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Multiligament Knee Injuries & the STaR Trial

Disclosure

- none

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Spectrum Pathology

- Energy
  - 53%high, 47% low
  - BMI
- Associated Injuries
  - 0.072% orthopedic trauma
  - Neurovascular injury 18%
  - Fractures
  - Head trauma

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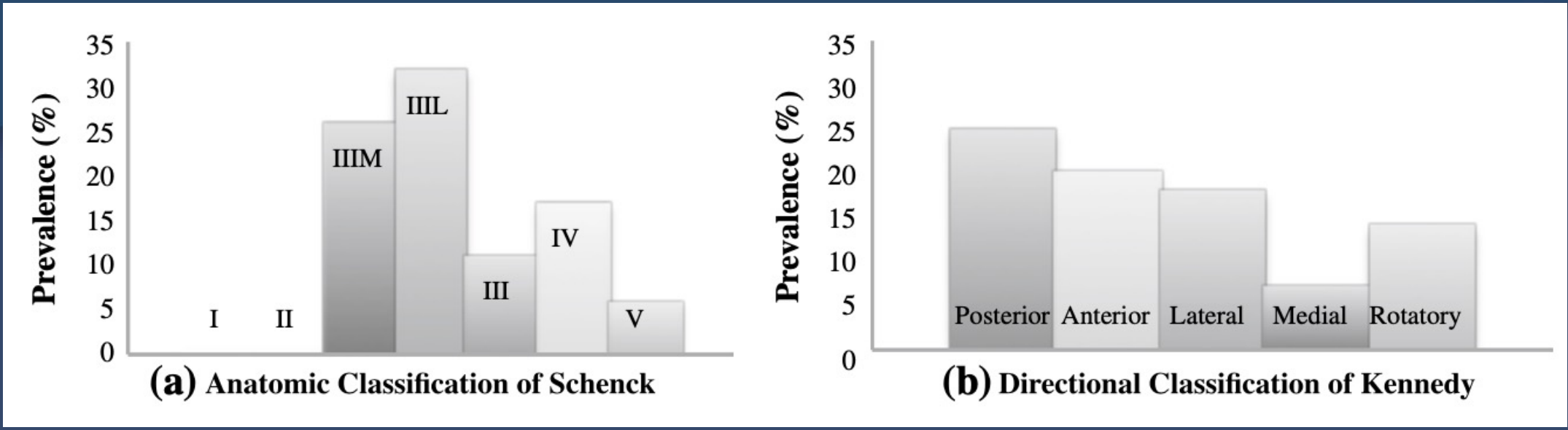
Multiligamentous Injury Classification System

- Schenck classification

Table. Anatomically Based Knee Dislocation Classification System	
KD-I	Single cruciate + collateral injury
KD-II	ACL and PCL injury
KD-III M	ACL, PCL, and MCL injury
KD-III L	ACL, PCL, and LCL + PLC injury
KD-IV	ACL, PCL, MCL, and LCL + PLC injury
KD-V	Dislocation + fracture

Prevalence of Vascular Injury



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KD-IV	ACL, PCL, MCL, and LCL + PLC injury
KD-V	Dislocation + fracture

Maslaris et al: *European Journal of Orthopaedic Surgery & Traumatology* (2018)

HSVI

- Absent pulses
- Bruit or thrill
- Active or pulsatile hemorrhage
- Arterial Occlusion (the 5 Ps)
    - Pallor, pain, paresthesia, paralysis, pulseless
- Expanding hematoma

Feliciano et al. *The Journal of Trauma: Injury, Infection, and Critical Care 2011*

SSVI

- History of arterial bleeding at the scene or in transit
- Proximity of injury to an artery
- Non-expanding hematoma
- Major Single Nerve Deficit
- Reduced Pulses
- Posterior or lateral knee dislocation

Feliciano et al. *The Journal of Trauma: Injury, Infection, and Critical Care 2011*

Poor Prognostic Indicators

- Poor prognostic factors with significant posttraumatic amputation rates

  – Major soft tissue injury (26%)
  – Compartment syndrome (28%)
  – Multiple arterial injuries (18%)
  – Ischaemia duration > 6 h (24%)

Maslaris et al: *European Journal of Orthopaedic Surgery & Traumatology* (2018)

ABI (SBP) or API (doppler arterial pressure)

$$\frac{\text{SBP injured lower extremity}}{\text{SBP uninjured arm brachial}}$$

If either < 0.9 ➡ CTA, Angiography, or duplex US

OR If ABI or API of the affected limb vs uninjured limb > 0.1 ➡ CTA or Angio

API cutoff ≥ 0.9 to determine need for imaging is 95% sensitive, 97% Specific for arterial injury

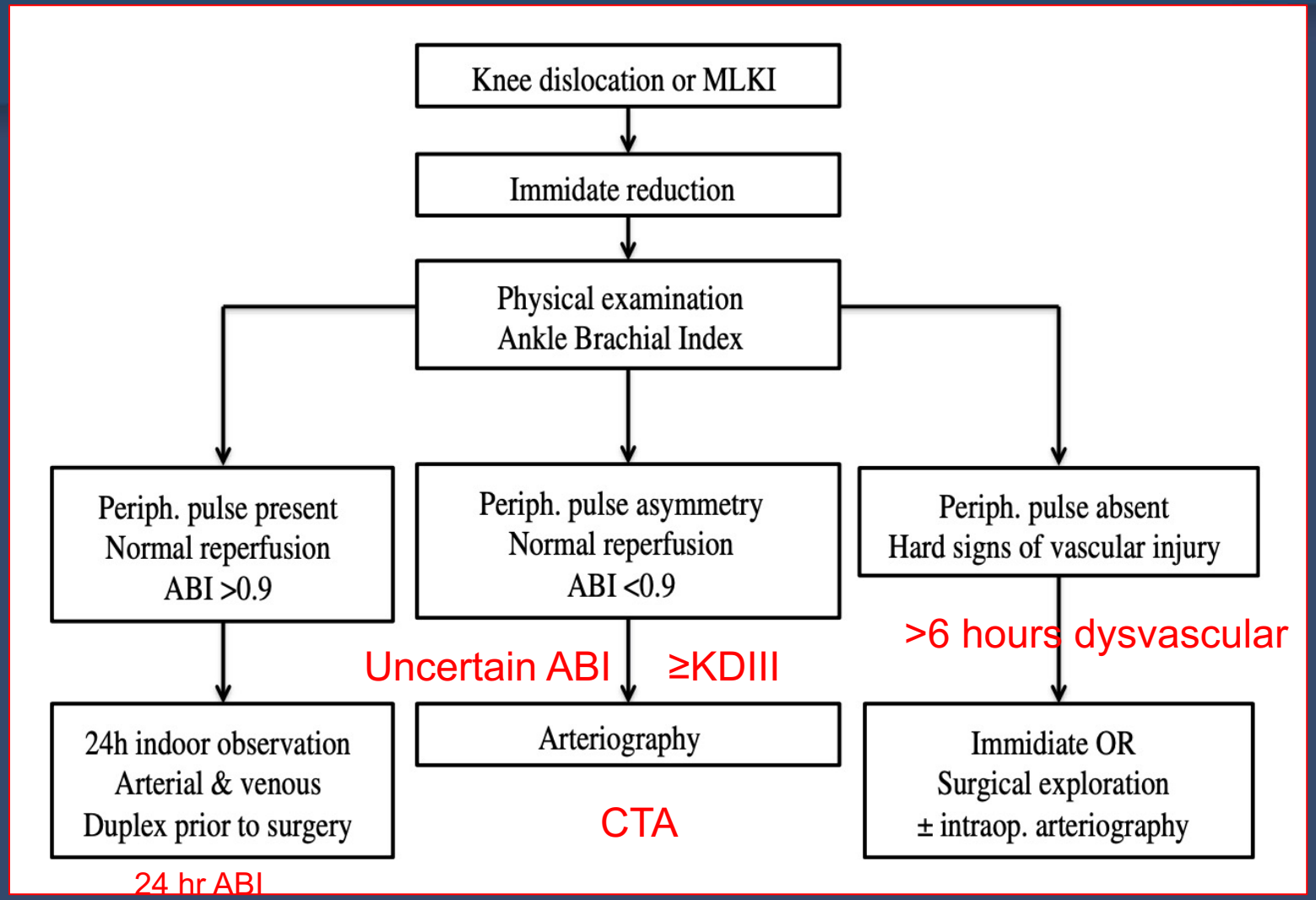
Lynch et al *Ann Surg* 1991

ABI result uncertain

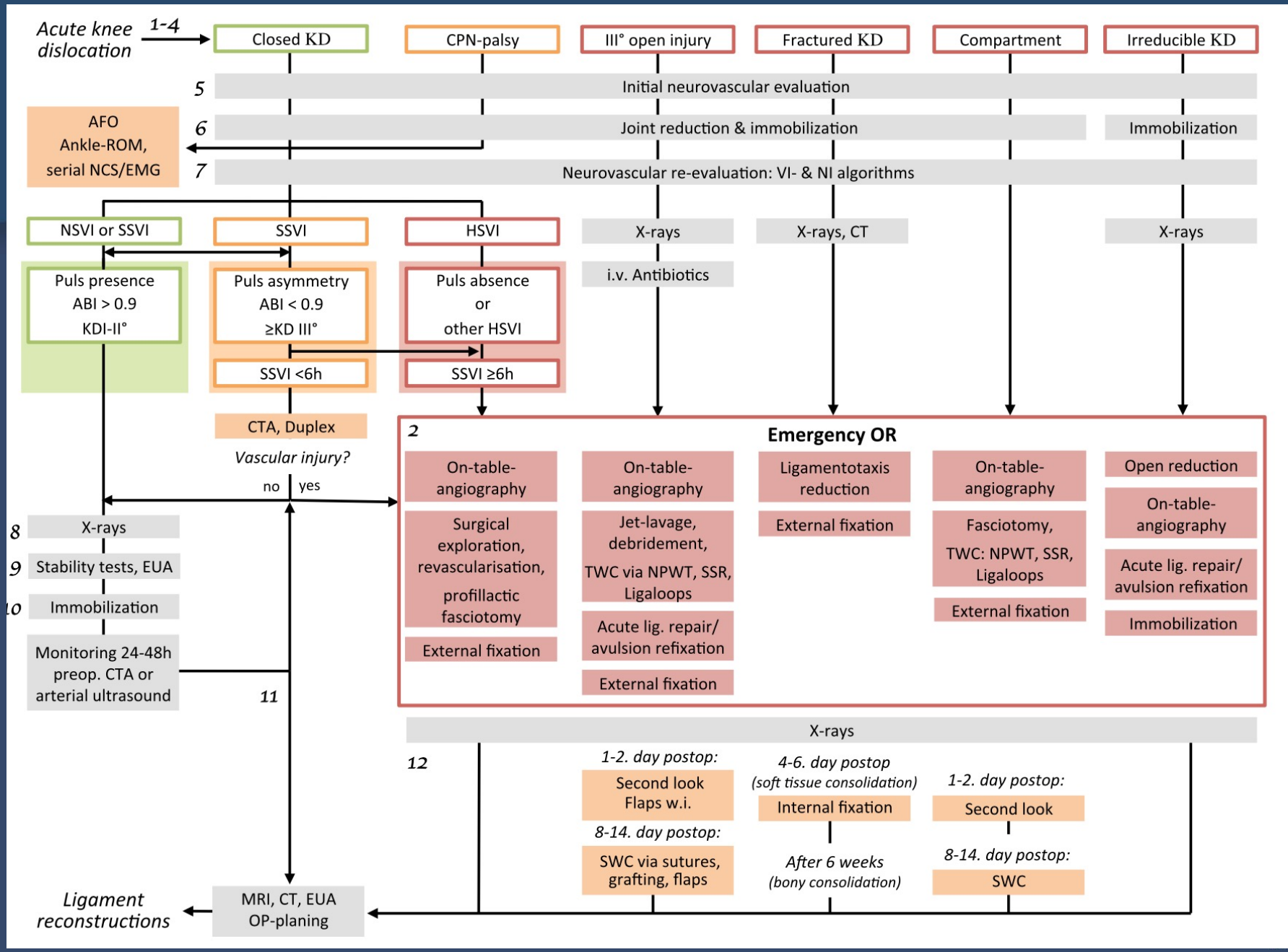
- Obesity
- Shock
- Hypothermia
- Pre-existing peripheral artery disease
- Multiple extremity trauma

– CT angio vs duplex sonography

Management Algorithm



Nicandri et al *Knee Surg Sports Traumat Arthrosc Off J ESSKA* 2010



Maslaris et al: *European Journal of Orthopaedic Surgery & Traumatology* (2018)

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Straight to OR

- Irreducible
- Hard signs of vascular injury
  - Vascular surgery might get CTA to localize
- Compartment Syndrome
- Open Injury +/- Fracture
- > 6 hours SSVI (prophylactic fasciotomy +/- vascular repair)

Common Peroneal Nerve Injury

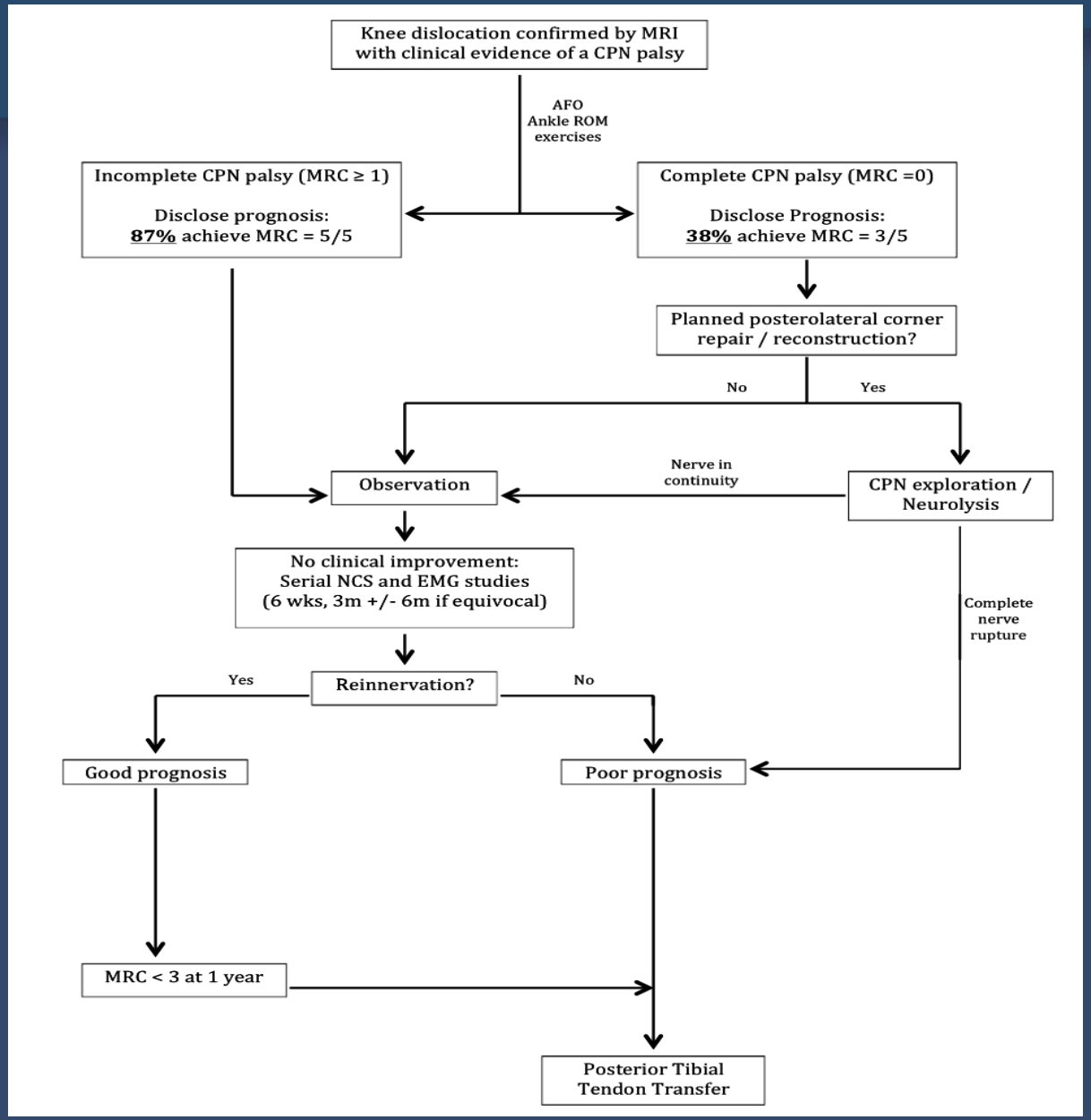
- 14-25% KD
- 45% with posterolateral dislocation
- 50% neural lesions after KD heal spontaneously
- Functional Foot Dorsiflexion Recovery ≥3/5
  - 38% complete CPN injuries
  - 87% partial CPN injuries
  - PTTT most reliable to restore function with persistent CPN palsy

Woodmass et al. *Knee Surg Sports Traumatol Arthrosc* (2015)

Common Peroneal Nerve Injury

- No difference from routine neurolysis
  - If 0/5 TA but nl EMG and positive intraop Nerve Action Potential (NAP) 100% recovery from neurolysis (no control)
    - Kim et al *Neurosurg* 1996
- Inadequate discouraging data for nerve repair, cable graft, nerve transfer
- PTTT most reliable
  - Expect 40% strength, 70% ROM contralat
    - Molund et al *Clin Orthop Relat Res* 2014

Woodmass Algorithm



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Immobilization

- External Fixator
  - Open Trauma
  - Vascular Injury
  - Compartment Syndrome
  - Unstable Fx Dislocation
  - Polytrauma
  - Obese
- Hinged Dynamic External Fixator
  - Angelini et al *Orthop Traumatol Surg Res* 2015
  - Popular 2002-2006
- Hinged Knee Brace

Surgical Outomes

Surgical Treatment of Combined PCL–ACL Medial and Lateral Side Injuries (Global Laxity): Surgical Technique and 2- to 18-Year Results

- 35 patients -16 chronic injuries, 9 acute
- 16/35 (46%) nl posterior drawer
- 33/35 (94%) nl Lachman
- 6/25 (24%) nl posterolateral stability
  - 19/25 over-tensioned from normal
- 22/25 (88%) nl varus stress test
  - 3/25 (12%) grade 1 opening (<5mm)
  - lysholm=91, tegner=5.3,
  - HS knee ligament rating scale 86

- 28 “global laxity”
- 2 mm KT1000 posterior drawer
- 0.2 mm KT1000 anterior drawer
- Lysholm 82, HSS= 89, tegner 4

Fanelli et al. *J Knee Surg* 2012

Surgical Outomes

Surgical Treatment of Combined PCL–ACL Medial and Lateral Side Injuries (Global Laxity): Surgical Technique and 2- to 18-Year Results

- 60% return to preinjury function
- 30% develop post traumatic OA at follow up

Fanelli et al. *J Knee Surg* 2012

Staged Surgical Management

Staged protocol for initial management of the dislocated knee

Bruce A. Levy · Aaron J. Krych · Jay P. Shah · Joseph A. Morgan · Michael J. Stuart

- 9 patients- PREOP ex fix
  - Open injury, vascular injury, inability to maintain reduction in brace
  - 75 days avg in ex fix prior to reconstruction (21-171)
- ROM 0-97, lysholm 76, IKDC 62, 44% HO
- 1+ laxity 2/9 (<5mm in varus/valgus)
- No Revisions
- 11% manipulation (13-57% in acute repair studies)

Acute vs. Delayed

SURGICAL TECHNIQUES

Surgical Management of Knee Dislocations

Chhabra, Anikar MD, MS[1]; Cha, Peter S. MD[2]; Rihn, Jeffrey A. MD[1]; Cole, Brian MD[3]; Bennett, Craig H. MD[4]; Waltrip, Robert L. MD[5]; Harner, Christopher D. MD[1]

Author Information

The Journal of Bone & Joint Surgery 87(1):p 1-21, March 2005. | ***DOI:*** 10.2106/JBJS.D.02711

31 pts: 19 acute/ 12 chronic

	Acutely repaired <3 weeks	**Chronically repaired >3 weeks**
lysholm	91	80
KOS-ADL	91	84
KOS- Sports	89	69
Excellent Meyer rating score	16/19 (84%)	7/12 (58%)
manipulation	4/19	0/12
Stability	No statistical difference	

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Review

TABLE 8. *Summary of Demographics and Functional Results in Studies Comparing Early With Late Surgical Treatment in Multiligament Knee Injuries*

	No. of Patients		Mean Age (yr)		Mean F/U (mo)		Mean Interval From Injury to Surgery (wk)		Mean Lysholm Score		Tegner Score		IKDC (% Excellent/ Good)	
Study	Early	Late	Early	Late	Early	Late	Early	Late	Early	Late	Early	Late	Early	Late
Tzurbakis et al.[32]	35	9	29	29	51	51	1	29	88	82	4	NR	77	56
Harner et al.[31]	19	12	29	29	44	45	2	28	91	80	NR	NR	53	8
Liow et al.[30]	7	14	26	27	25	38	1	123	87	75	5	4	43	36
Wascher et al.[14]	9	4	26	31	38	40	3	22	92	79	NR	NR	44	50
Fanelli et al.[29]	10	11	NR	NR	39	39	3	99	90	92	5	5	NR	NR
Total	80	50	28	29	40	43	2	51	90	82	5	5	47	31

TABLE 9. *Summary of Functional and Clinical Results in Studies Comparing Early With Late Surgical Treatment in Multiligament Knee Injuries*

	Knee Outcome Survey							
	Activities of Daily Living		Sports Activity		Mean ROM		Mean Flexion Loss	
Study	Acute	Chronic	Acute	Chronic	Acute	Chronic	Acute	Chronic
Tzurbakis et al.[32]	NR	NR	NR	NR	130°	132°	8°	6°
Harner et al.[31]	91	84	89	69	128°	129°	13°	10°
Liow et al.[30]	NR	NR	NR	NR	NR	NR°	4°	8°
Wascher et al.[14]	NR	NR	NR	NR	132°	126°	5°	3°
Fanelli et al.[29]	NR	NR	NR	NR	NR	NR	NR	NR
Total	91	84	89	69	130°	129°	7°	7°

Abbreviation: NR, not reported.

	pts	age	flexion	Clancy Excellent Outcome	Clancy Good outcome	Failure
Chronic multilig	35	35	95-135 (118 avg)	7/35 (20%)	14/35 (40%)	3/35 (8%)

Karatagis et al. *Knee Surg Sports Traumatol Arthrosc* 2006

Timing Conclusions

- Systematic review data shows trend towards better Outcome Scores with acute treatment
- Acute treatment associated with increase in arthrofibrosis and need for manipulation

Repair vs. Reconstruction

TABLE 6. *Summary of Demographics and Functional Results in Studies Comparing Repair With Reconstruction of Damaged Structures in Multiligament Knee Injuries*

	No. of Patients		Mean Age (yr)		Mean F/U (mo)		Mean Lysholm Score		IKDC (% Excellent/Good)		Failures	
Study	Repair	Recon	Repair	Recon	Repair	Recon	Repair	Recon	Repair	Recon	Repair	Recon
Stannard et al.[27]	35	22	31	36	33	33	88	91	71	77	37%	9%
Mariani et al.[28]*	17	6	25	35	83	83	85	85	24	25	NR	NR
Total	52	28	28	36	58	58	87	88	48	51	37%	9%

Levy et al. *Arthroscopy* 2009

- 12 Transosseous ACL/PCL repair vs 14 ACL/PCL reconstructions had no difference in lysholm, IKDC, Stability
  - Richter et al AJSM 2002
- 21 ACL/PCL/Lateral Injury treated with “en masse” lateral repair & ACL recon. Nonop PCL tx
  - 89% nl varus stress, 82% Neg Post Drawer,
  - Pts treated >4 weeks out had inferior lysholm, IKDC and return to sports
    - Shelbourne et al AJSM 2007

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Higher success rate observed in reconstruction techniques of acute posterolateral corner knee injuries as compared to repair: an updated systematic review

Luc M. Fortier, Derrick M. Knapik, Josh J. Condon, Daniel DeWald, Zeeshan Khan, Benjamin Kerzner, Matthew J. Matava, Robert LaPrade & Jorge Chahla

Knee Surgery, Sports Traumatology, Arthroscopy (2023) | Cite this article

- 12 studies, 288 patients
  - 87% overall success rate
  - 22% failure rate in repair vs 7% failure rate in reconstruction

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Rehab??

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Weightbearing Protocols After Posterolateral Corner Reconstruction: A Systematic Review

Brandon L. Morris, MD,* Tanner Poppe, BS,* Kenneth Kim, DO,† Brandon Barnds, MD,* Paul Schroeppel, MD,* Scott Mullen, MD,* Armin Tarakemeh, BA,* Megan Bechtold, DPT,* and Bryan G. Vopat, MD*‡

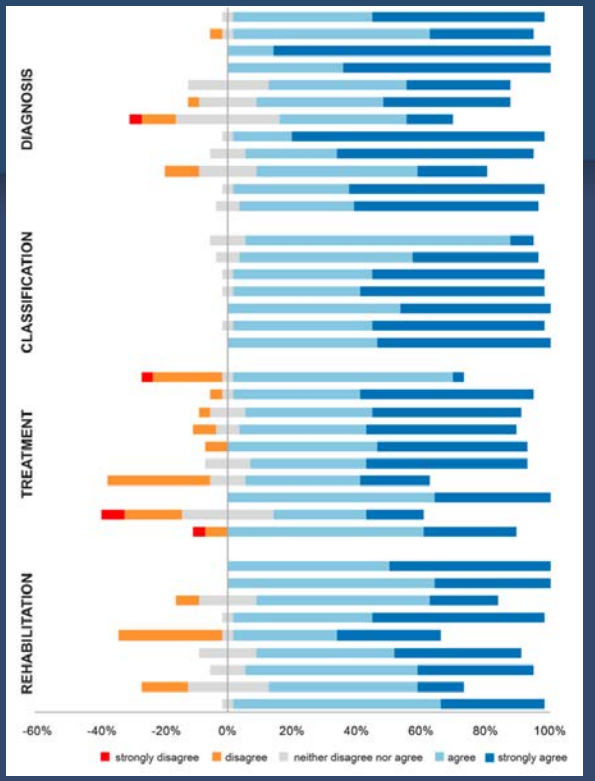
- 10 articles, 245 patients
  - Immediate WB, Progressive WB, Delayed WB
- No significant difference in outcome scores among the immediate, progressive, and delayed WB protocols.
- Time to permitted return to sport was not significantly different among the groups but trended toward significance, with the progressive WB cohort being earliest
- Delayed and immediate WB had higher overall complication rates

Examples

- Fanelli: 3 weeks NWB with knee locked in extension, progressive ROM weeks 4-6, progressive WB starts at 6 weeks, Brace X 10 weeks, sports after 9 months
- Harner: Locked in extension X2 weeks, passive ROM 2-6 weeks, start AROM at 6 weeks. Partial Progressive WB X 4 weeks then full unless PLC. Jog OK at 6 months, sports at 9 months

Posterolateral corner of the knee: an expert consensus statement on diagnosis, classification, treatment, and rehabilitation

Jorge Chahla ✉, Iain R. Murray, James Robinson, Koen Lagae, Fabrizio Margheritini, Brett Fritsch, Manuel Leyes, Björn Barenius, Nicolas Pujol, Lars Engebretsen, Martin Lind, Moises Cohen, Rodrigo Maestu, Alan Getgood, Gonzalo Ferrer, Silvio Villascusa, Soshi Uchida, Bruce A. Levy, Richard Von Bormann, Charles Brown, Jacques Menetrey, Michael Hantes, Timothy Lording, Kristian Samuelsson, Karl Heinz Frosch, Juan Carlos Monllau, David Parker, Robert F. LaPrade & Pablo E. Gelber



- A future classification system should indicate the structures injured, the type of injury (avulsion versus intrasubstance) and chronicity (100%)
- A future classification system should guide treatment and reflect prognosis (100%)
- Acute posterolateral corner injuries should be surgically addressed within 2–3 weeks following injury (83%)
- Common peroneal nerve neurolysis should be performed systematically when performing a PLC reconstruction (57%)
- Hybrid procedures—reconstruction of primary structures (FCL, popliteus and popliteofibular ligament) and repair of secondary restraints (biceps avulsions, lateral capsule, iliotibial band avulsions) can yield satisfactory outcomes (100%)
- Repair of primary PLC structures (FCL/popliteus tendon) is a valid treatment option in bone avulsions Rehabilitation (87%)
- An early mobilization protocol (starting with range of motion on day 1) should be implemented to avoid arthrofibrosis (85%)

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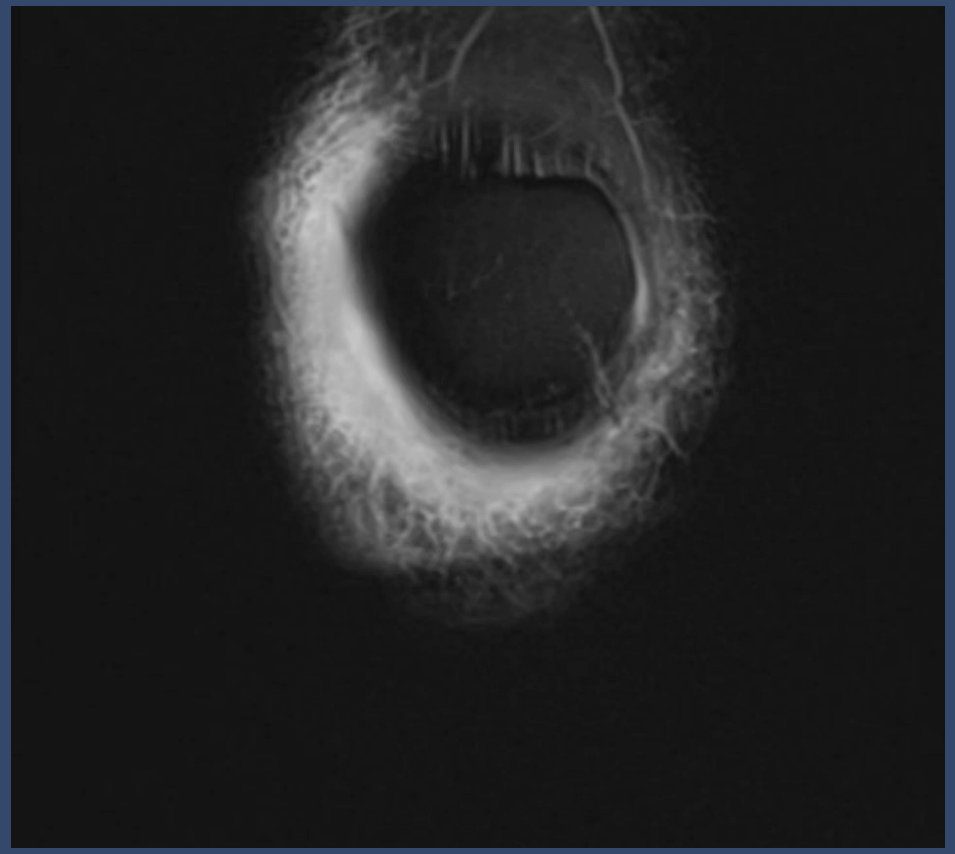
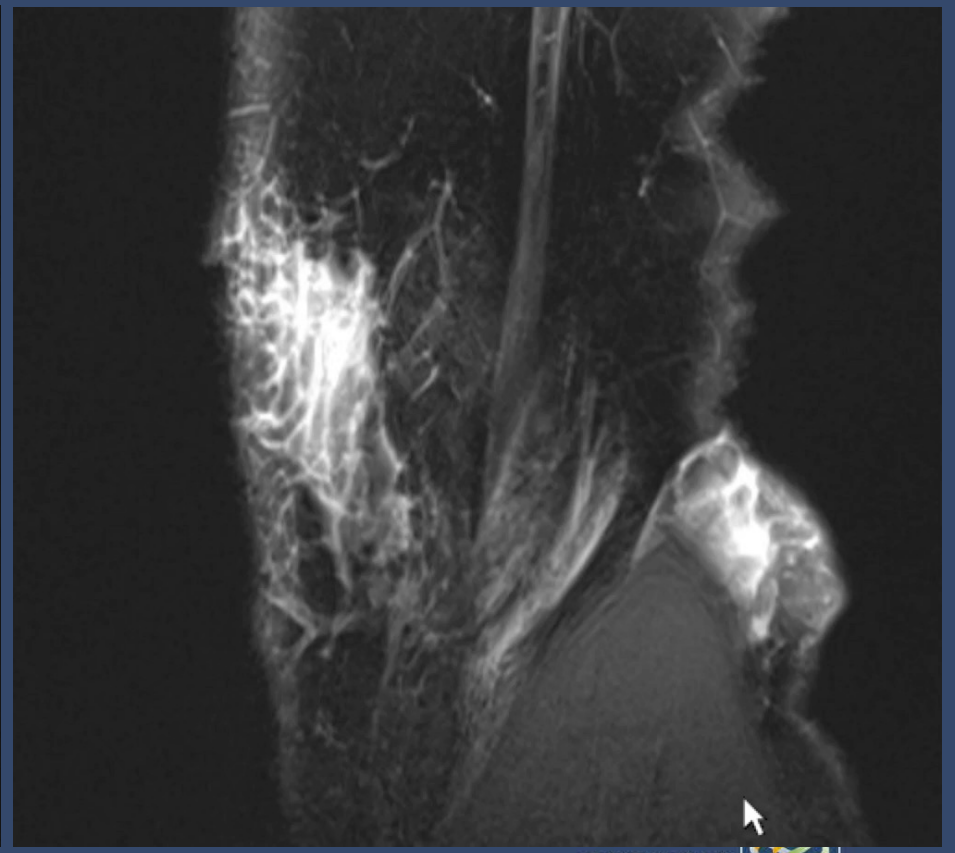
Clinical Case 1

- 31 yo cyclist crashed with laceration to anterior knee





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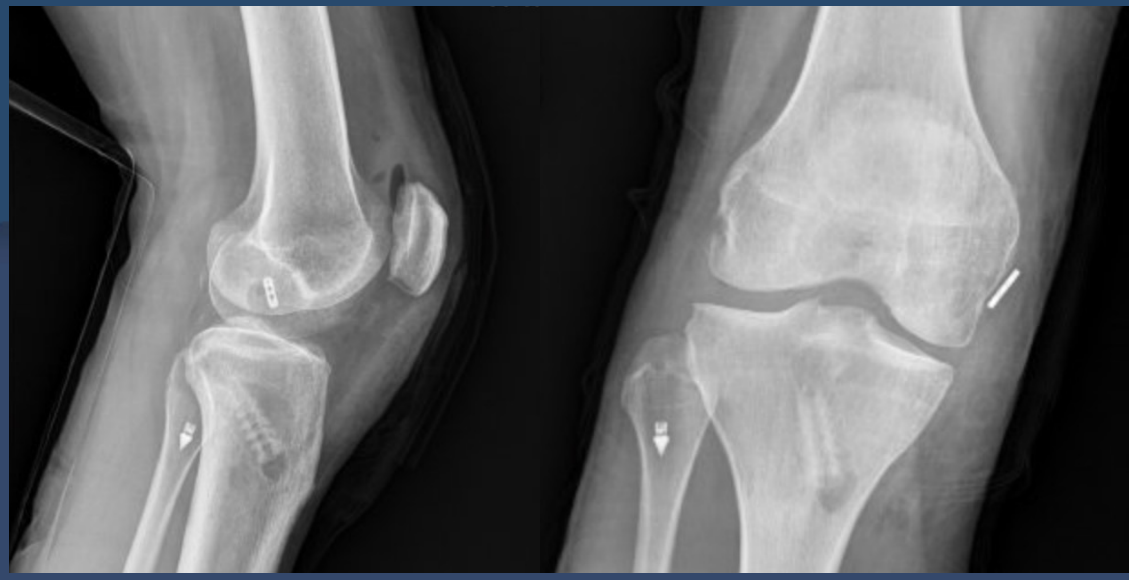

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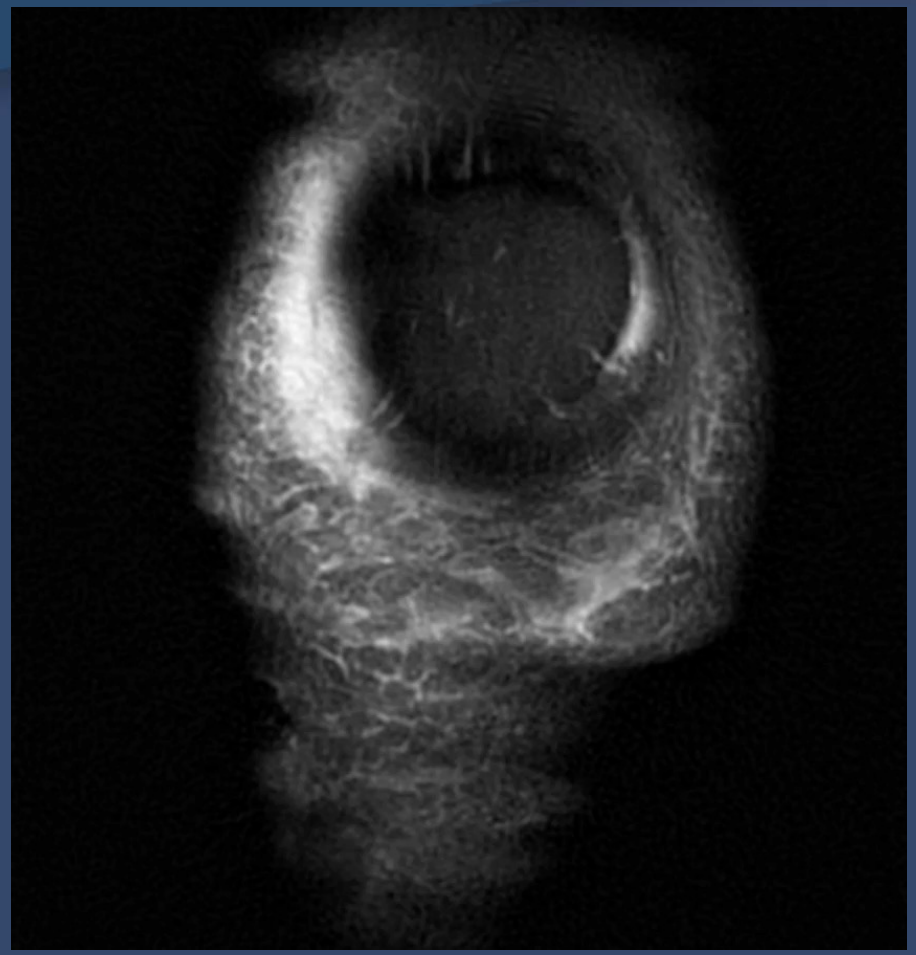
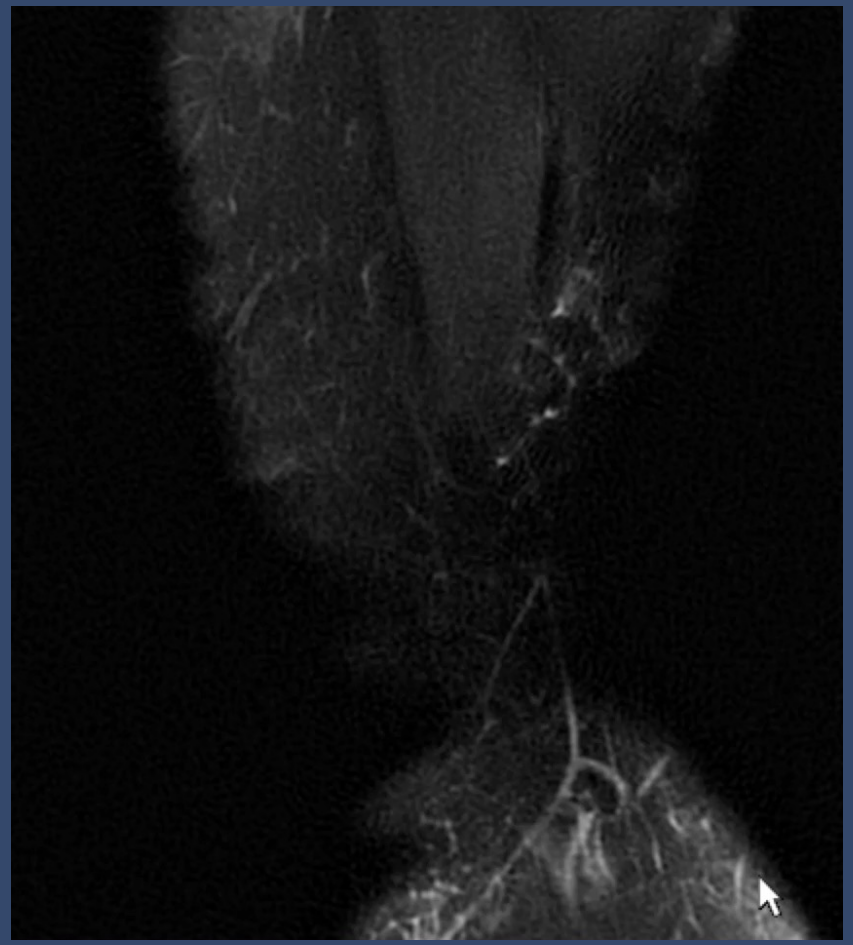
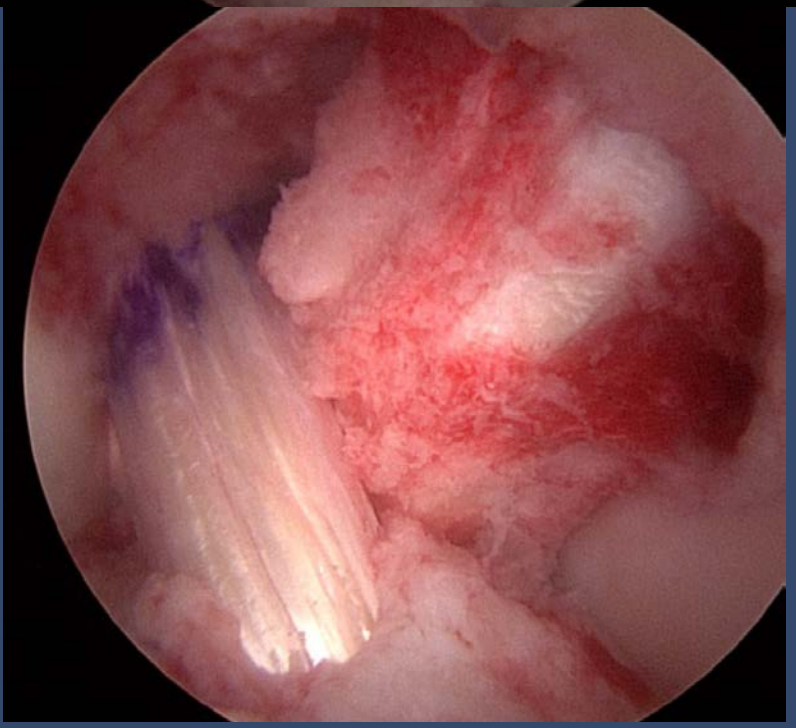
Clinical Case 2







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STaR (Surgical Timing and Rehab) Trial

- Aim 1: Acute vs delayed surgery
  - 6 weeks vs 12 weeks
- Aim 2: Early vs delayed rehabilitation
  - Start with weight bearing vs delay it

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POSSIBLE GROUPS:

AIM 1:

- **Early Surgery and Early Rehabilitation**
- **Early Surgery and Delayed Rehabilitation**
- **Delayed Surgery and Early Rehabilitation**
- **Delayed Surgery and Delayed Rehabilitation**

AIM 2:

- **Early Rehabilitation**
- **Delayed Rehabilitation**

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Inclusion Criteria

- Age 16 – 55 years
- Grade III injury of 2 or more ligaments
- Aim 1: must be able to have surgery within 6 weeks

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Exclusion Criteria

- Ex fix use 10 or more days
- Vascular injury precluding early rehab
- Polytrauma precluding inability to participate in post-op care
  - Skin/soft tissue injury
  - Surgical procedure (patellar tendon repair, vascular repair)
  - Any condition precluding inability to participate (head injury, developmental delay)

Early vs. Delayed Surgery for MLKI

Aim 1

Early Surgery

- Definitive surgery performed within 6 weeks of injury

Delayed Surgery

- Definitive surgery between 12 and 16 weeks after injury

Aim 2

Surgery should be performed when clinically indicated

Surgical Principles for MLKI in the STaR Trial (Aims 1 & 2)

STaR TRIAL

- Surgery may include primary repair, augmentation, and/or reconstruction
- Should be performed anatomically and allow for early motion and weight bearing
- Graft choice for reconstruction is not standardized
- Address cartilage & meniscus lesions as necessary

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Early vs. Delayed Surgery for MLKI

STaR TRIAL

At the conclusion of surgery:

- Hinged, long-leg brace will be placed on the patient's knee joint
  - Locked in extension (anatomic 0°)

- Record the following (decision at discretion of surgeon)
  - Medication for pain control
  - Anti-coagulation/deep vein thrombosis prophylaxis
  - Antibiotics
  - Discharge decision – home vs. admit to the hospital for monitoring

Early vs. Delayed Rehabilitation for MLKI

STaR TRIAL

Early Rehabilitation

- After the first post-op visit:
  - Weight bearing as tolerated
  - Unrestricted motion in ROM brace
- NOT an "accelerated" protocol
  - No overpressure
  - No end-range stretching/mobilization
  - No painful weight bearing

Delayed Rehabilitation

- First four weeks after surgery:
  - Brace locked in extension
  - No joint motion
  - Non-weight bearing gait

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Eligibilty

- Do NOT exclude
  - Nerve injury
  - Avulsion/rupture of biceps or popliteus

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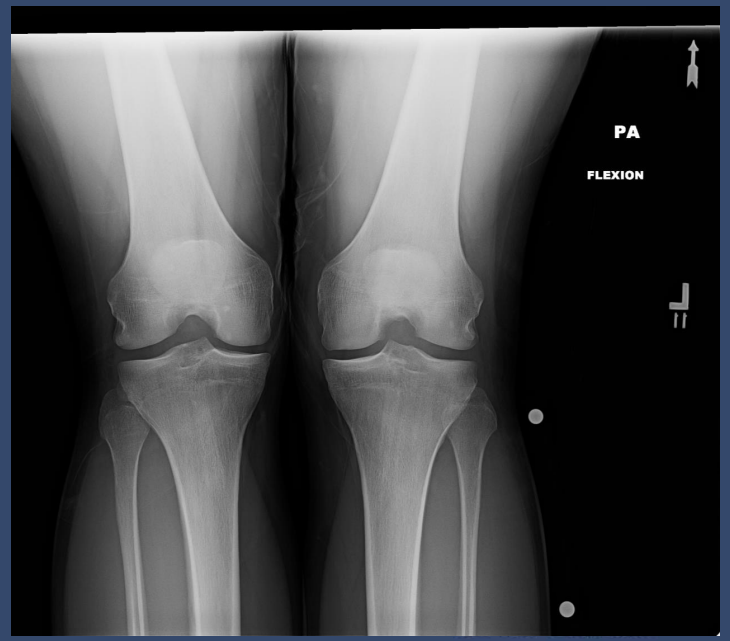
? Eligibility Case 1

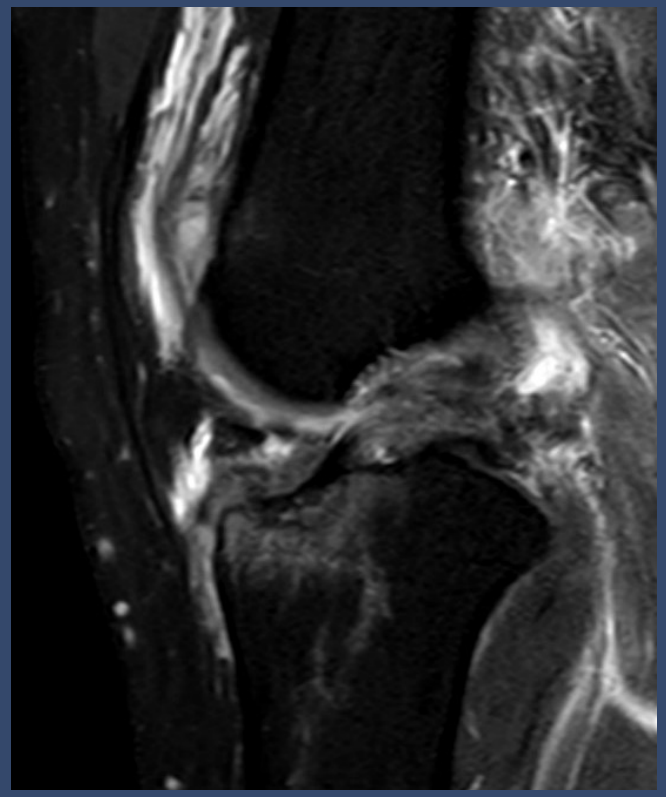
- 31 y/o M
- Injury to left knee 3 weeks ago
- 2B Lachman
- Grade 3 posterior drawer with sag
- Varus/valgus/dial neg



- Right distal radius fx

Case 1

- MRI confirms ACL/PCL
- Eligible?
  - If able to bear weight (platform walker)



? Eligibility Case 2

- 17 y/o M
- Football injury
- Dislocation during practice, reduced in ED

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Case 2

- Placed in ex fix at outside hospital
- ABI normal
- 2+ pulses
- Neuro exam intact

- MRI confirms ACL/PCL/MCL

- Eligible?
  - Only if ex fix off before 10 days

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Summary

- Multiligamentous injuries are a spectrum of injuries
- Timing of surgery for optimal results is inconclusive
- Increased arthrofibrosis for acute surgery
- Reconstruction of the posterolateral corner has lower failure rate than repair (unless bony avulsion)
- Rehab is anyone's call

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Thank you

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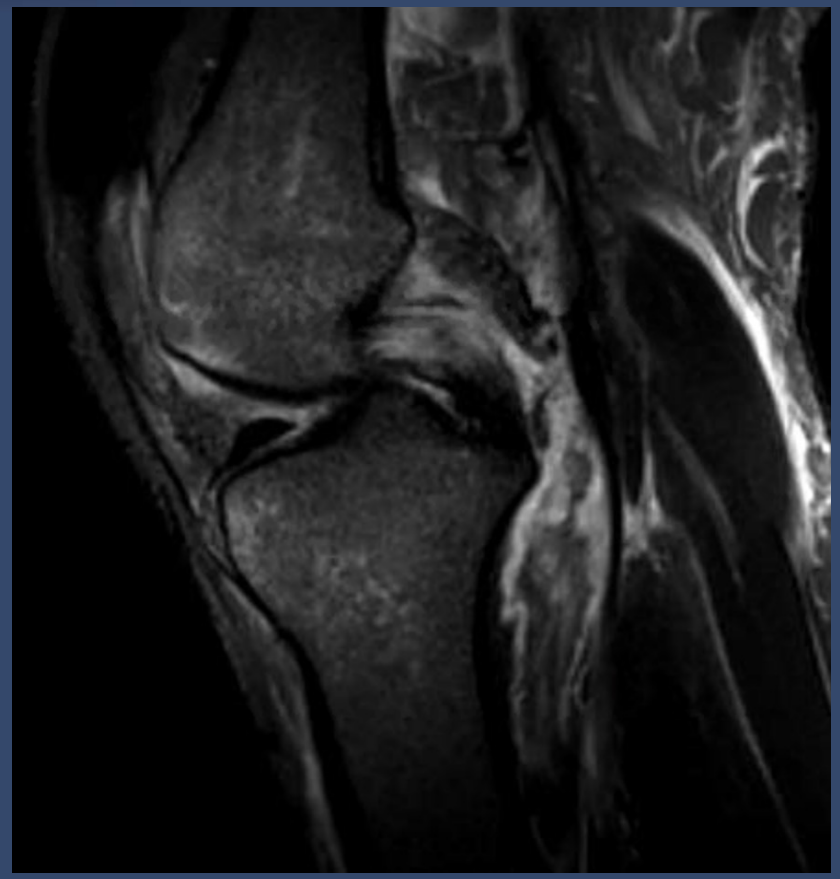
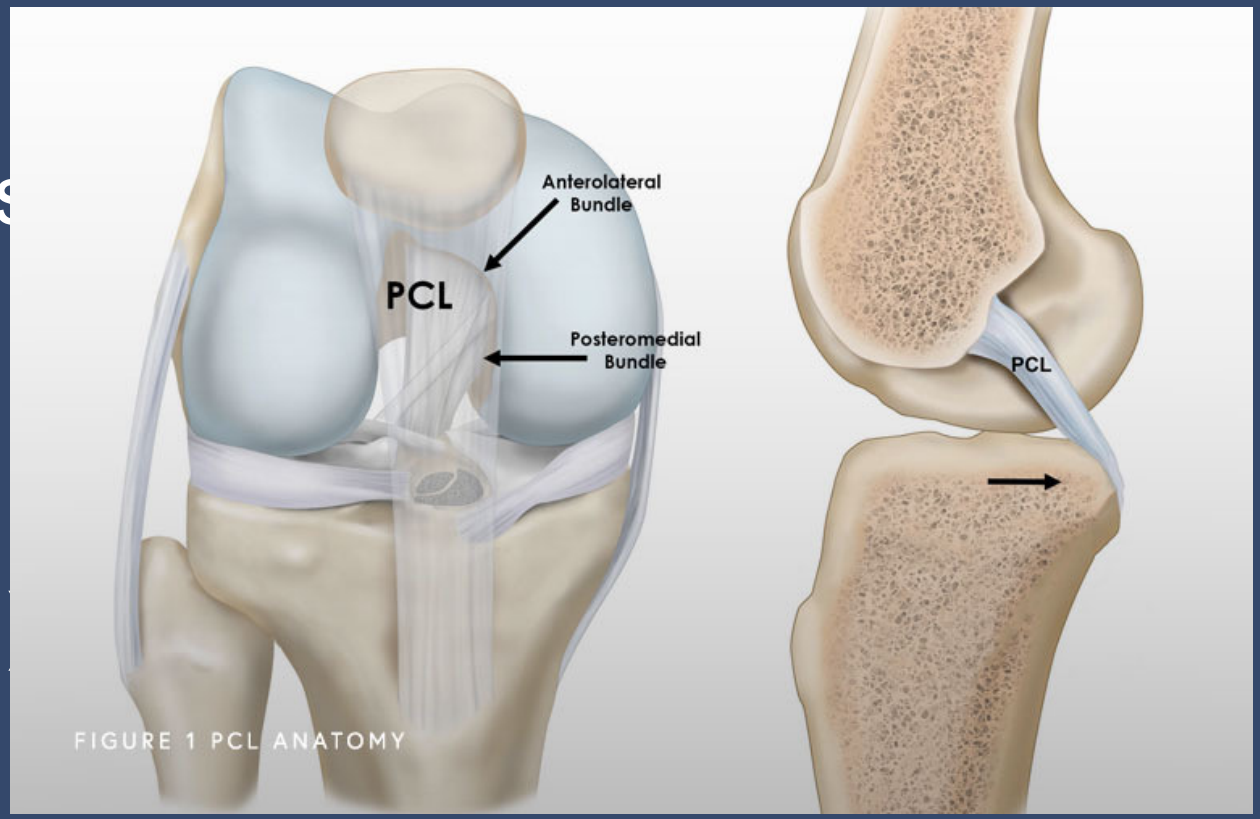
What we know

- PCL injuries
  - Injury in isolation is rare
  - Acute PCL reconstruction = risk for stiffness
  - Beware radiology read of “Grade 3”



PCL

- Two bundles
- (Images courtesy of Jorge Chahla, MD)



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PCL: posterior sag

PCL quad active test (contract quad)

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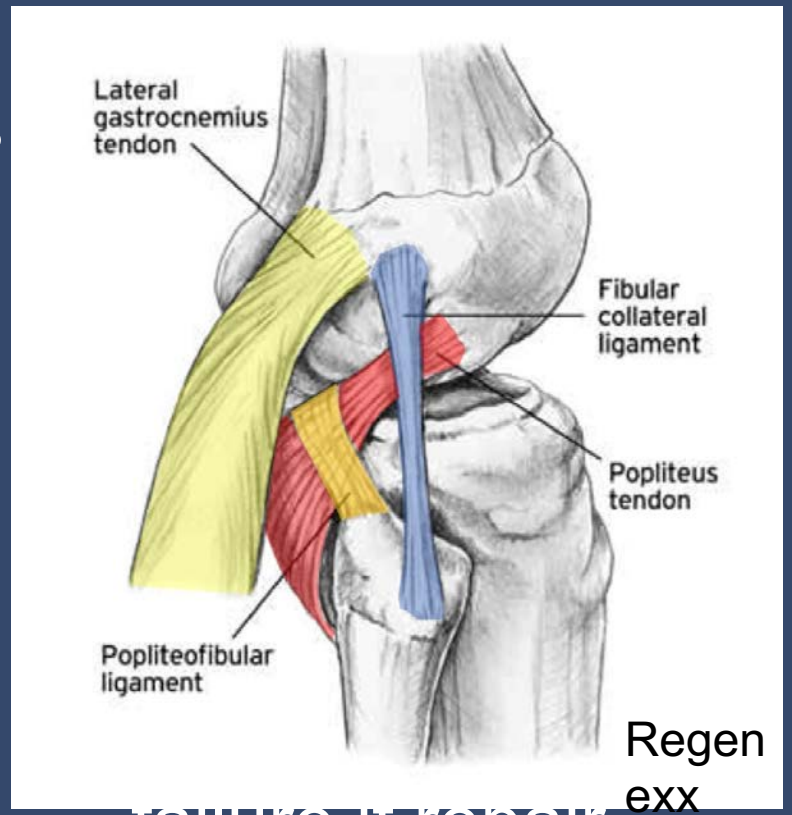
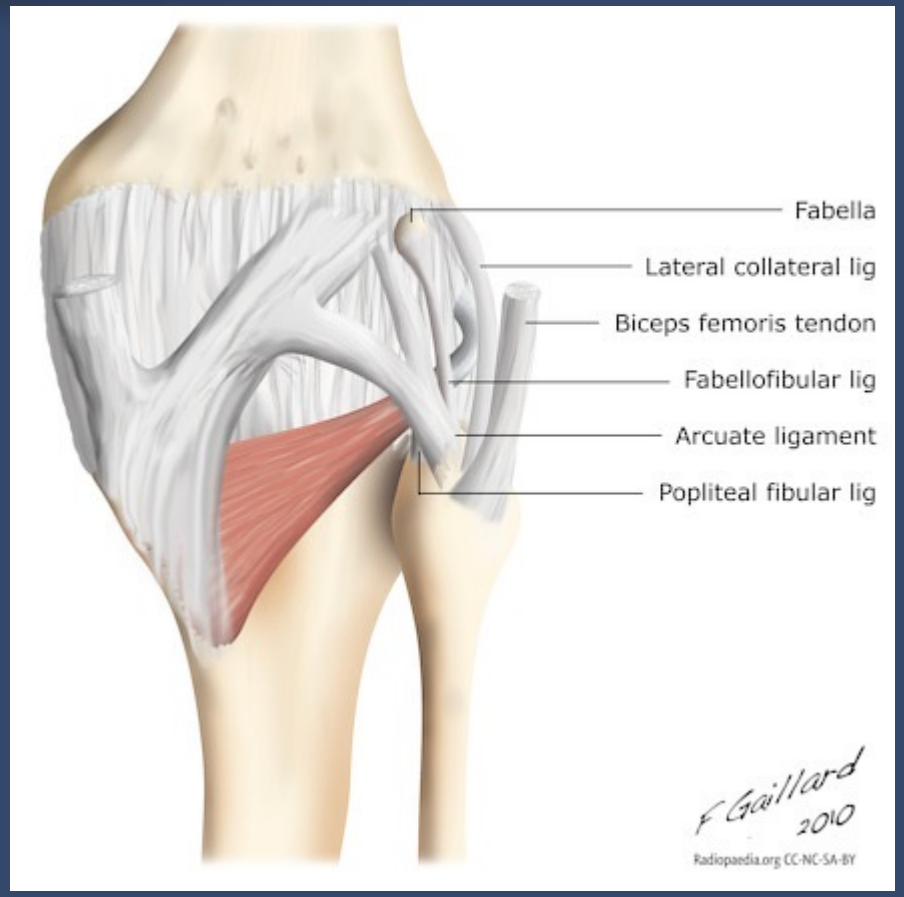
What we know



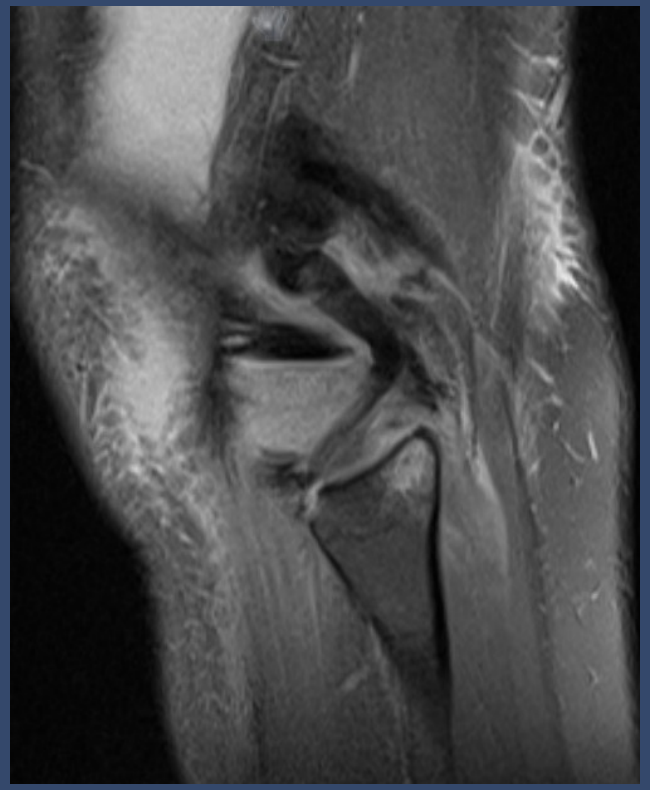


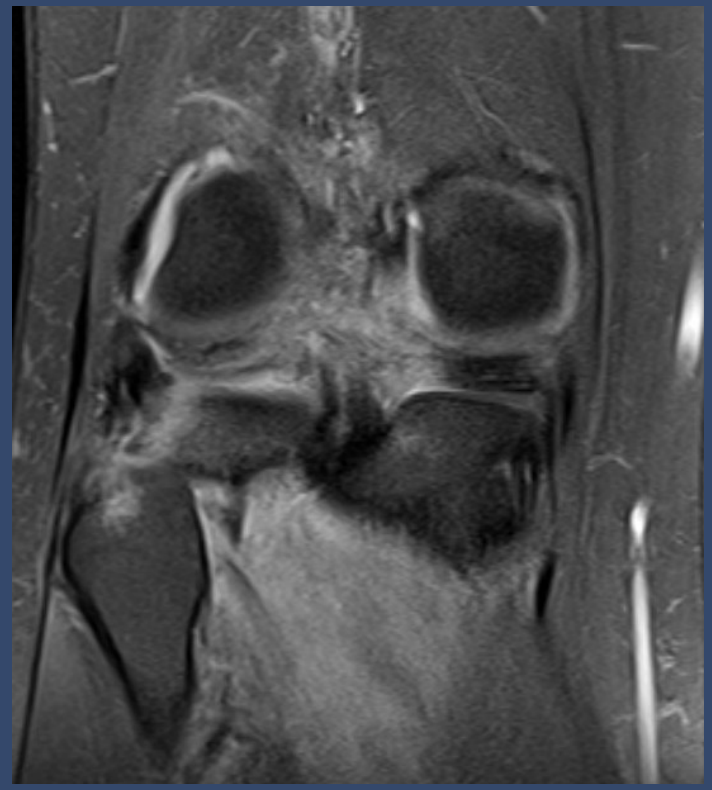
- Regen exx

failure if repair alone

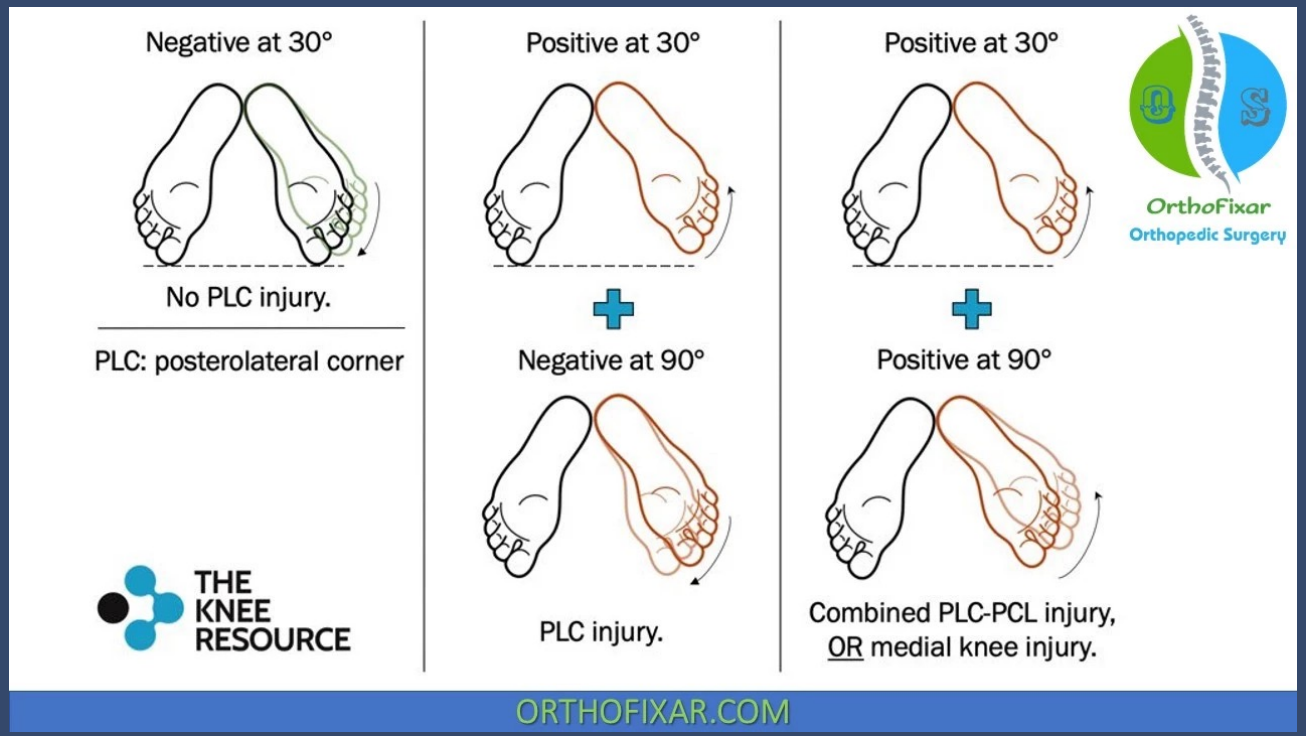
- Both Stannard and

Fibular Attachments



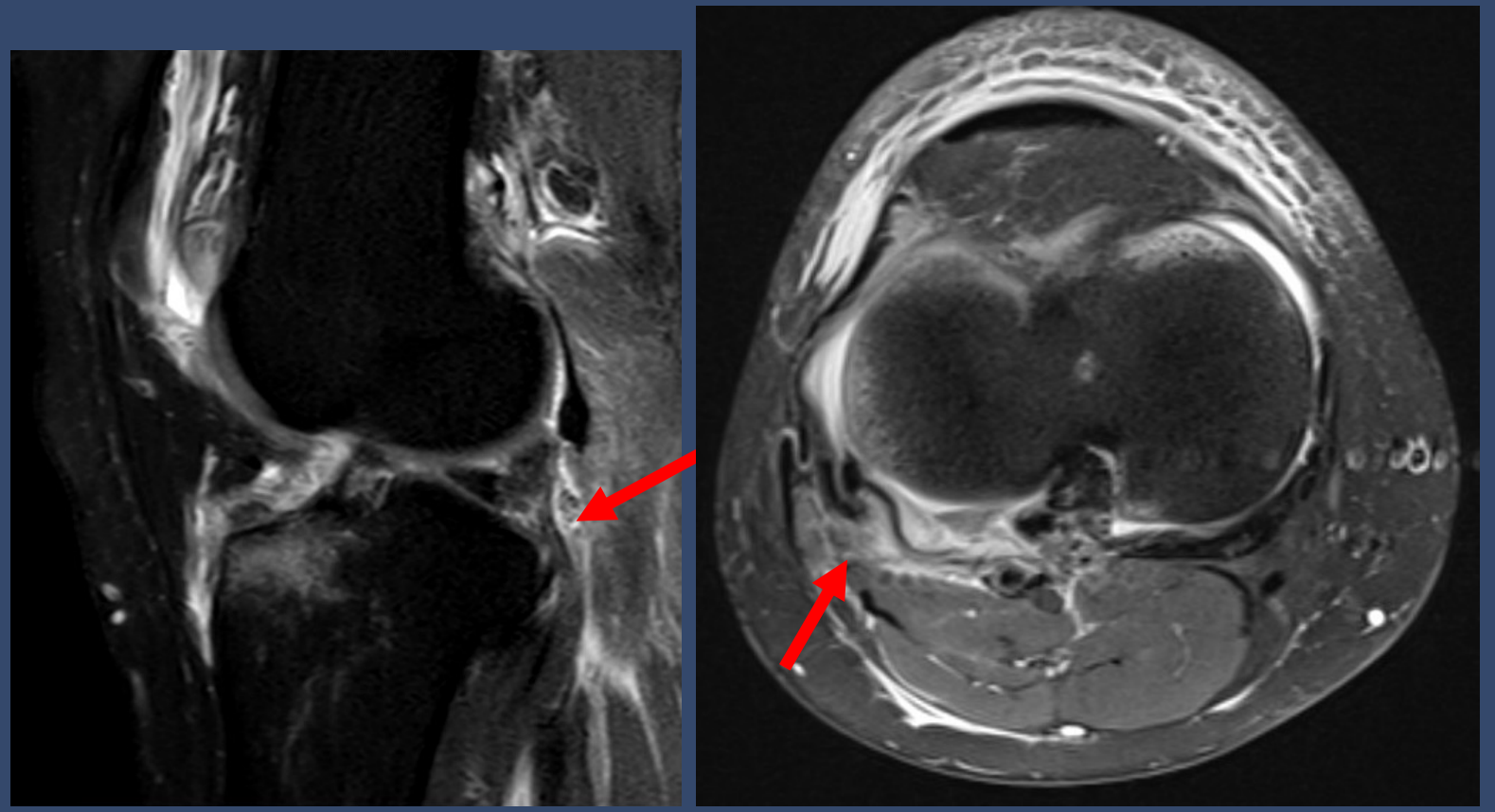


Dial Test


Negative at 30°
No PLC injury.
PLC: posterolateral corner
THE KNEE RESOURCE
Positive at 30°
Negative at 90°
PLC injury.
Positive at 30°
Positive at 90°
Combined PLC-PCL injury, OR medial knee injury.
OrthoFixar
Orthopedic Surgery
ORTHOFIXAR.COM

Stress Views can be Helpful

Don’t forget popliteus myotendinous junction

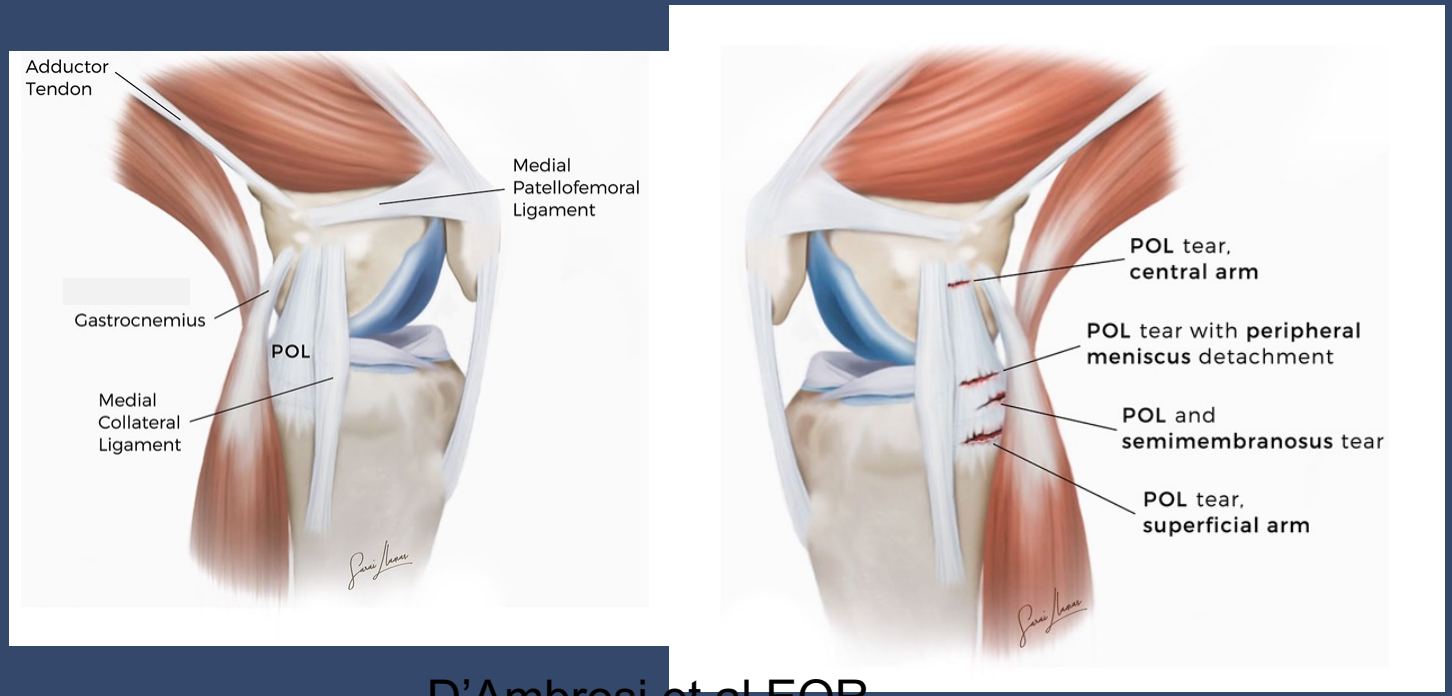


What we know

- MCL injuries
  - If simple and femoral-sided, might heal well enough to ignore
    - Not always the case with multiligament knee injuries
    - Less predictable for intrasubstance/tibial side
  - Look for valgus opening in FULL EXTENSION
    - Posterior oblique ligament/posteromedial

Posterior Oblique Ligament

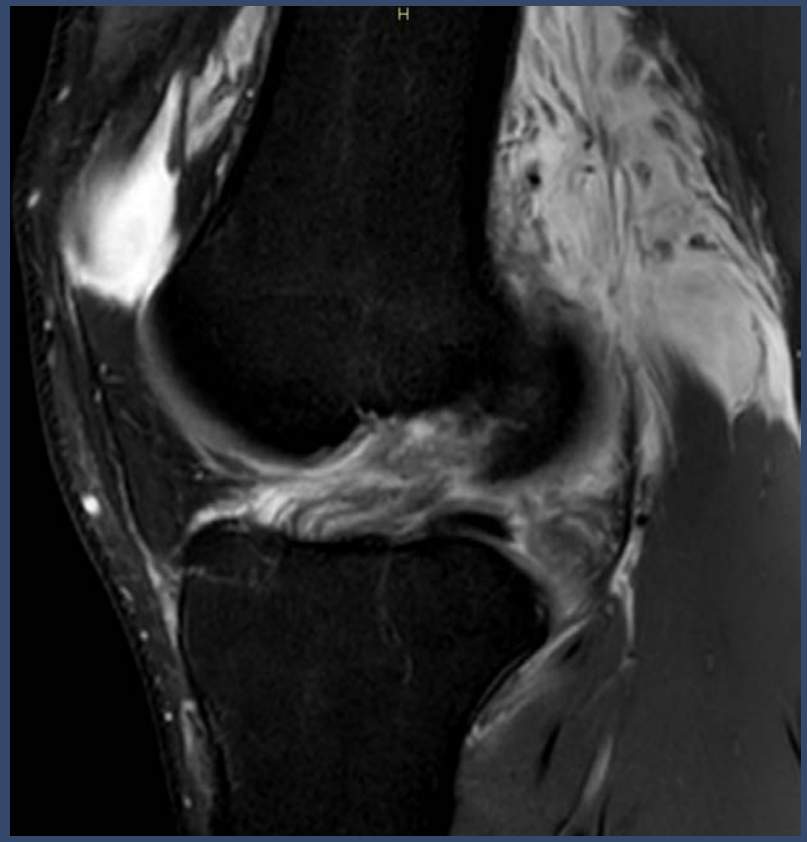
- Valgus opening in extension



D'Ambrosi et al EOR May 2021

What we know

- ACL injuries
  - Higher rate of failure if ipsilateral other ligament injury ignored
  - When in isolation, failure rates go up with

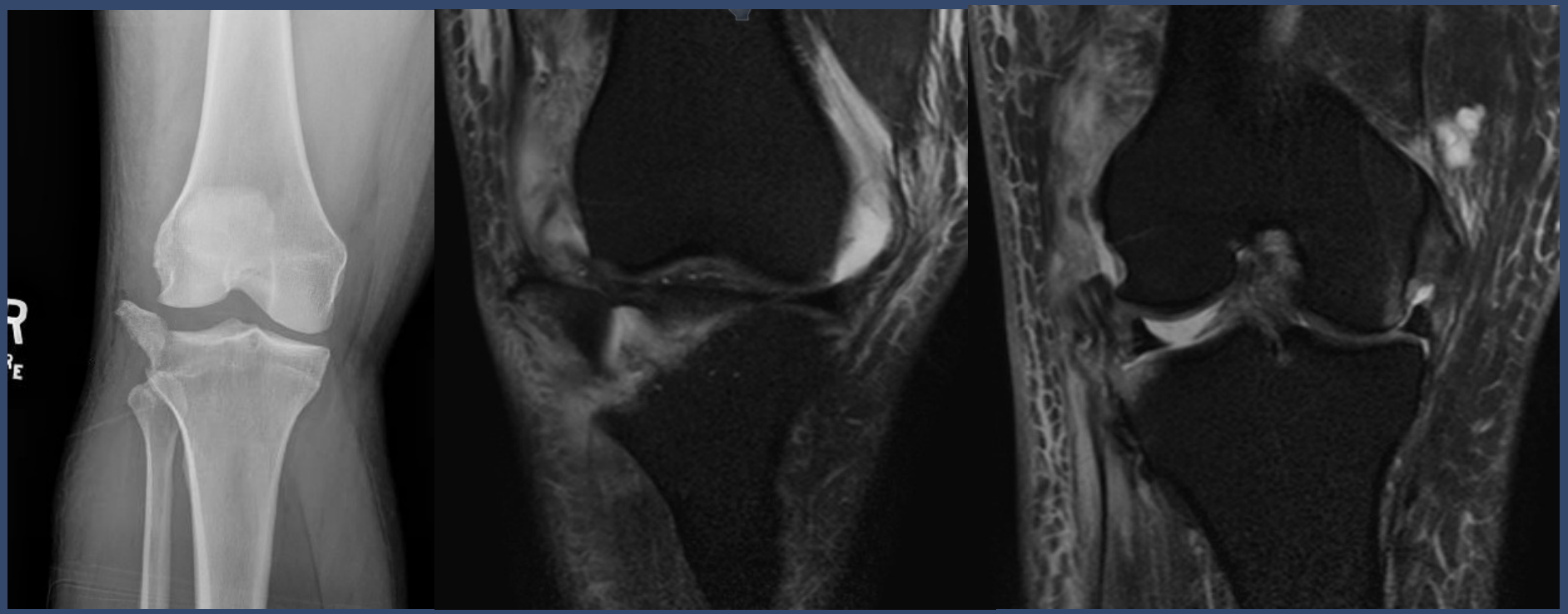


Bony edema and mechanism

Beware the tibial rim fracture

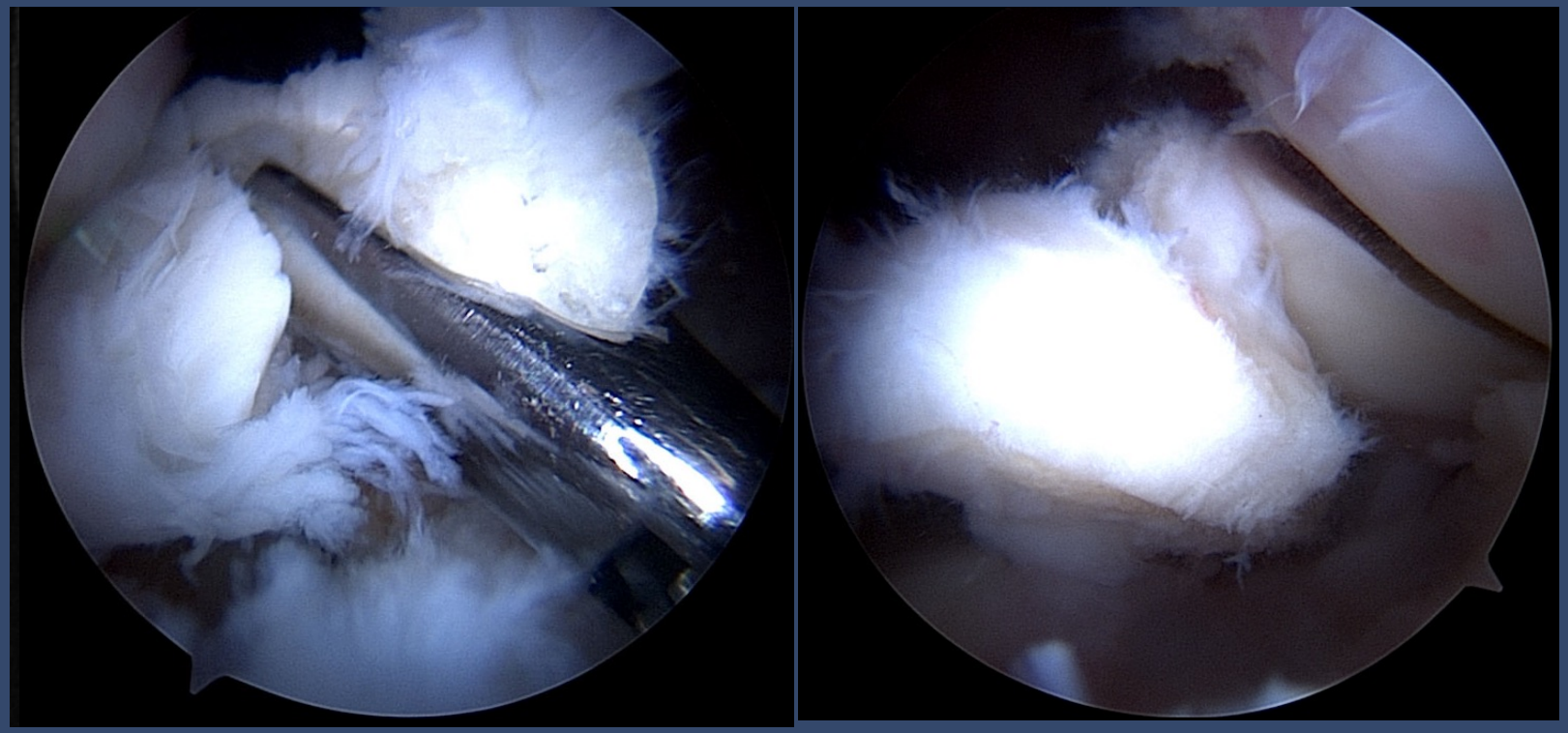
Subtle tibial rim fracture

Not just a “tibial plateau”

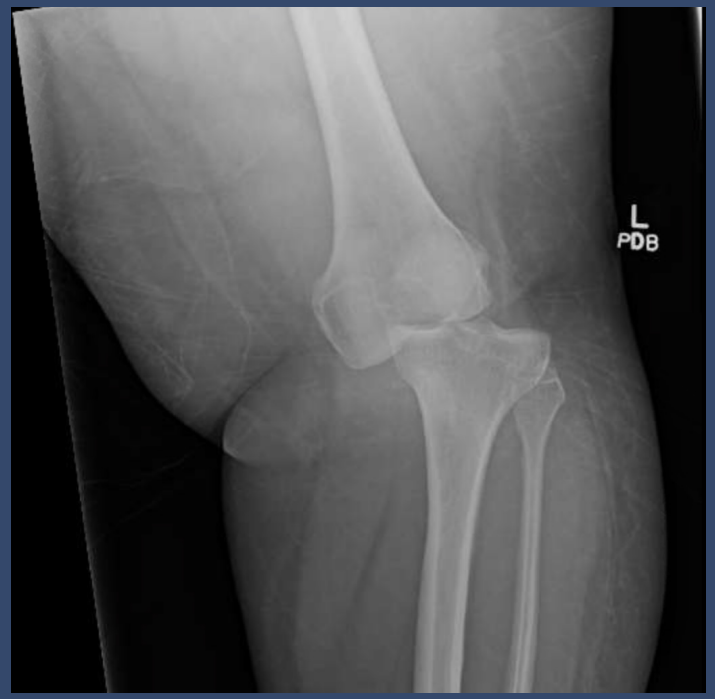


Not just a “tibial plateau”

Not just a “tibial plateau”



Meniscus Pathology Can Drive Deformity



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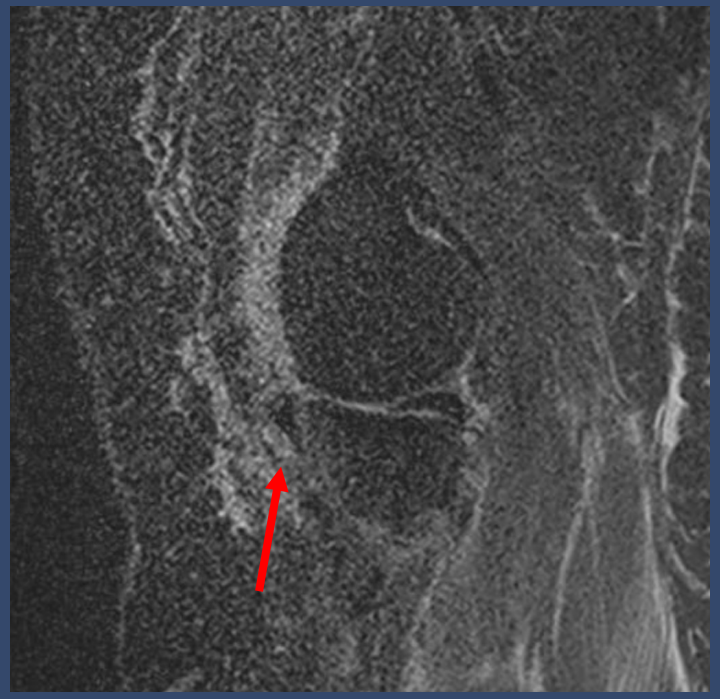
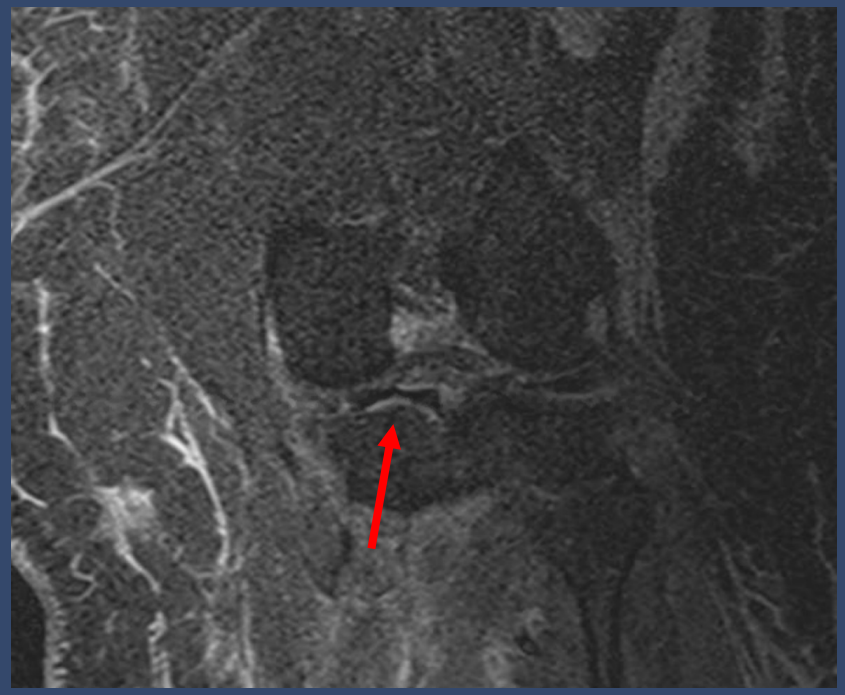
Medial Meniscus Tear





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Ex Fix Removed, and…

Pattern of Deformity

Medial Meniscus Bucket Handle Tear

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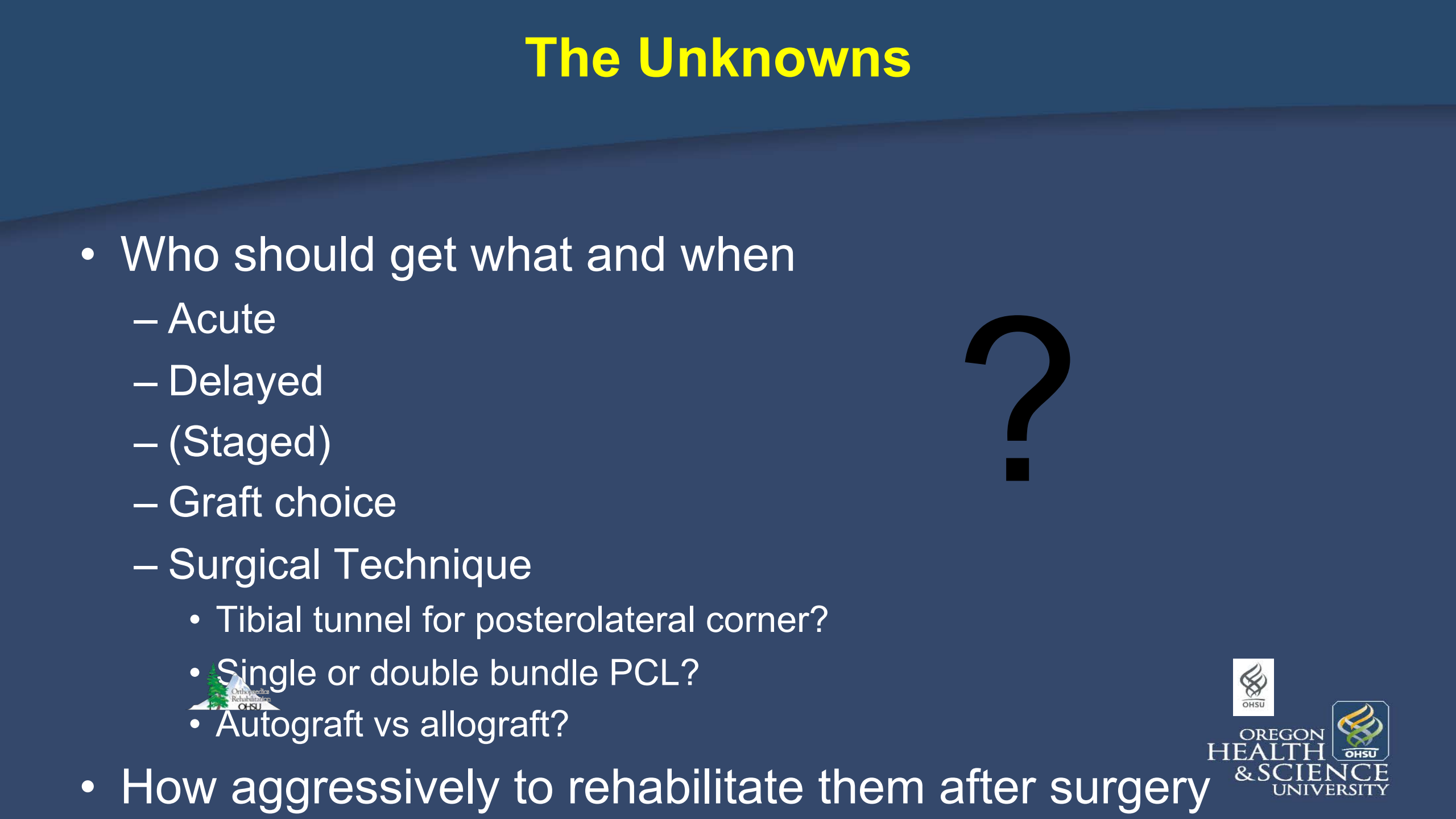
Pattern of Deformity

The Unknowns

- Who should get what and when
  - Acute
  - Delayed
  - (Staged)
  - Graft choice
  - Surgical Technique
    - Tibial tunnel for posterolateral corner?
    - Single or double bundle PCL?
    - Autograft vs allograft?
- How aggressively to rehabilitate them after surgery



Equipoise

- Balance of forces or interests
- Research: non-inferiority