

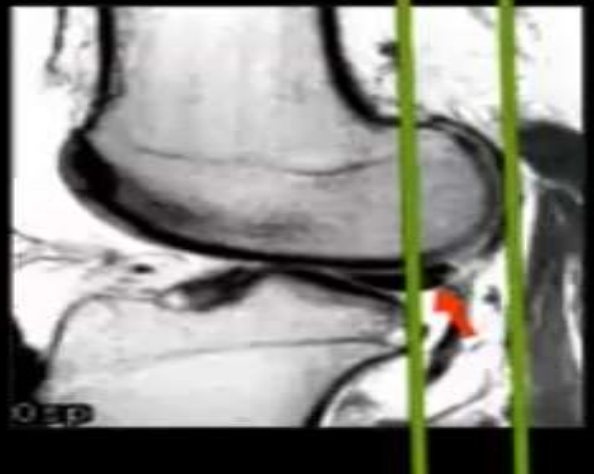




Anterior translocation of the tibia

Anterior tibial translocation with" uncovered meniscus sign"



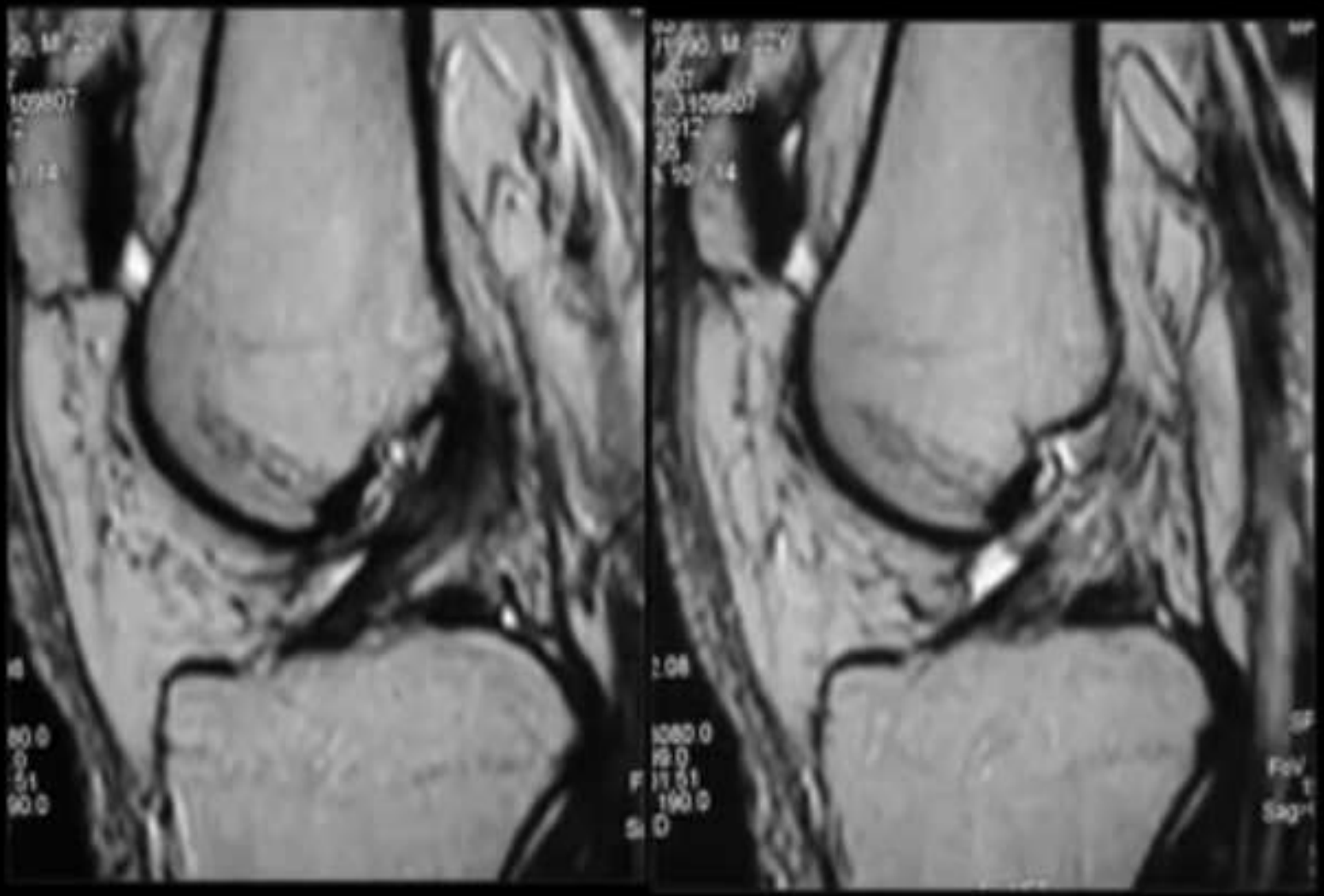


Partial ACL tear

- Single band appear & the other one not

Partial ACL tear

Single bundle sign



NB

- The AM bundle stabilizes **the flexed knee**, and the PL bundle stabilizes the **knee in extension**

- The primary function of AM bundle is **to prevent anterior tibial translation**, while PL bundle **stabilizes the knee, especially during rotation**

- Specific symptoms of **isolated AM bundle tear are anterior instability of knee mimicking complete** ACL tear. While **PL bundle tear presents with rotational instability, as these fibers are rotatory stabilizers of knee**

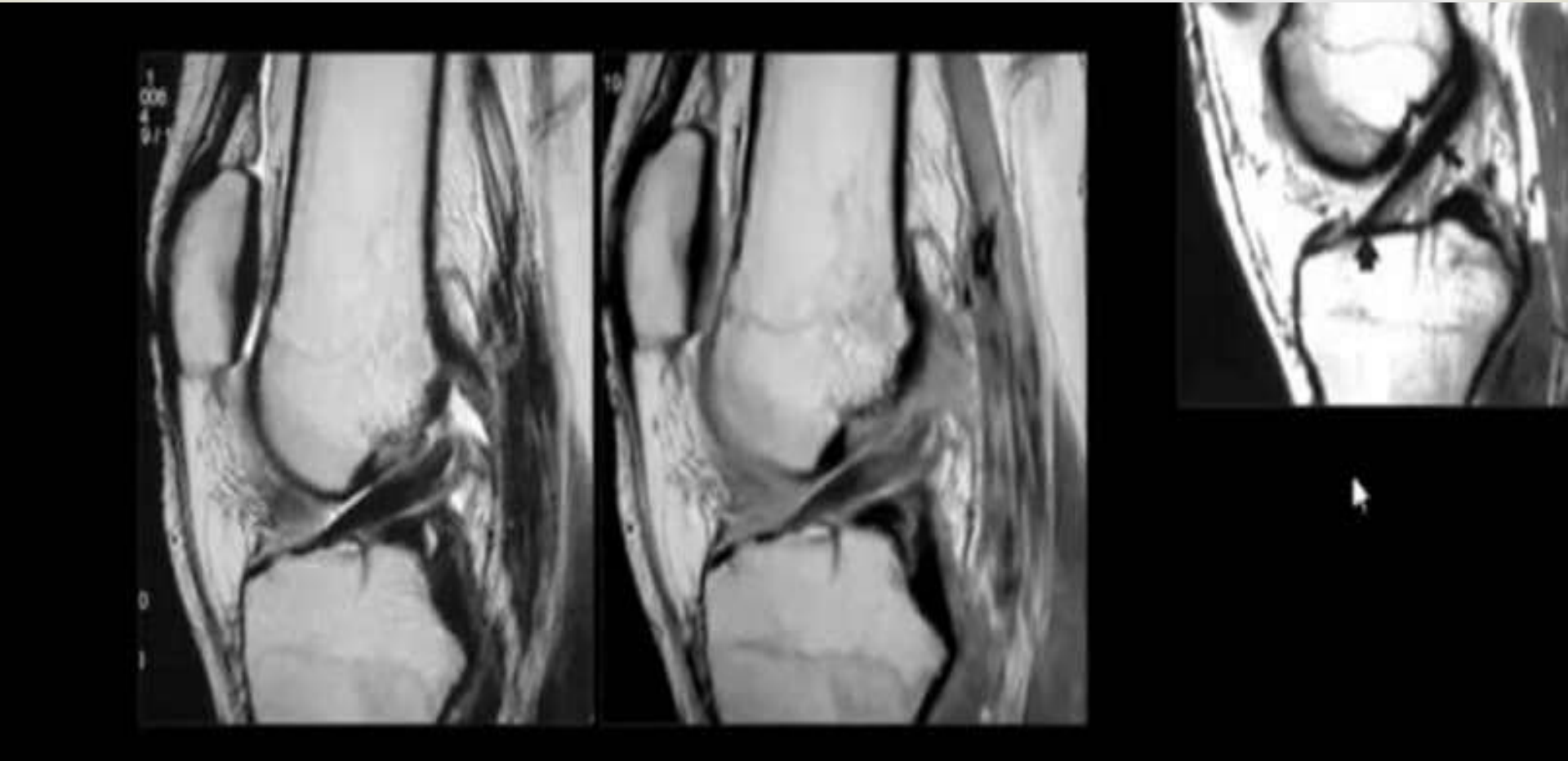
Can we differentiate ?

Is that matter?

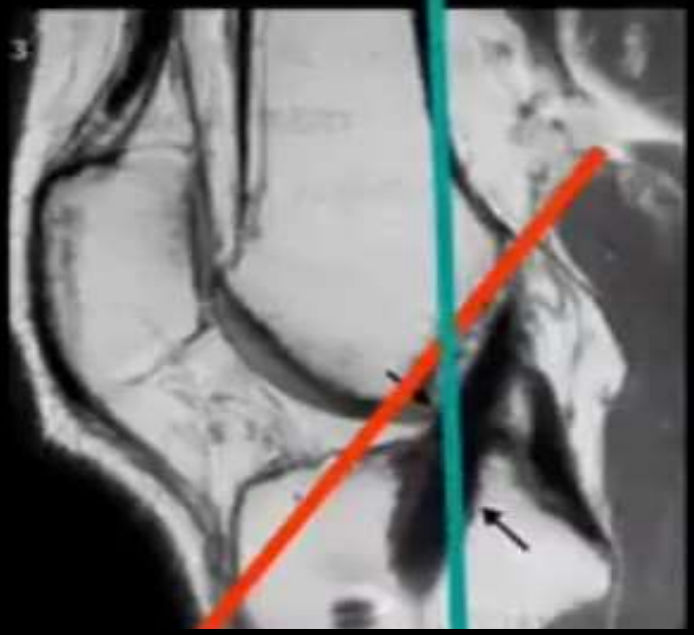
- Check the most intact part to lateral femoral condyle this is the PL bundle if you saw bright signal this mean tear in PL bundle which can be confirmed by rotational instability in the patient

- If course our rehab with this patient will focus to regain the rotational stability so which bundle is torn is very important to us

Lax or sprained ACL



Complications of ACL reconstruction

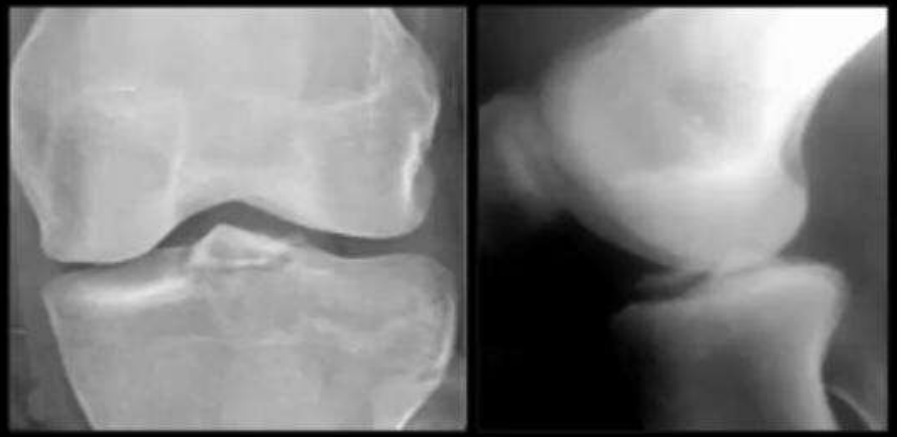


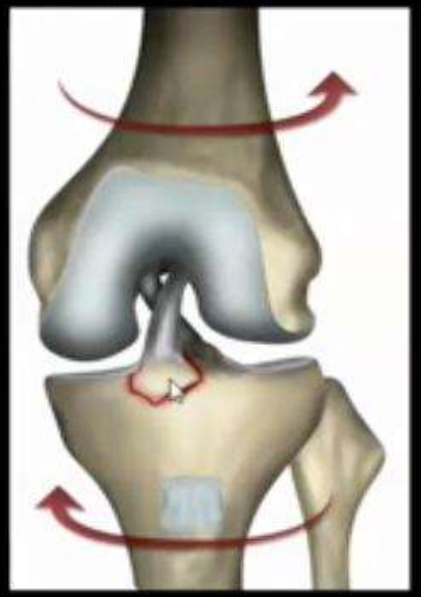
- Mal position of the graft tunnels
- Graft failure and tears
- Cyclops lesions
- Tunnel cysts

ACL graft impingement

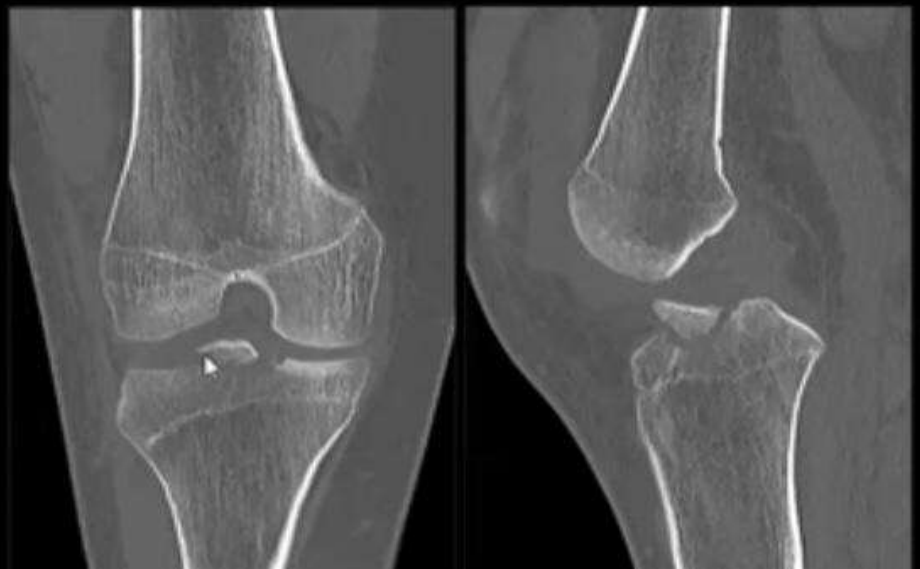
The LCA graft is indented by the anterior roof of the intercondylar notch in extended position of the knee typically results from inaccurate positioning of the tibial tunnel

Anterior cruciate ligament bony avulsion





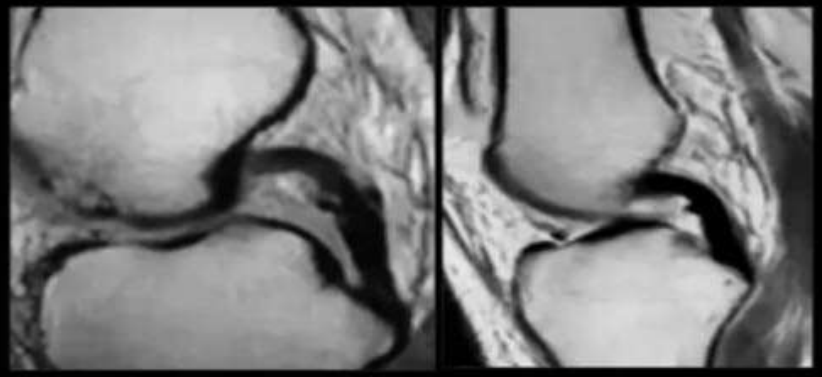
Bony ACL avulsion



PCL

Normal PCL

- The major stabilizer of the knee
- Uniform low signal , no striations
- Twice strong as the ACL



The menisco -femoral ligaments

Ligament of **Humphrey** anterior to PCL

Ligament of **Wrisberg** posterior to PCL

PCL tears

- Complete tear 40%
- Partial tear 55%
- Avulsion tear 7%

- PCL injuries represent about 12% of knee injuries
- Combined PCL injuries represent 97%

ACL 65%
MCL 50%
MM 30%

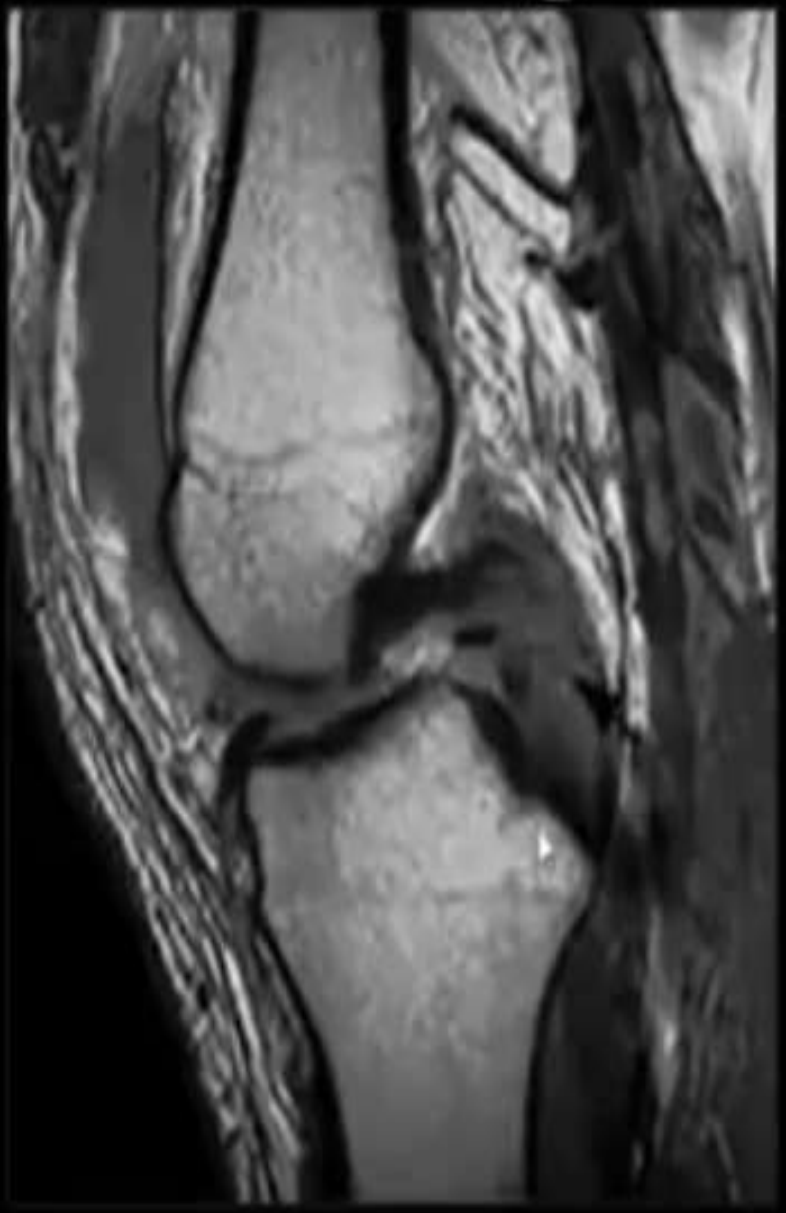
- Increased signal due to hemorrhage and edema
- Diffuse enlargement of PCL

Posterior Cruciate Ligament Tear

Proton density and T2W Sagittal images demonstrate thickening and heterogenous appearance of PCL, which is torn.

Partial PCL tear

Posterior Cruciate Ligament Tear



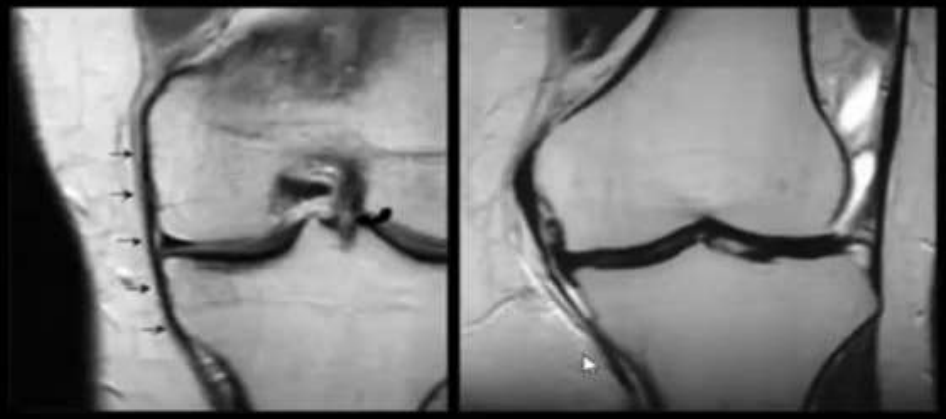
Collaterals

Normal medial collateral ligament

A thin, well-defined, low-signal structure extending from the medial femoral epicondyle to the medial tibial metaphysis

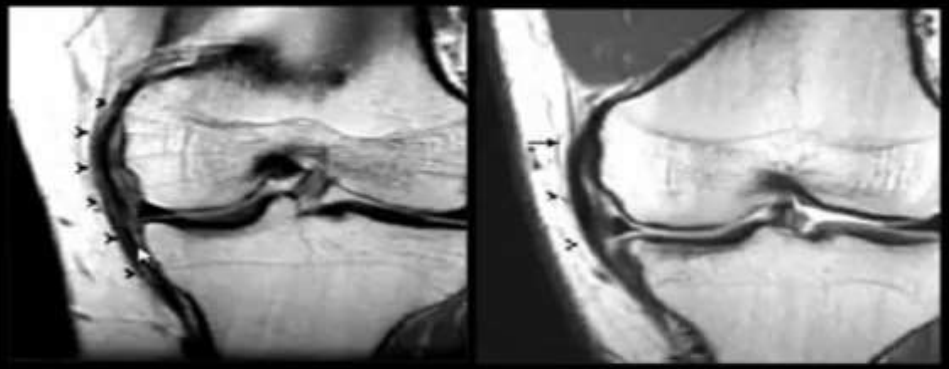
Grade I

Note the normal thickness and signal of the medial collateral ligament and continued close apposition to the femoral and tibial cortices.



Grade II

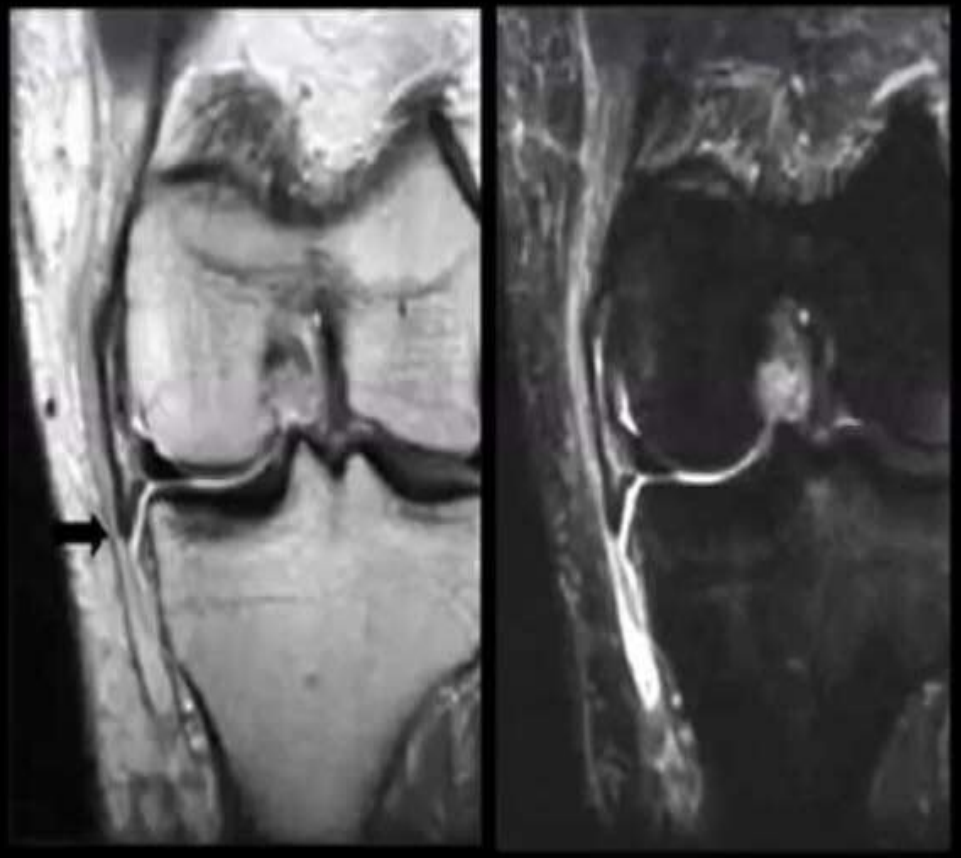
Slight thickening of the medial collateral ligament and separation from the underlying cortices.



Grade

III

Folded medial collateral ligament (arrow) and surrounding edema on a coronal proton density image.



Conclusions

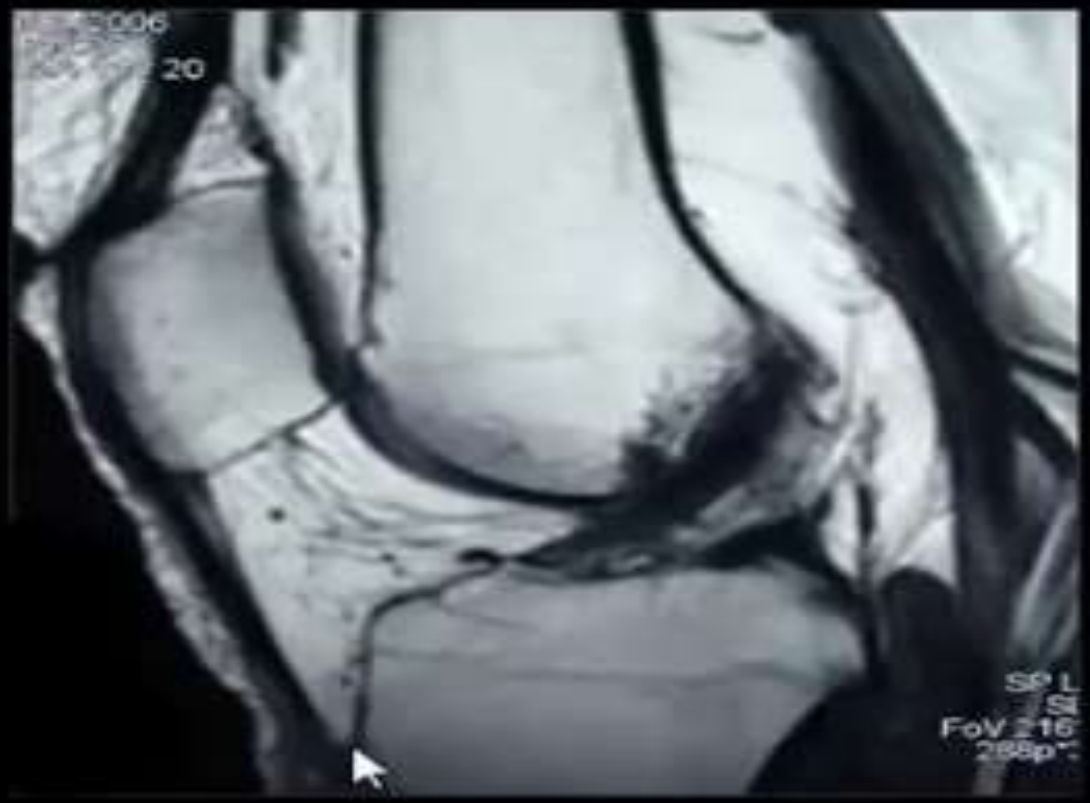
- 1-complete ACL tear >>according to all factors , (no more black ,translocation , contusion, empty notch sign)
- 2-single bundle tear (PL)>>single bundle reconstruction , rotational stability)
- 3- very important to read post operative graft ACL

Time	ACL	M.Repair	Tunnel	Meniscectomy	ACL + Repair
Extension	0-2 W	0-2 W	0-2 W	0-2 W	0-2 W
Flexion	3-5 W full	0-2 W less than 90 3-5 W less than 120 6-8 W full	4-6w continue passive ROM as tolerated 4w begin wall slide less than 90 NO Active flexion in first 6 weeks 7- 11 full ROM	1-2 w restore complete ROM At 2 w hamstring curl	6W 130 7-12 W full
WB	Partial if no pain 6w if Hamstring graft	6W	6W	4-6 w run straight	7W
Return to sport	3-5 Month early 6 Month Return	3-5 Month early 6 Month Return	Tolerance	6 W	6 Month Early 8 Month Return

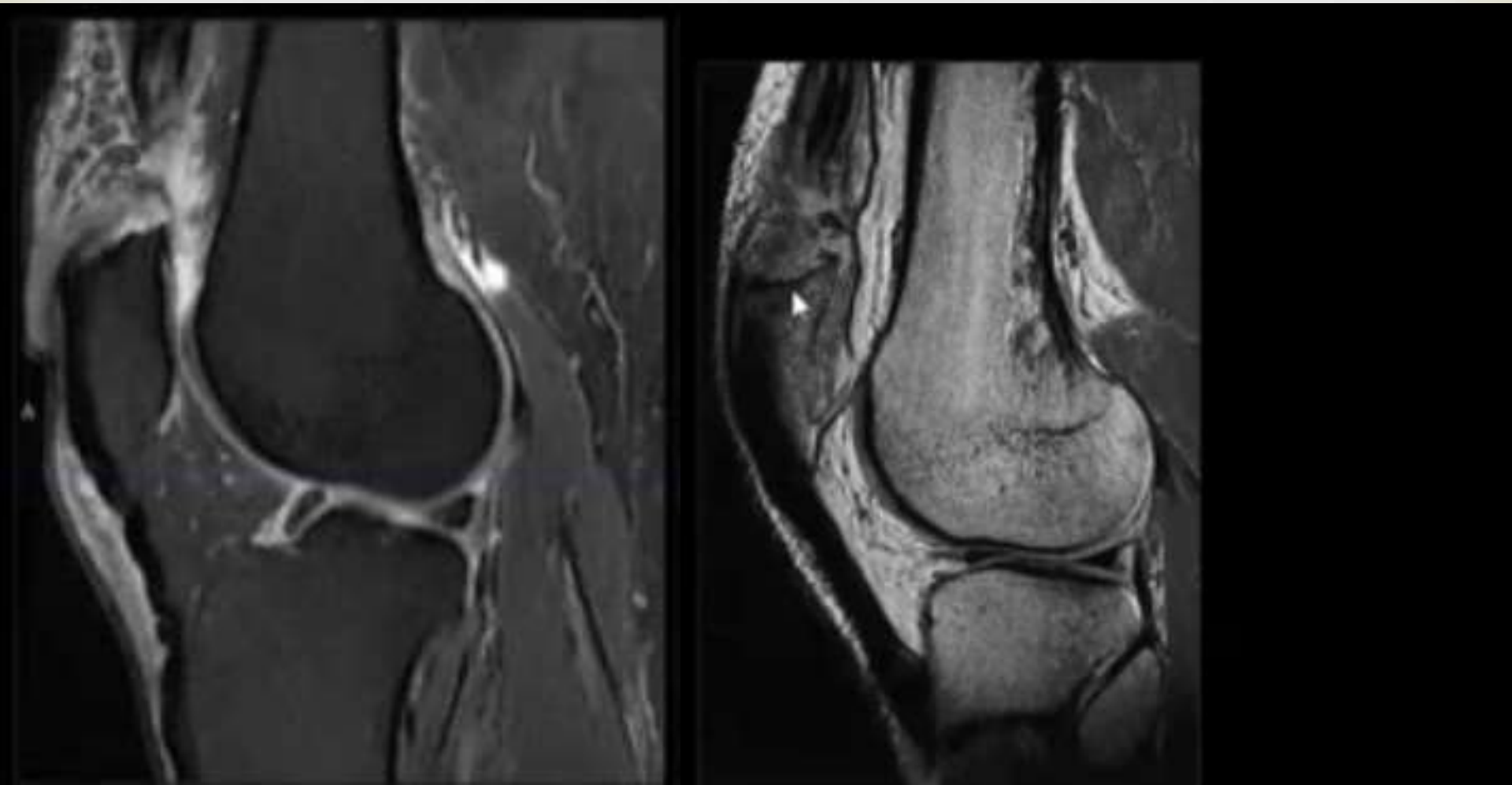
3-Tendons

	Quadriceps tendon	Patellar tendon
Site	Above patella	Below patella
Problems	Tear ,degeneration	Tear(patella Alta) , degeneration
Tear site	Near superior patellar pole	Near inferior patellar pole
	May occur without trauma	May be related with jumper knee , Osgood shclatter

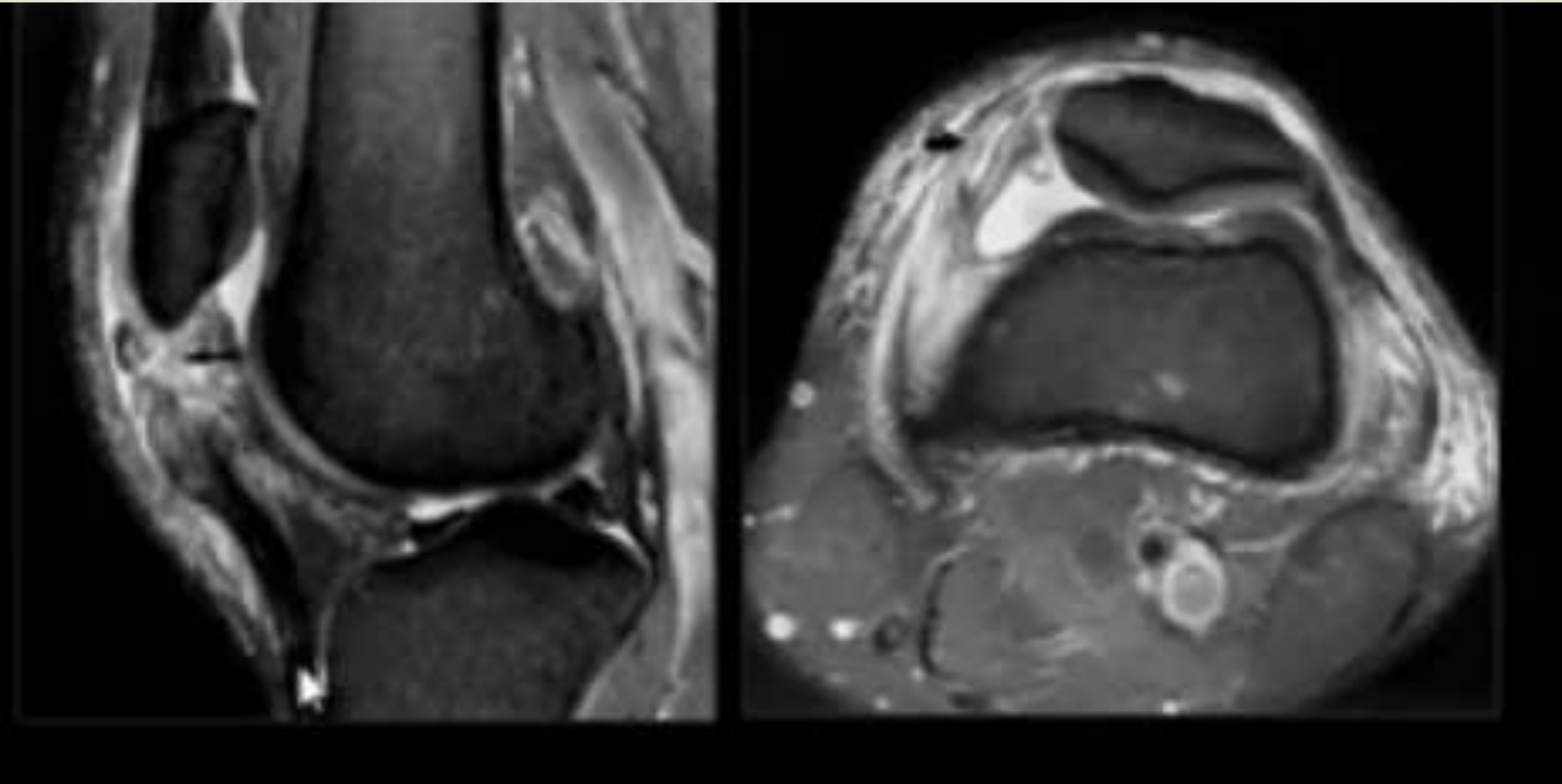
Normal



Quadriceps tendon tear

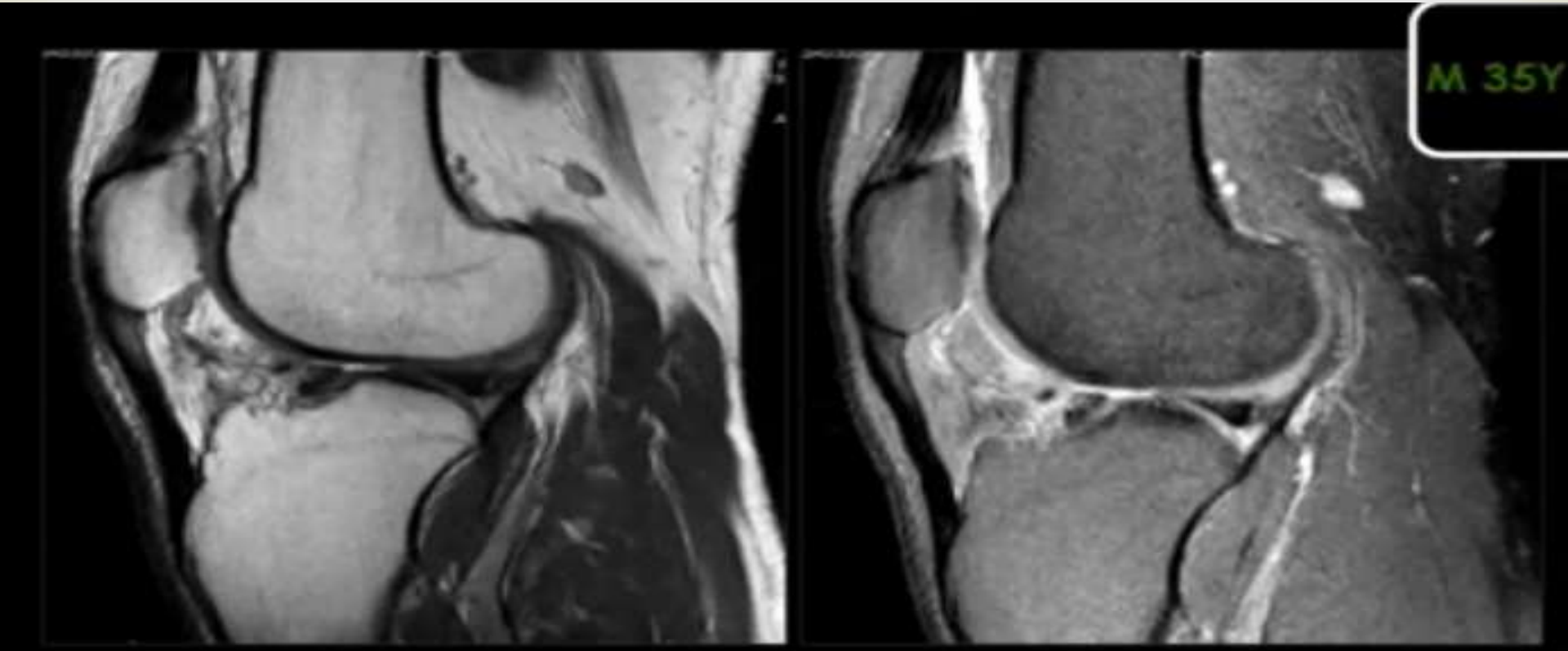


Patellar tendon tear

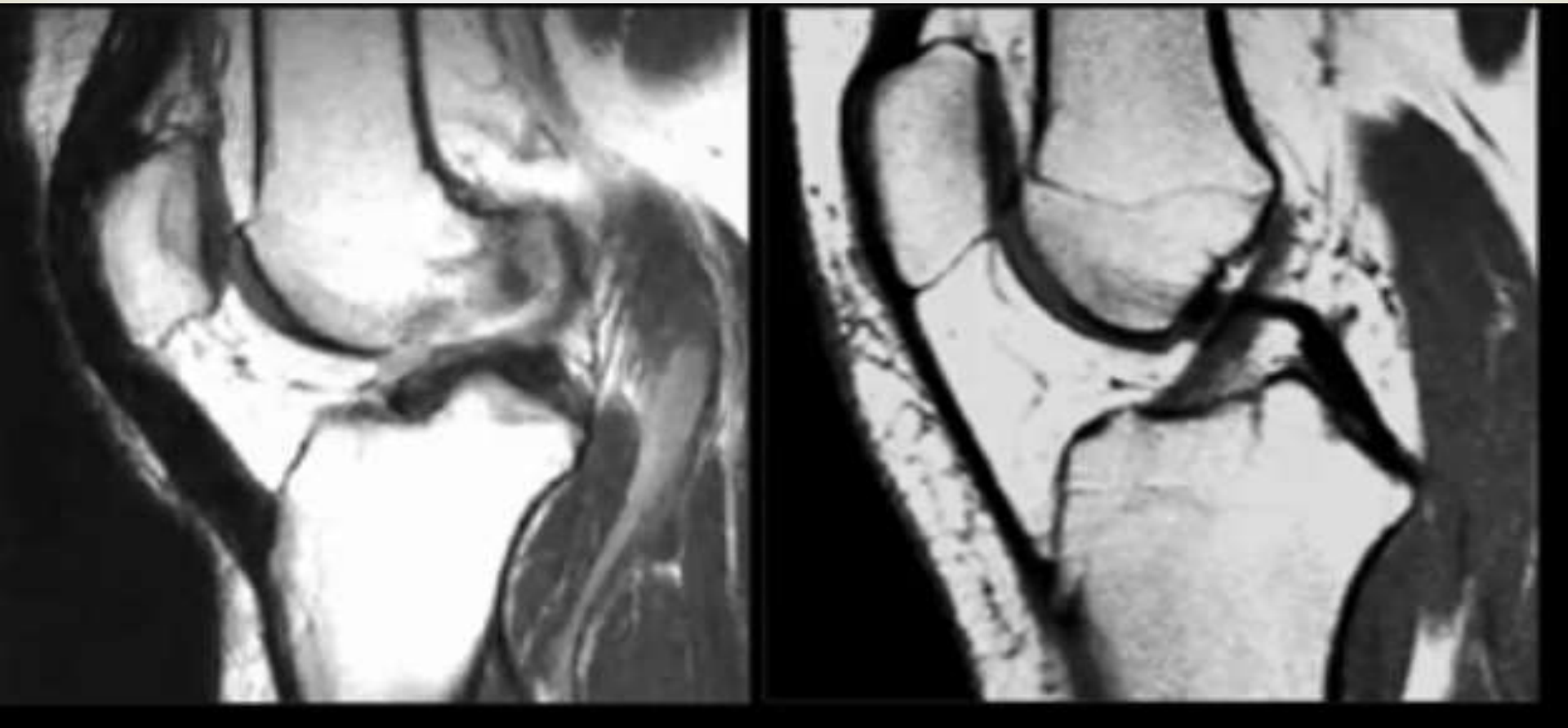


Quadriceps Acute degeneration

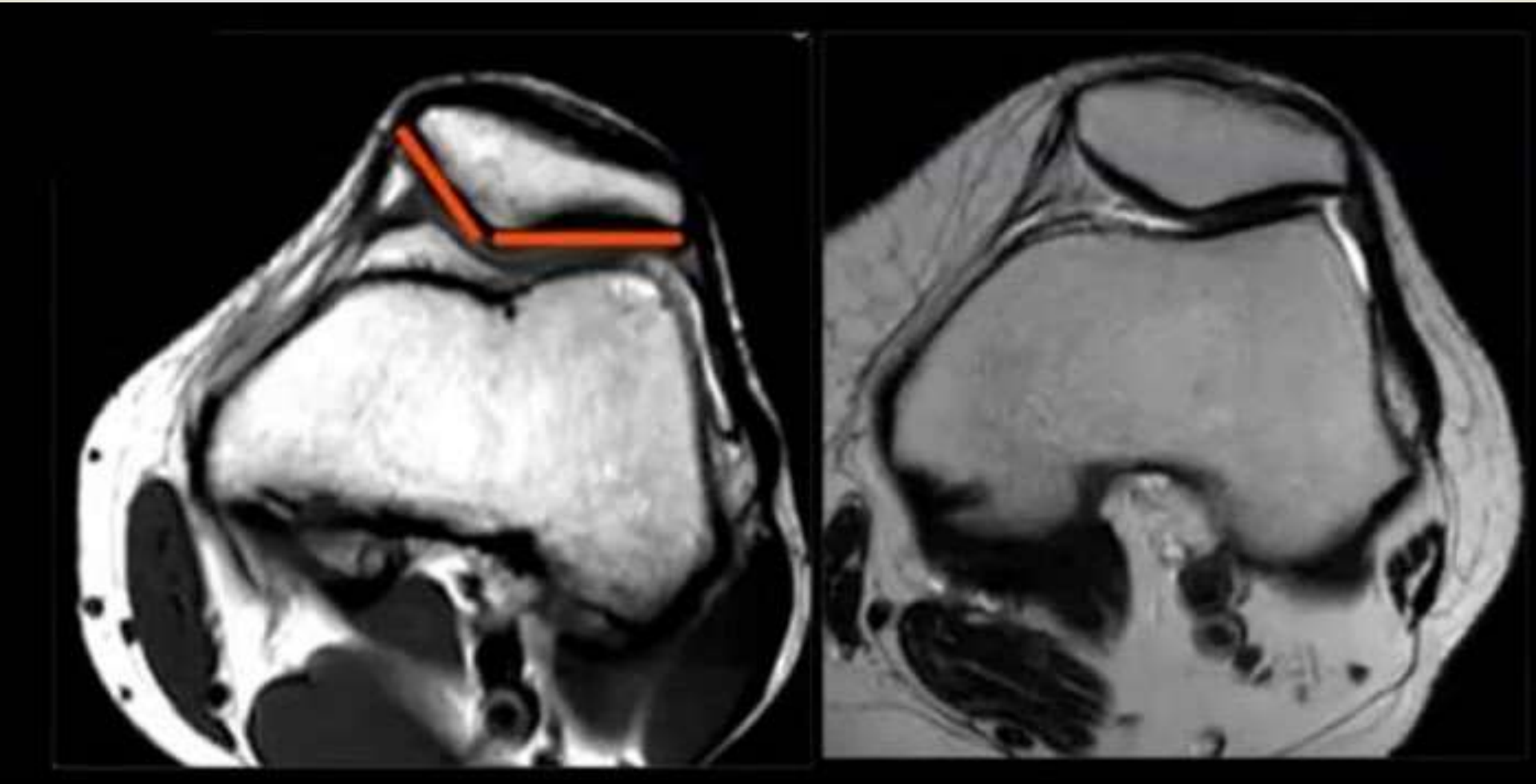
Acute patellar degeneration



Quadriceps chronic degeneration

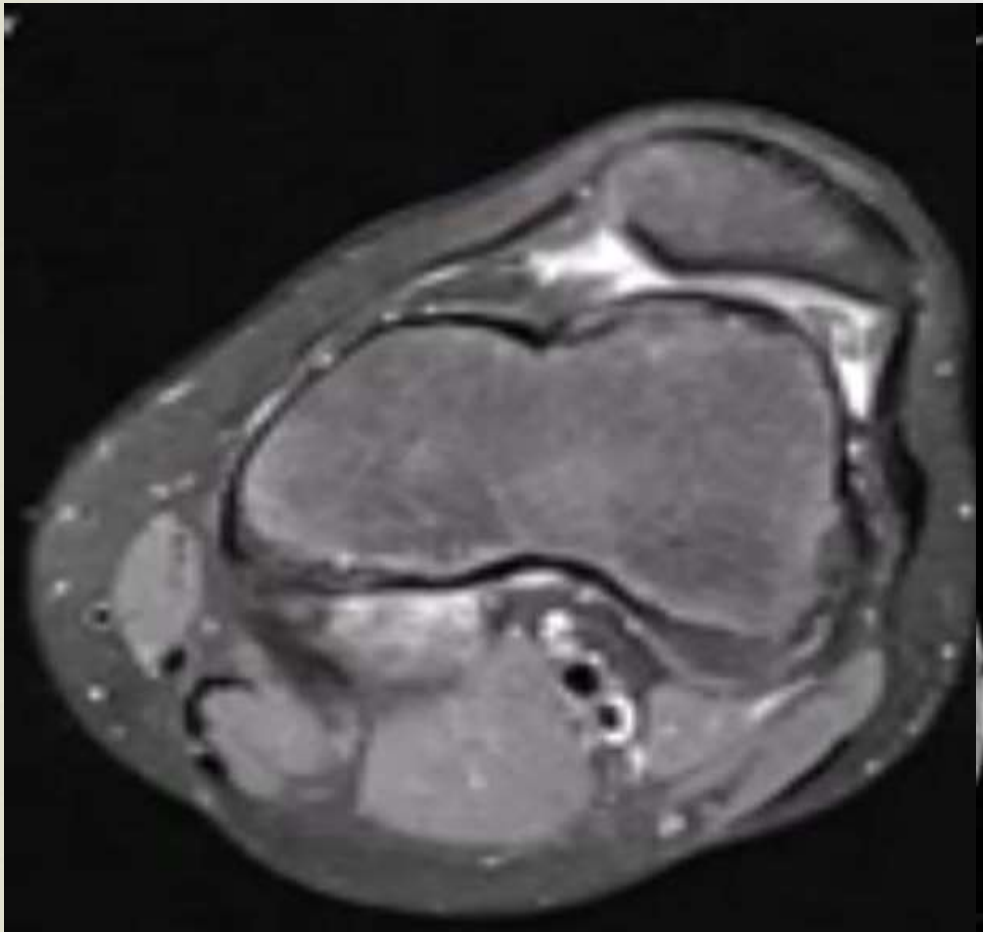


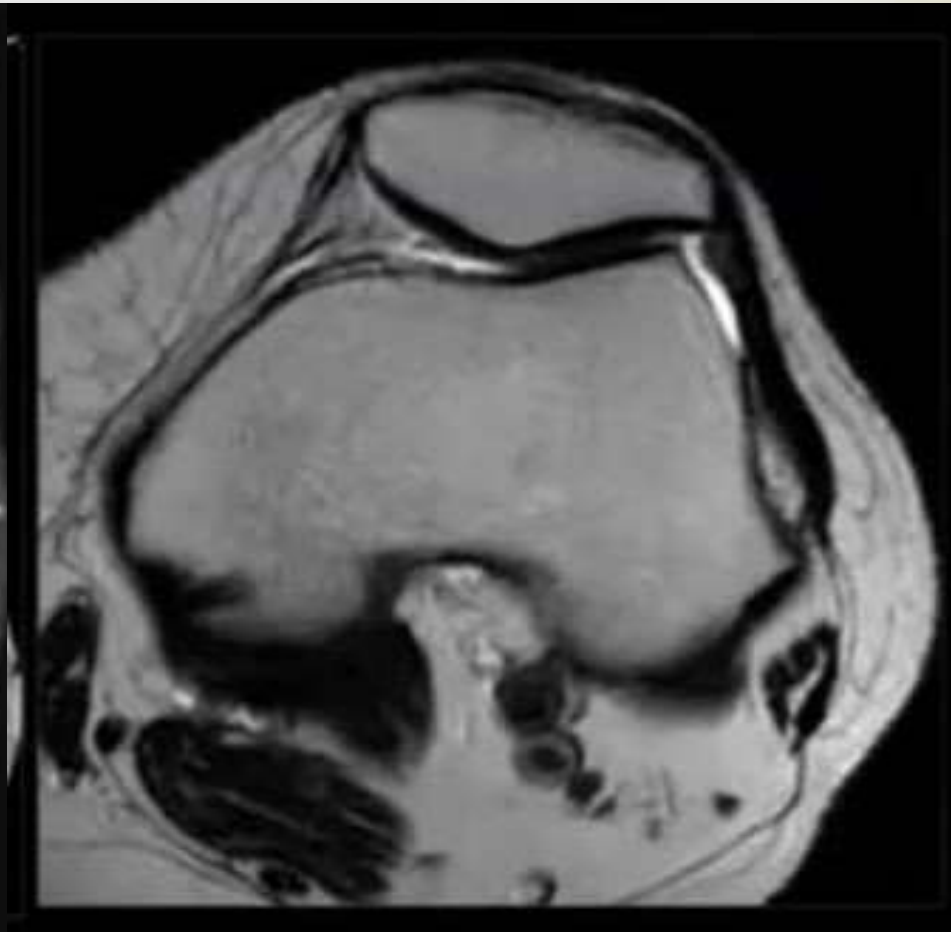
4-patella



Retinacula problems

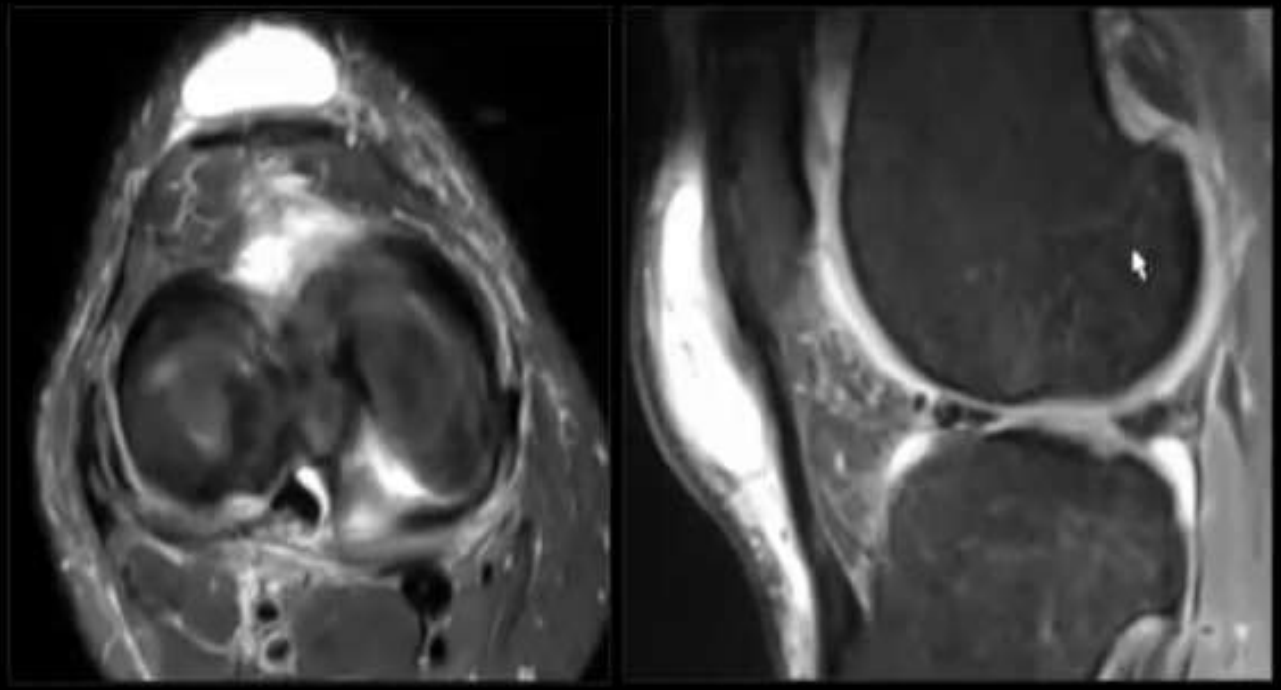
Maltracking

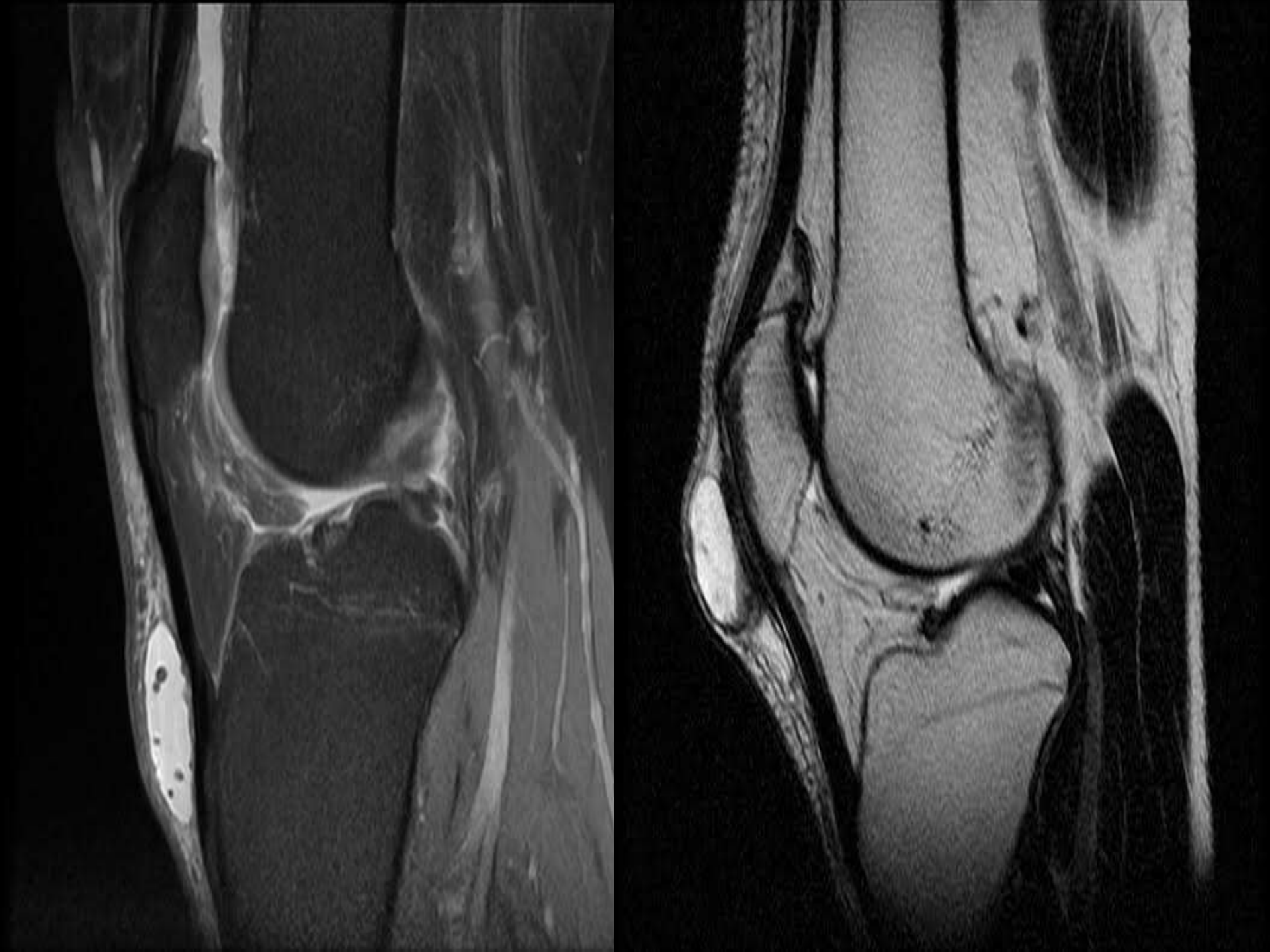




Bursitis

Prepatellar bursitis [housemaid's knee]





Lets be confirmed ?

- Active knee flexion forbidden in first 6 W in ….

1-ACL+ M.Repair

2- Meniscectomy

3- Tunnel surgery

If cr7 undergo operation after vertical Meniscus tear & Ramos undergo operation after root tear avulsion & Messi undergo operation due to radial Meniscus body tear

Who will run first ??

1- CR7

2- Messi

3- Ramos

- A player undergo ACL reconstruction & Meniscus repair surgery when do u expect him to return to sport ??

1- 3M

2- 6M

3- 5M

4- 8 M

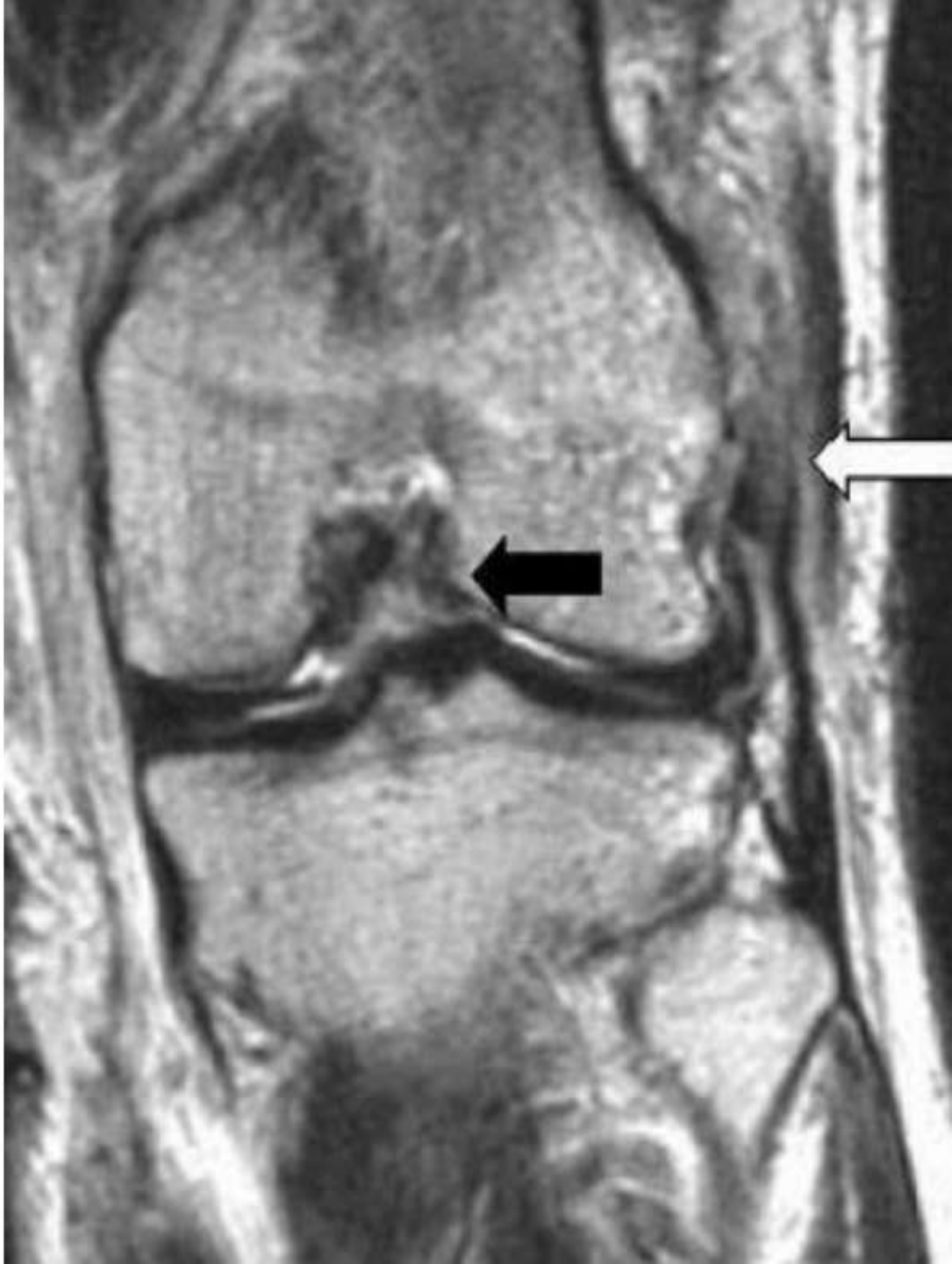
- We expected full flexion Rom after ACL reconstruction to be achieved in

1- 7-8 w

2- 6-8 w

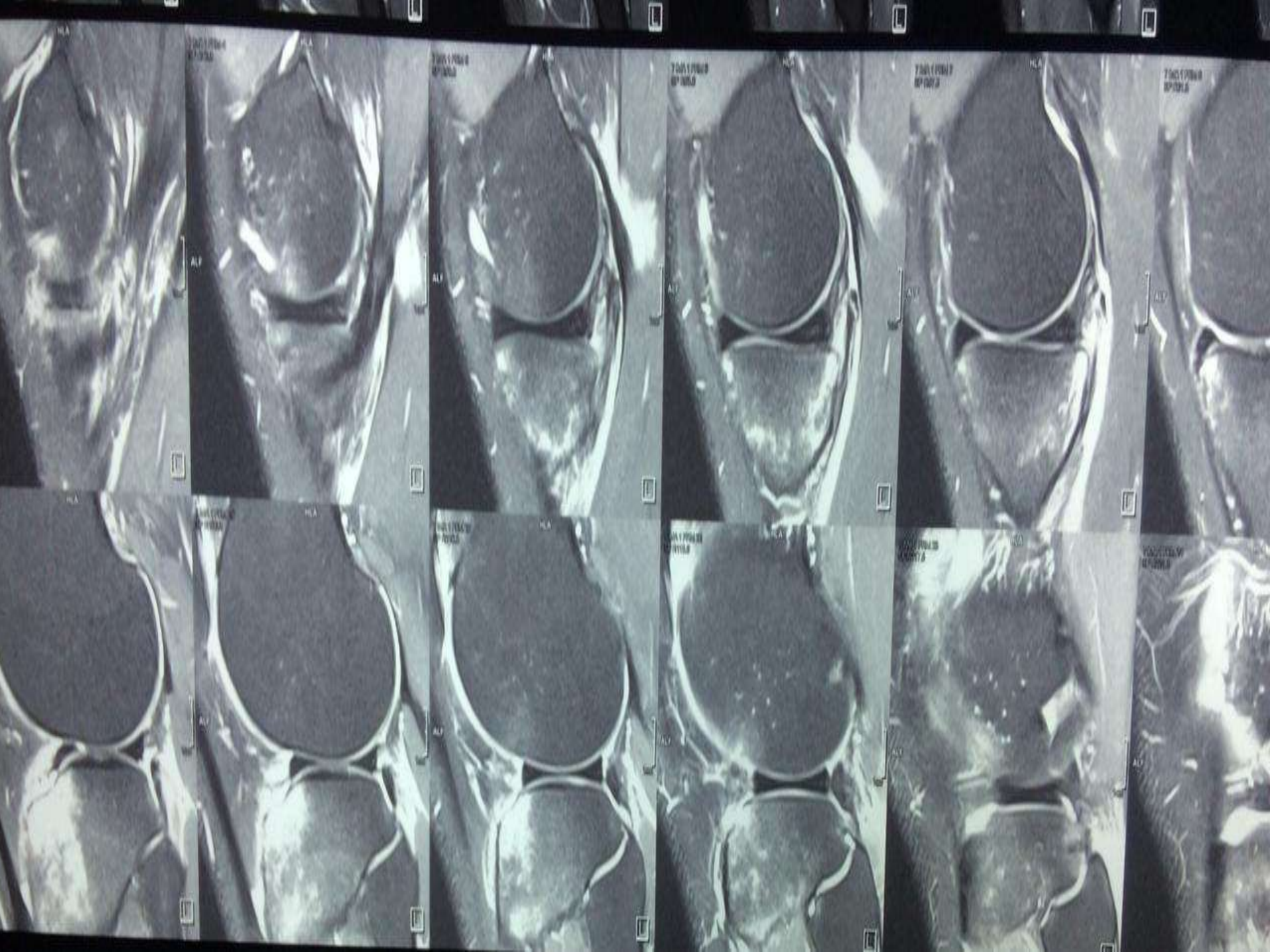
3- 3-5 w

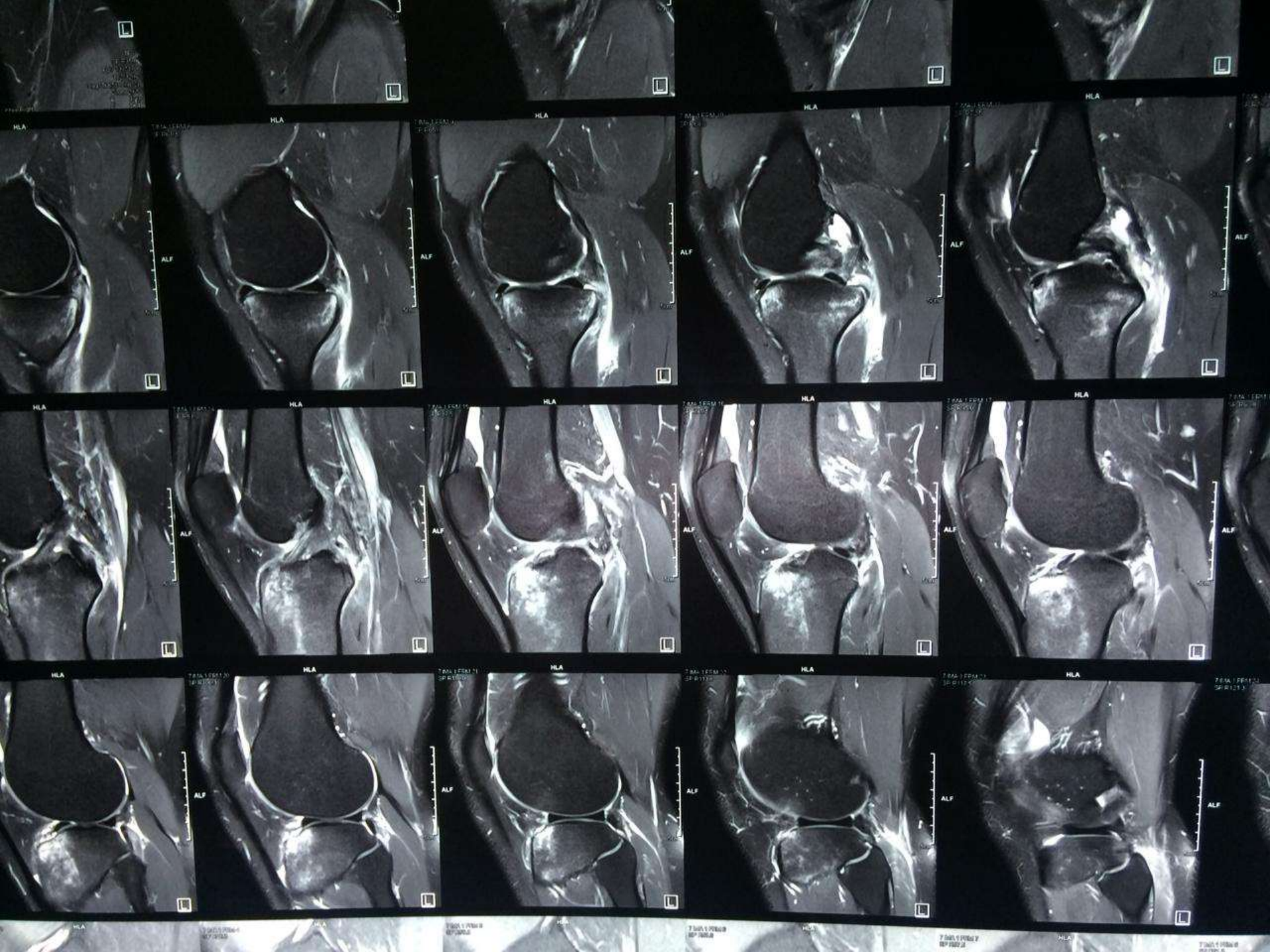
4- 2w



Quiz

- If u saw at MRI Empty notch sign this mean……..
- If u saw at MRI Double PCL sign this mean…….
- If u saw at MRI Flap meniscus this mean…….
- If u saw at MRI Flipped meniscus this mean ……
- Tendinopathy mean……
- Tendinitis mean ……




HLA
ALF