Biomechanics of the Knee

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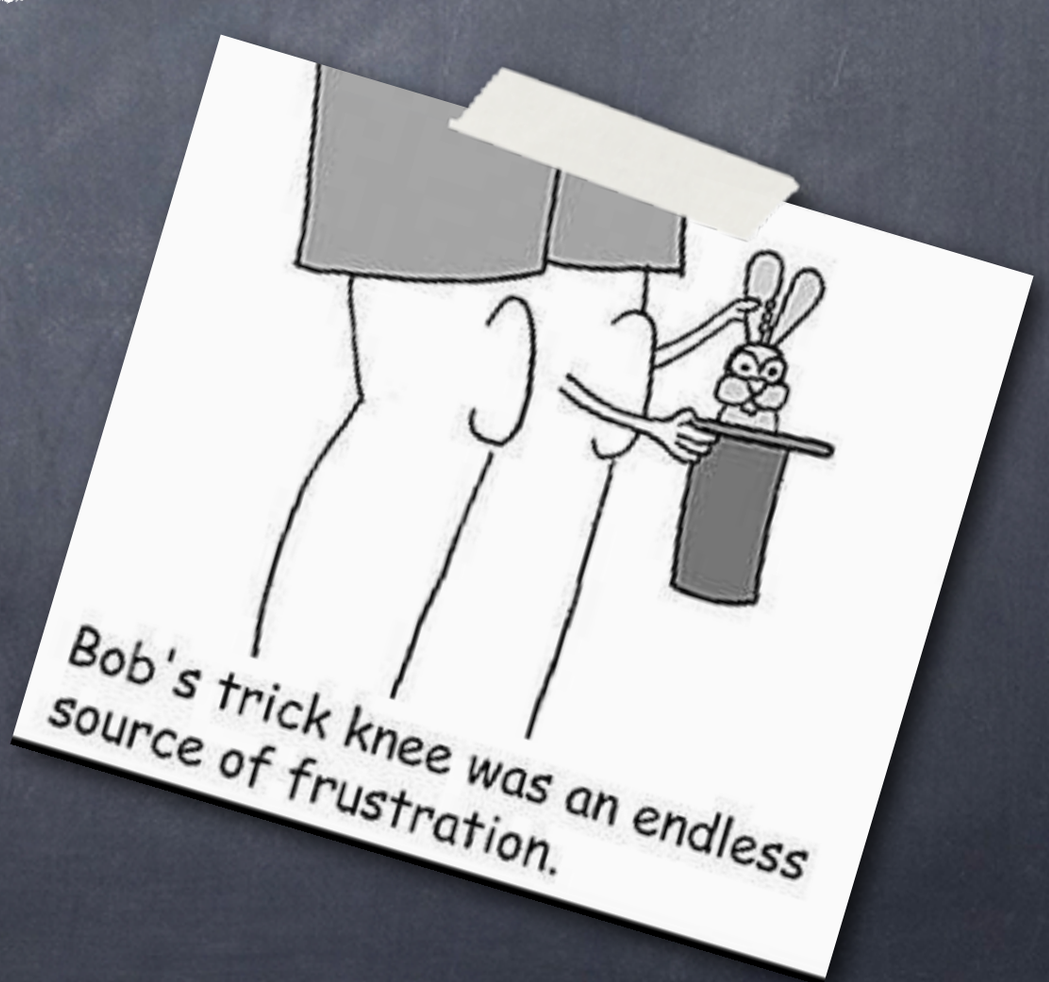
Introduction

- Biomechanics - (ˌbʌɪəʊmɪˈkanɪks)
- plural noun (treated as singular)
- "the study of the mechanical laws relating to the movement or structure of living organisms."



Today's Summary!

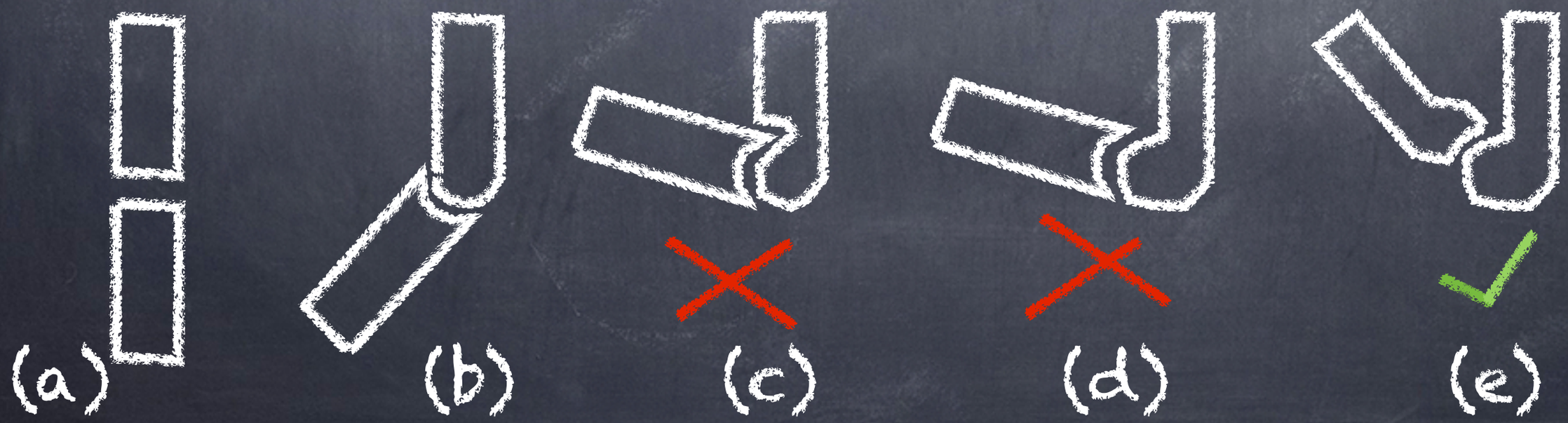
- Passive Motion of the Knee
- Function and Interplay of the Cruciate Ligaments
- Function of the menisci
- Collateral Ligaments and Varus / Valgus motion
- Properties of the Retinaculum
- ~~Patellofemoral Biomechanics~~

Passive Motion of The Knee

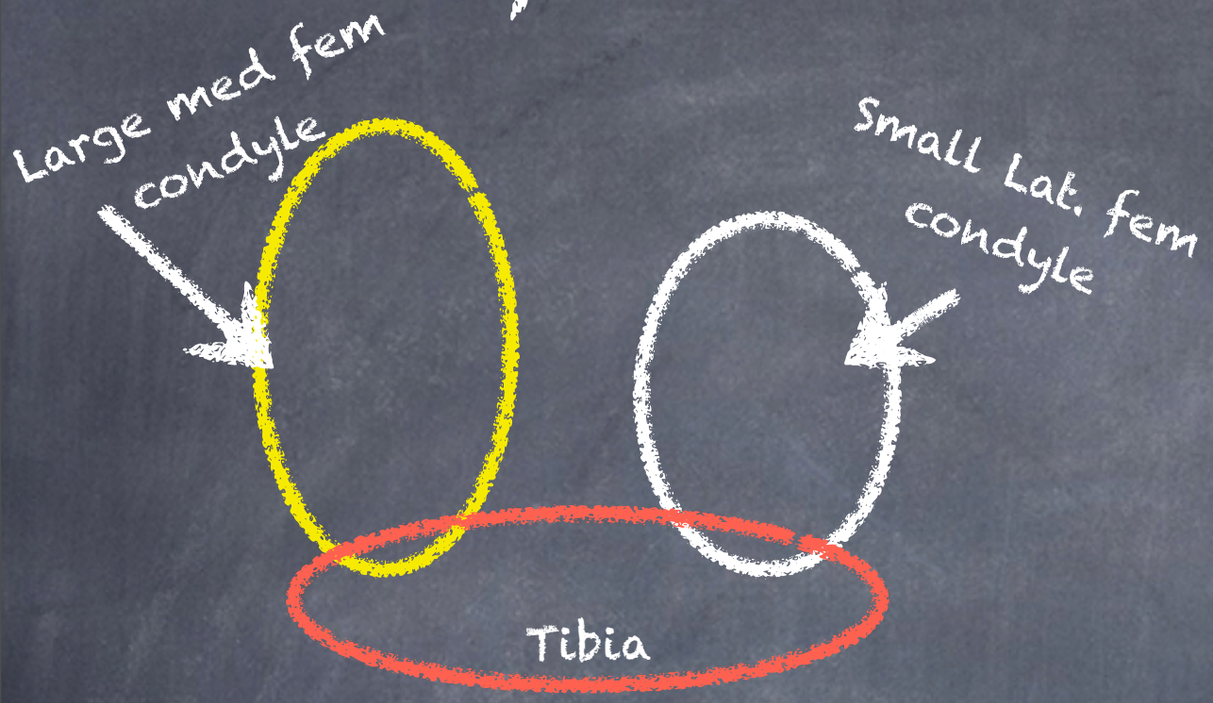
- 6 axes of motion
- Primarily flexion / extension

	Limits	Walking	Sitting	Stairs
Flexion / Extension	150 / -5°	70 / 0°	100 - 120°	70-90°
Internal/ External	±6 / 30°	±10°		
Varus / Valgus	± 0-10°	0°		
Rollback	5-15mm	8mm		

- Dictated by anatomy of the articular surface and its principal ligaments - NOT A SIMPLE HINGE
- Asymmetry of the condlyes - "screw home"
- Sagittal plane geometry/cruciate function - "roll and glide"



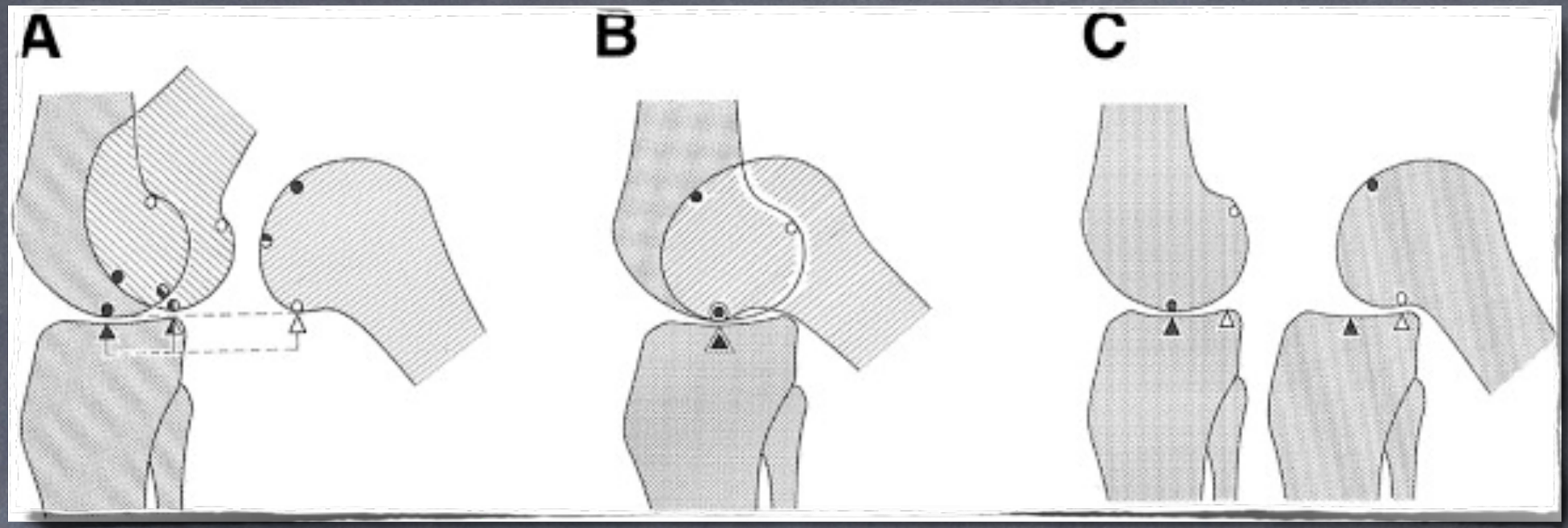
~60° flexn.



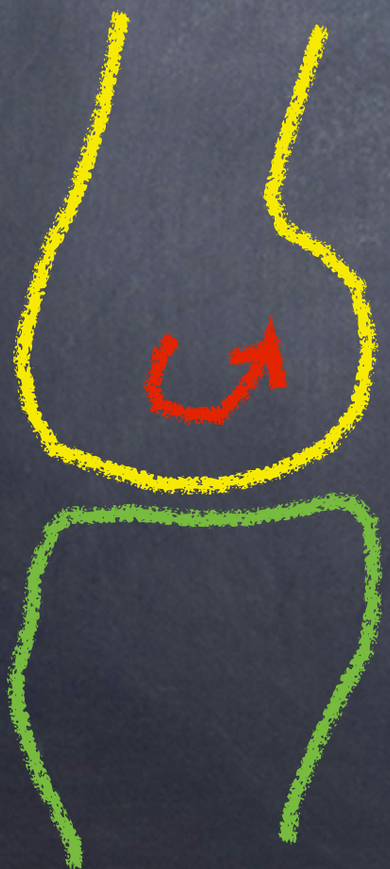
~20° flexn.

Screw home at full extn.

"Roll Back"



Fact or Fiction?-Instant Centre of Rotation



Knee is not a hinge with a single axis of rotation

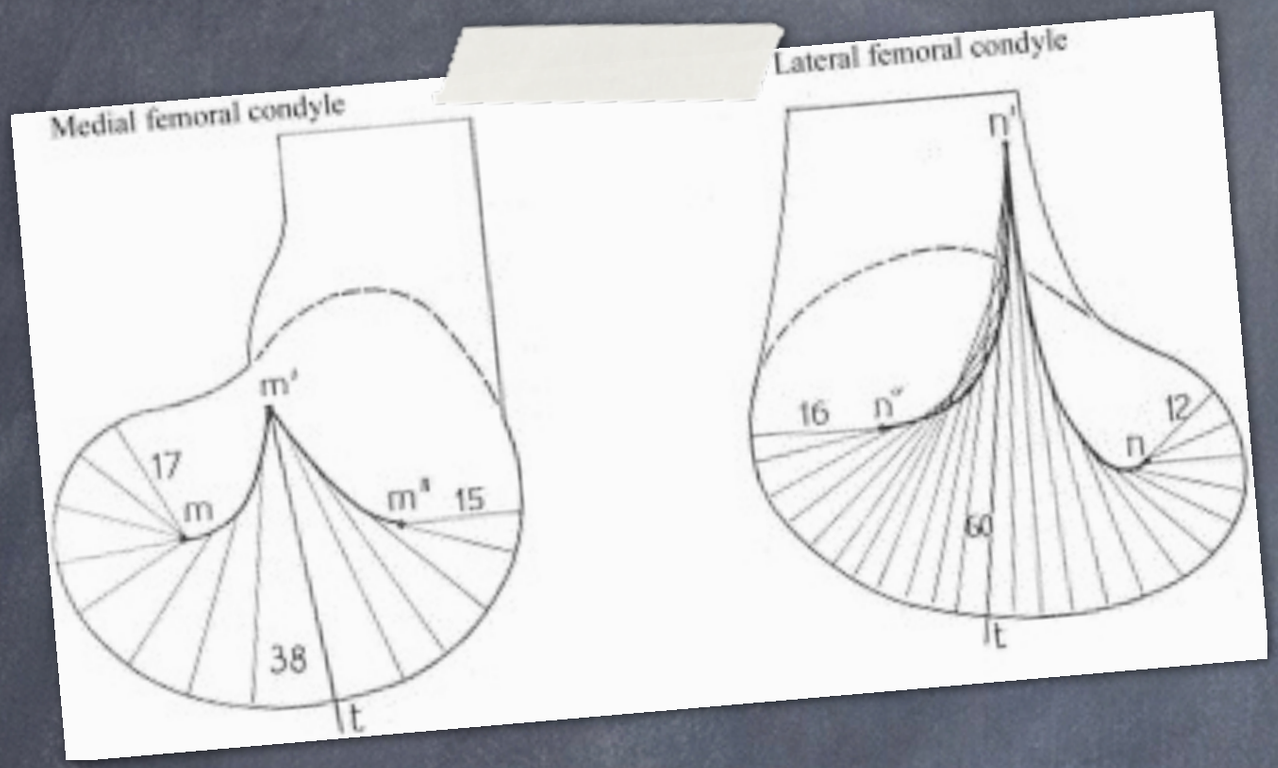
It has an instant centre of rotation 'J' shaped

like a hockey stick

Articular Geom + ICR + 4 bar linkage = Femoral Roll Back

Formula!

Instant centre of rotation



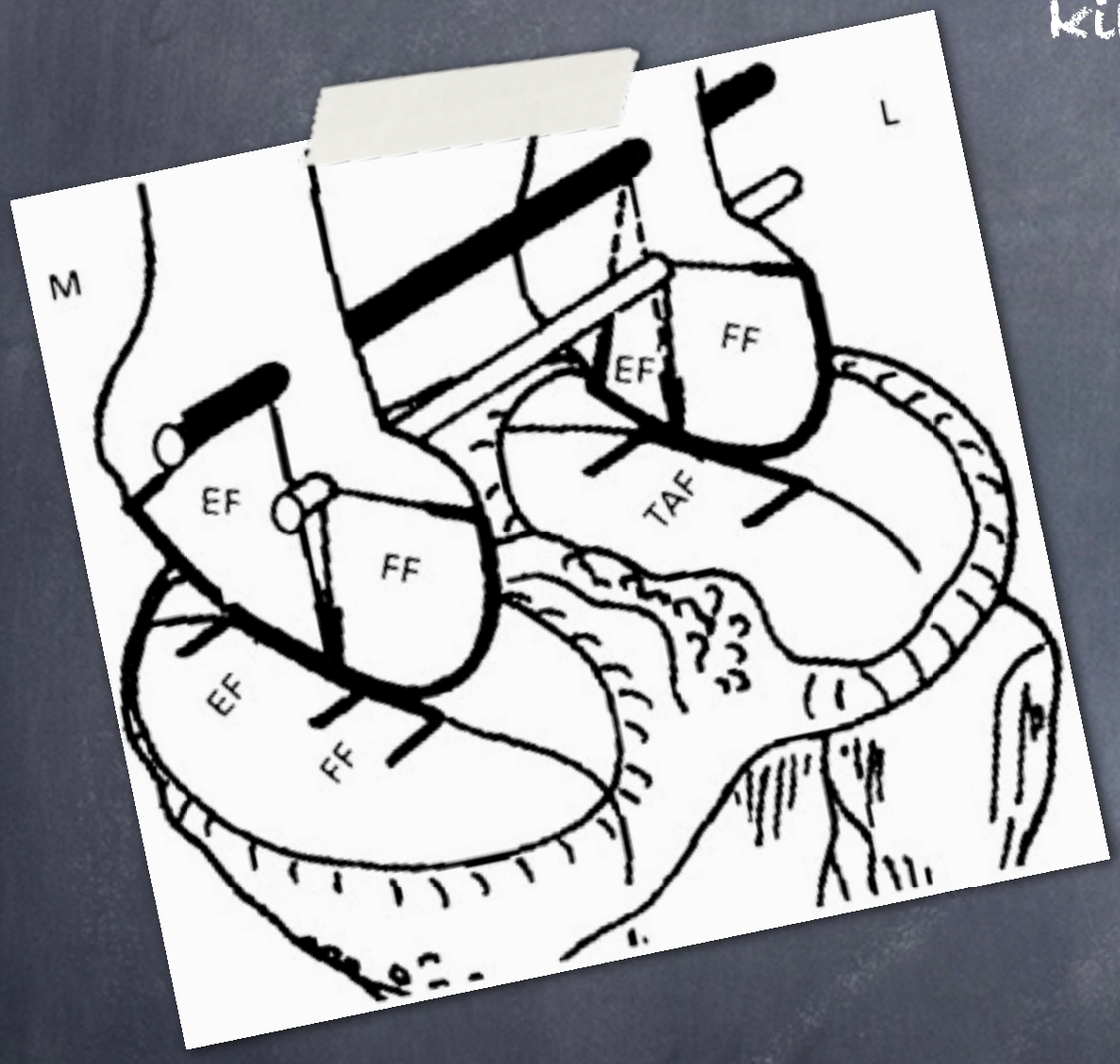
Instant centre pathway shown for the tibiofemoral and patellofemoral joint for medial and lateral femoral condyles.

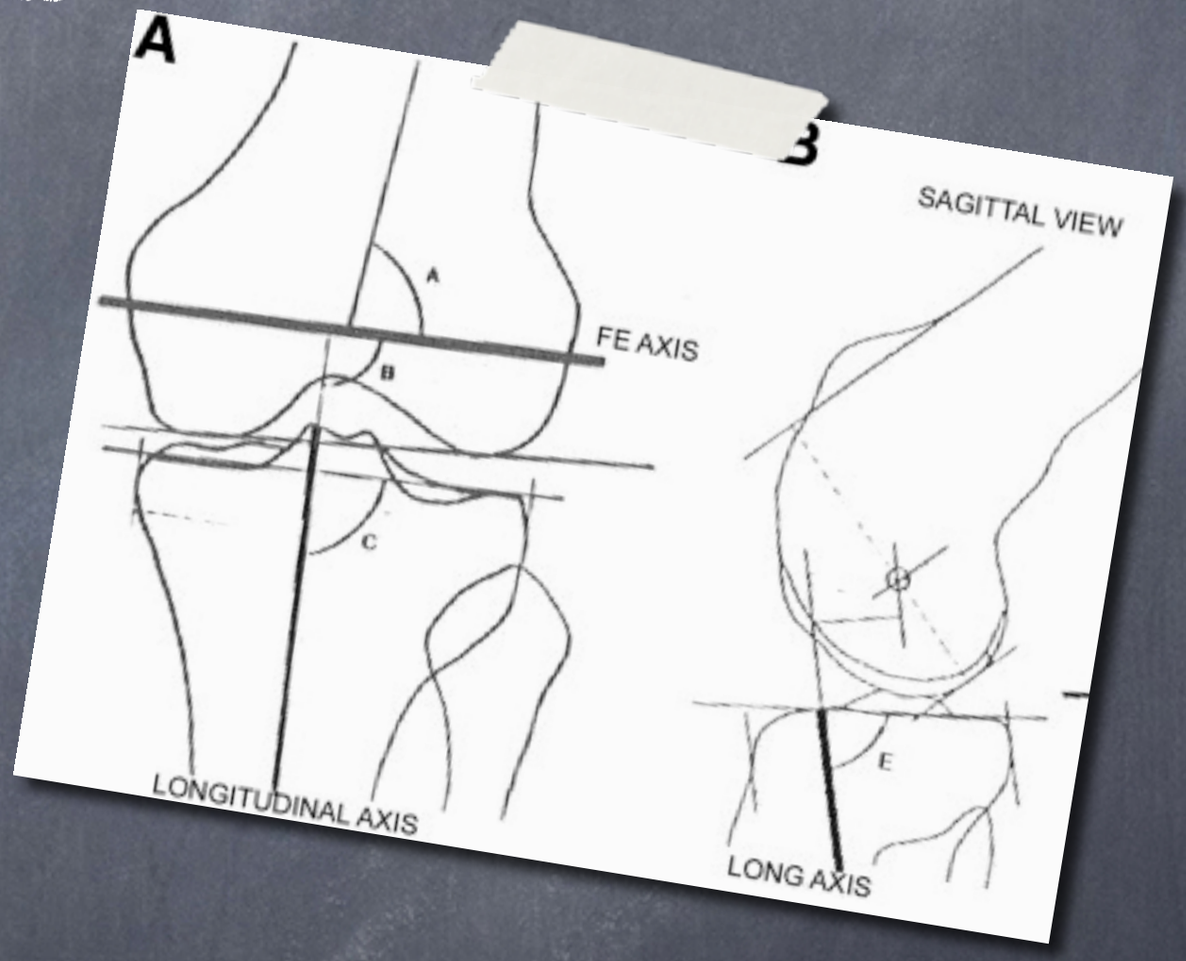
Criticisms of instant centre theory

- Assumes flexion extension axis lies exactly in sagittal plane.
- Constantly moving axis is inefficient - does not behave like other joint
- More sensitive kinematic measuring techniques identifies 3 axes model

3 axes theory

Current established theory borne from work on TKR kinematics



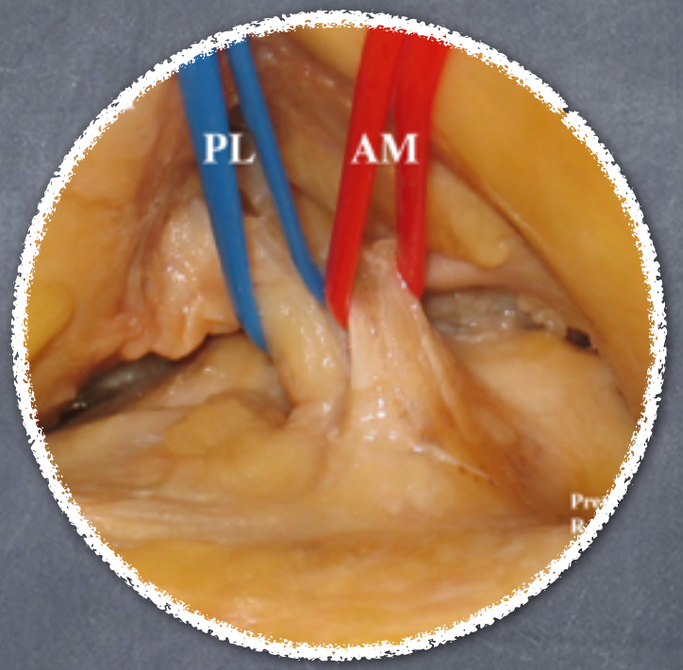


- Trans Epicondylar Axis (FF) - 20-150°
- Distal Femoral Axis (EF) - 0-20°
- Longitidinal Axis - 89° from tibial plateau (AP)
  - 85° from tibial plateau (Lat)

Function of The Cruciate Ligaments - ACL

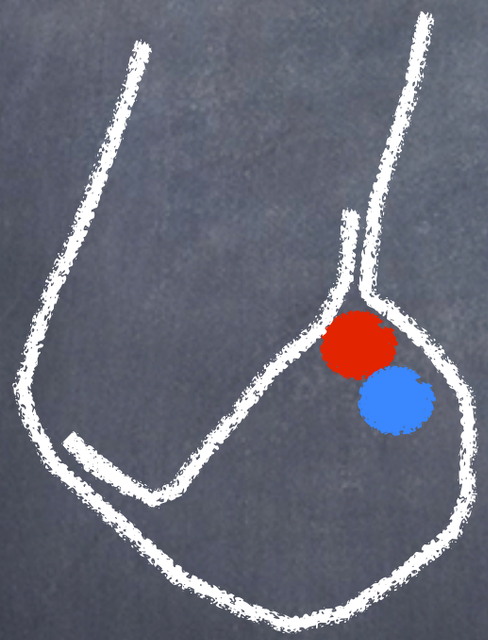
- Prevents anterior translation of the tibia
- Resists internal rotation of the tibia
- Secondary restraint to varus / valgus
- Ultimate tensile load - 2160N

Lat.

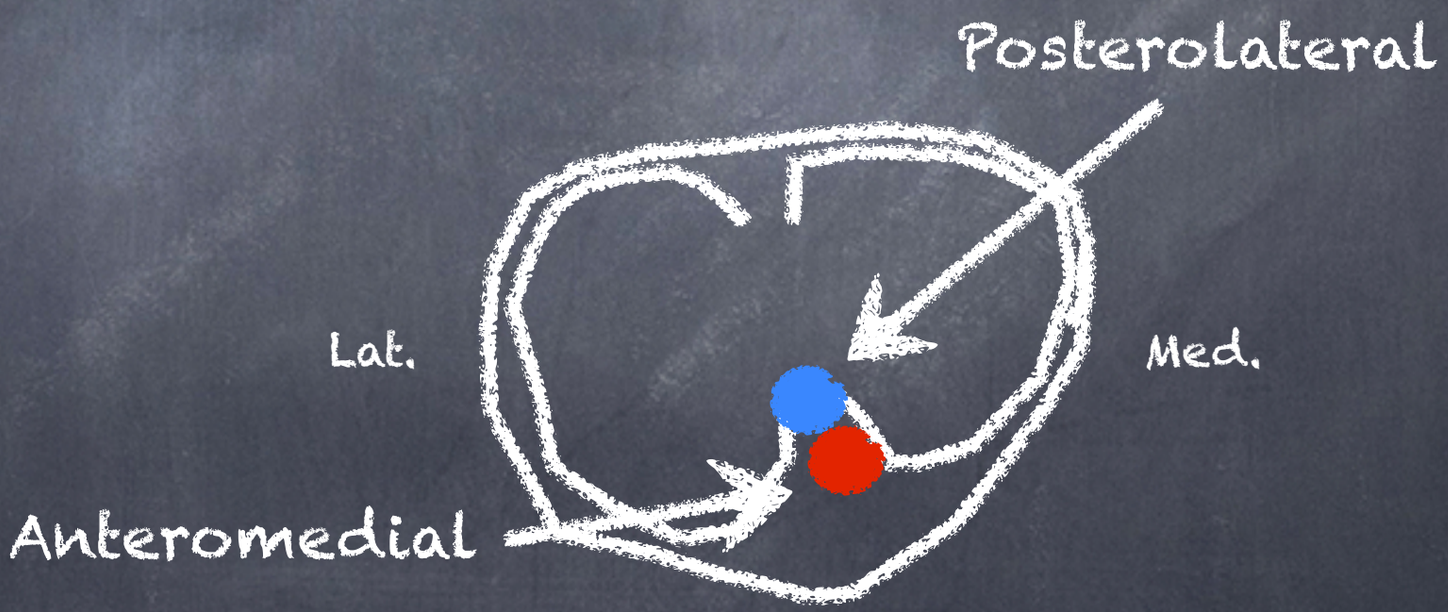


Med.

2 bundles



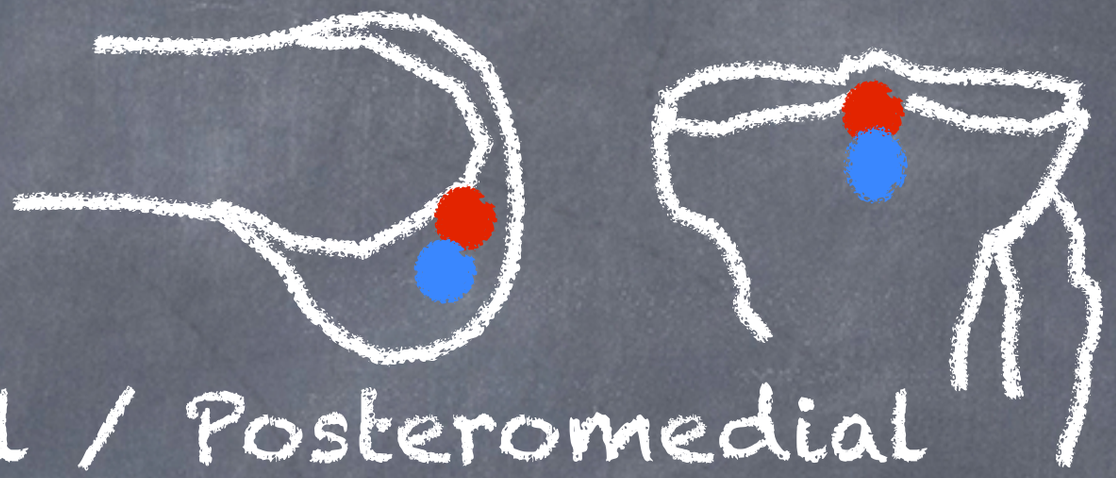
- AM bundle (thin) - prevents anterior translation
- PL bundle (fat) - prevents internal rotation of tibia



- AM bundle - tight in flexion
- PL bundle - tight in extension

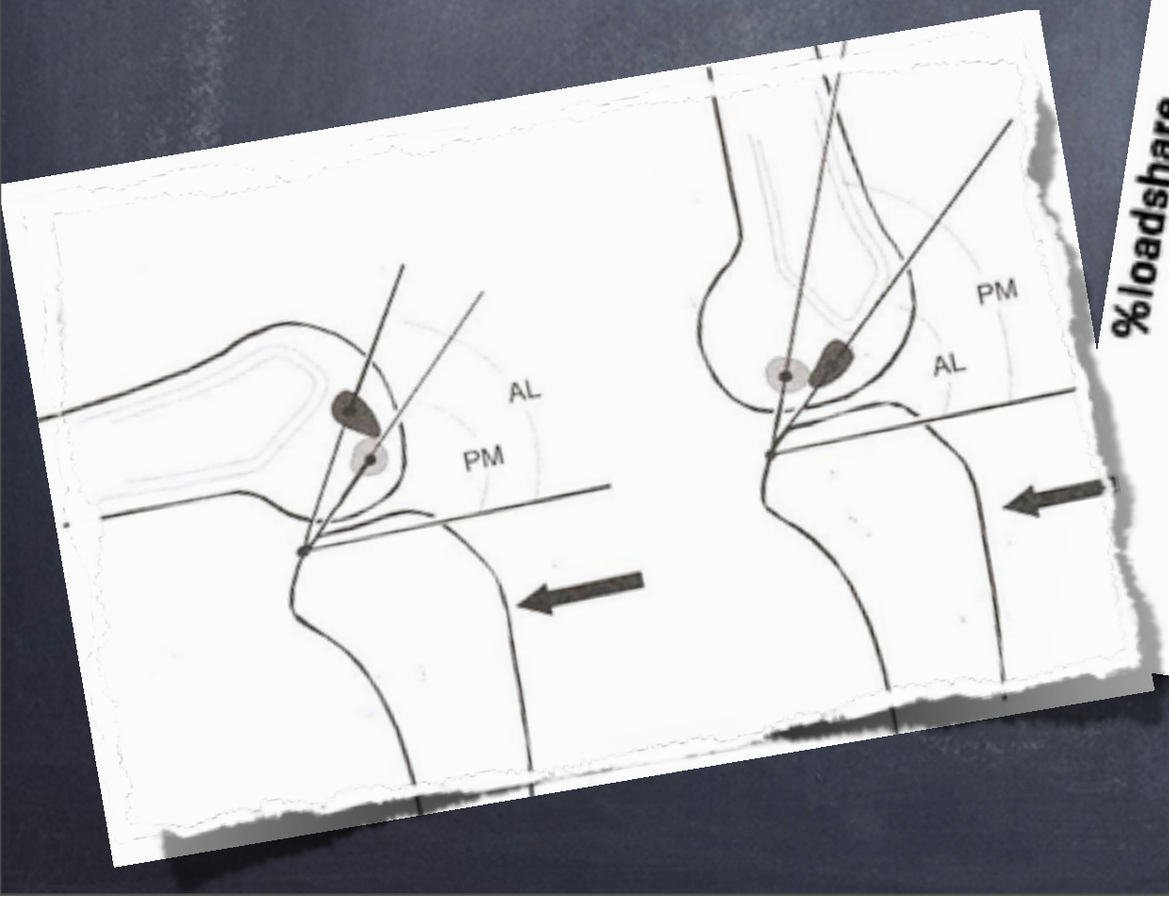
Function of The Cruciate Ligaments - PCL

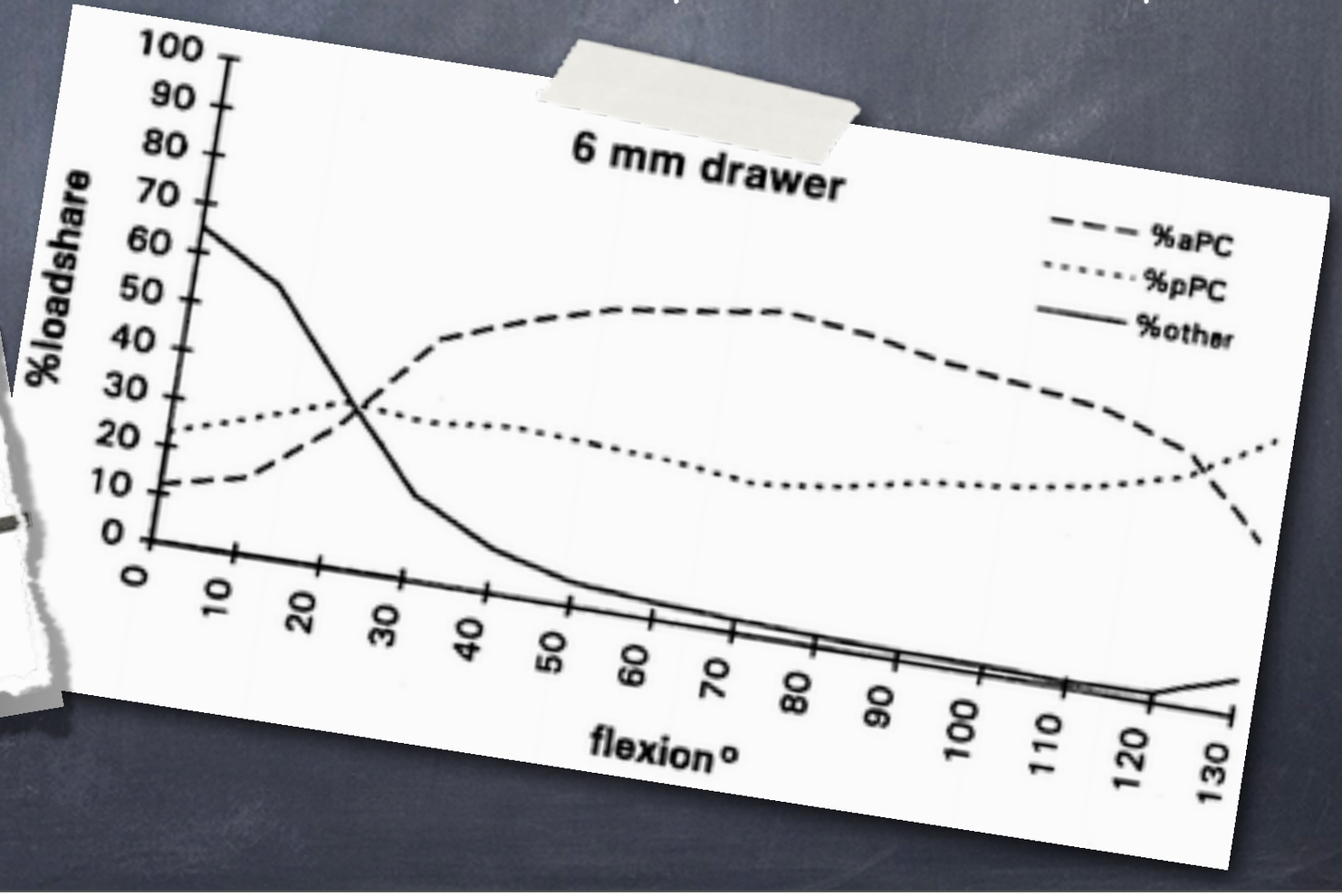
- Prevents posterior translation of the tibia
- Resists external rotation of the tibia
- Secondary restraint to varus / valgus
- Ultimate tensile load - 739-1051N



2 bundles - Anterolateral / Posteromedial

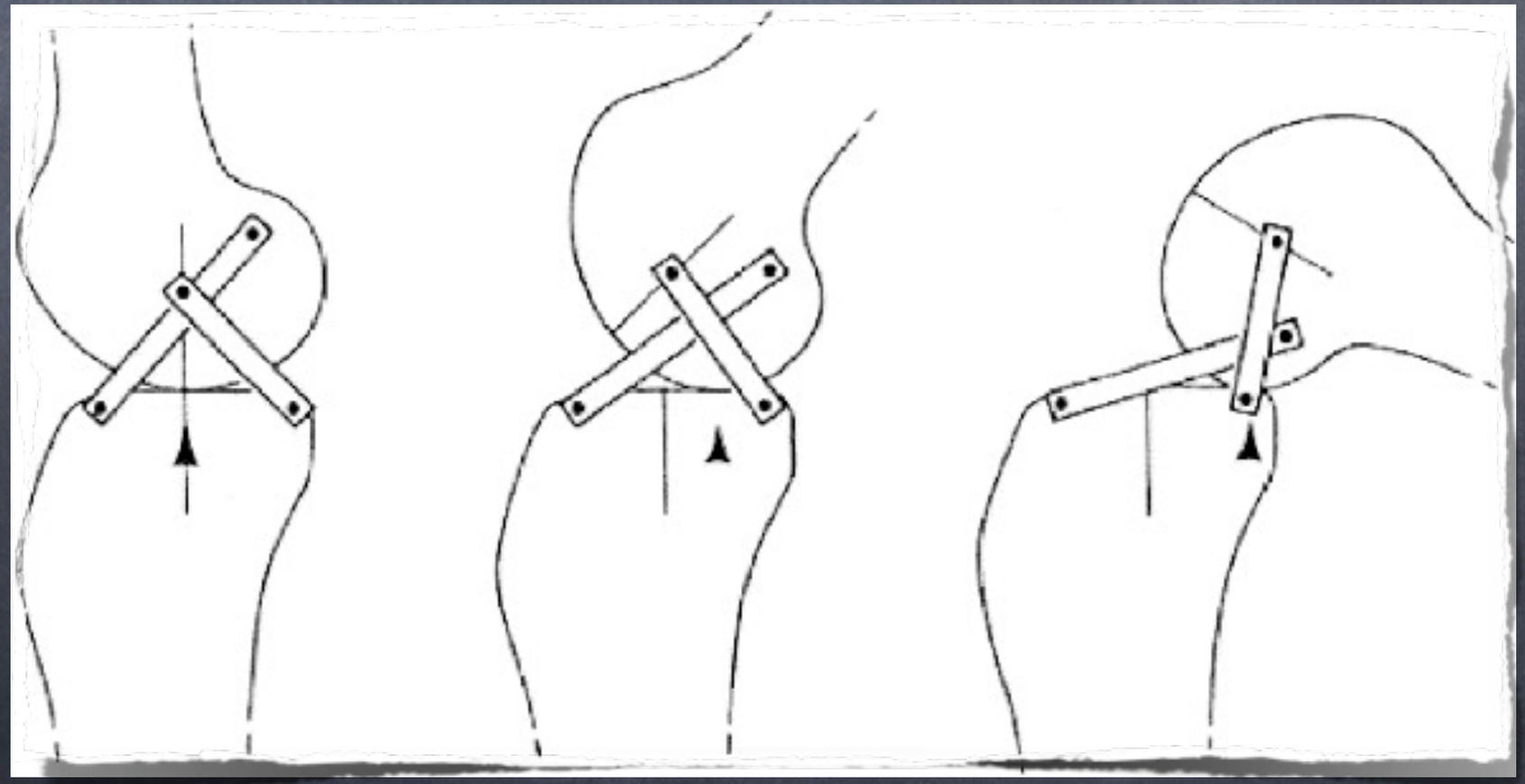
- AL bundle (fat) - primary restraint to posterior draw 30-120°
- PM bundle (thin) - shares load with AL bundle but more predominant in deep flexn.



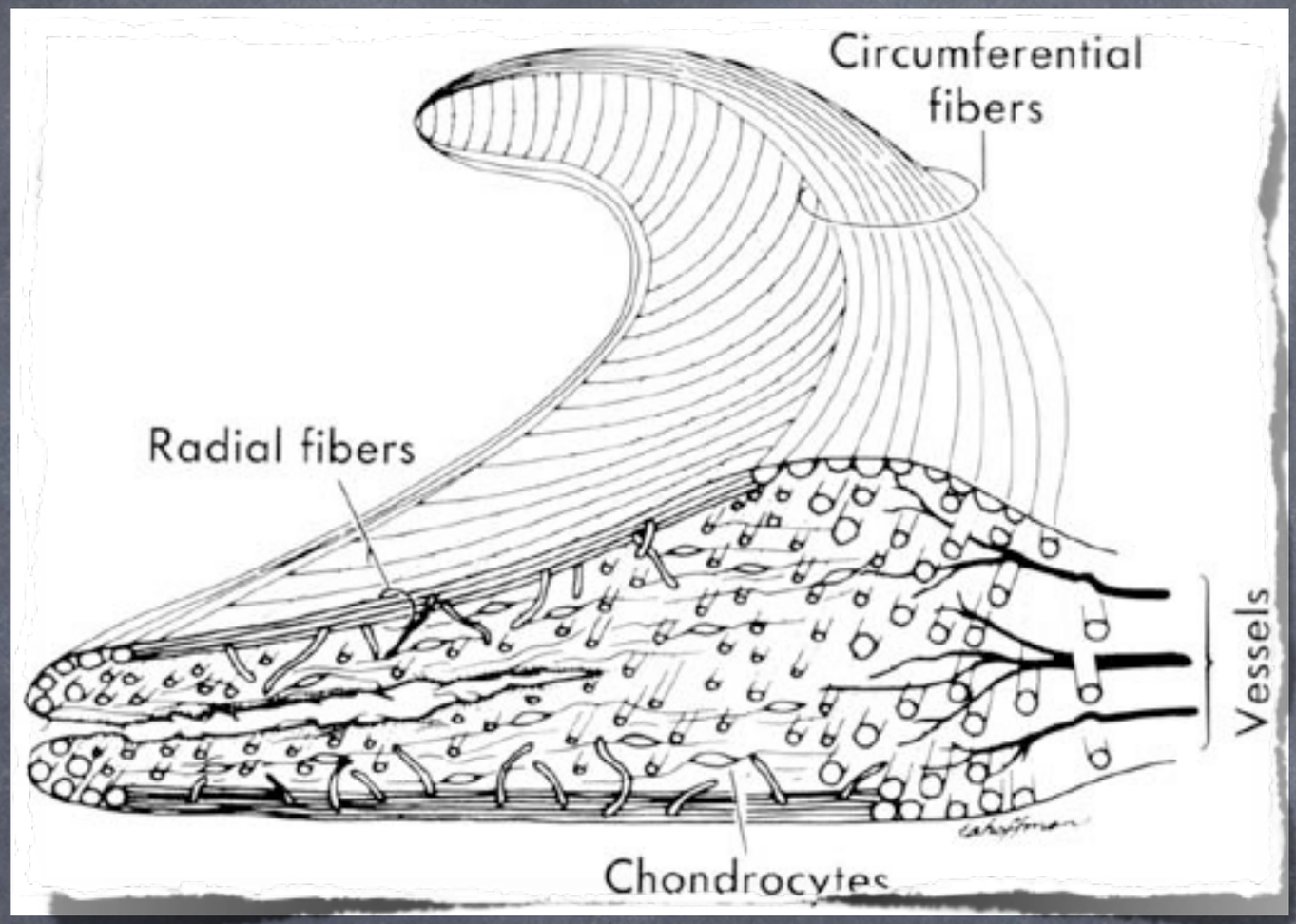


4-bar linkage theory

- Defines 4 rigid links as the ACL, PCL and the bony structures of the femur and tibia.
- Marries 2 concepts - ligament isometry & roll and glide
- Oversimplification
- Tibiofemoral joint has 3 independents axis of motion



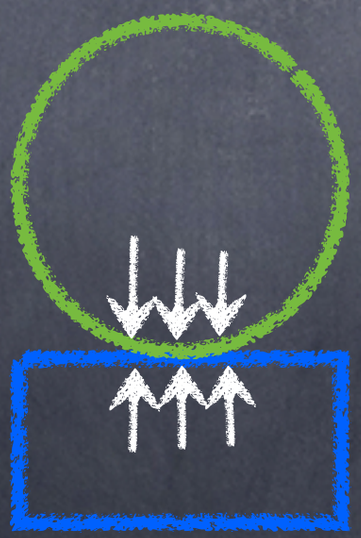
Function of Menisci



- Collagen fibres arranged radially and longitudinally
- High water content with viscoelastic properties

- Shape provides conformity to femoral and tibial articulations
- Convert axial loads to circumferential loads (hoop stresses) - 50% in extension. Up to 85% across med meniscus at 90°.
- Secondary restraint to anterior translation in ACL deficient knee.
- Lateral more mobile than medial (esp post. horn medial meniscus - injury?)

(a)



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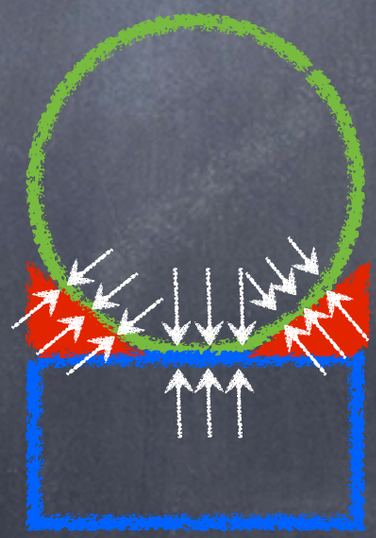

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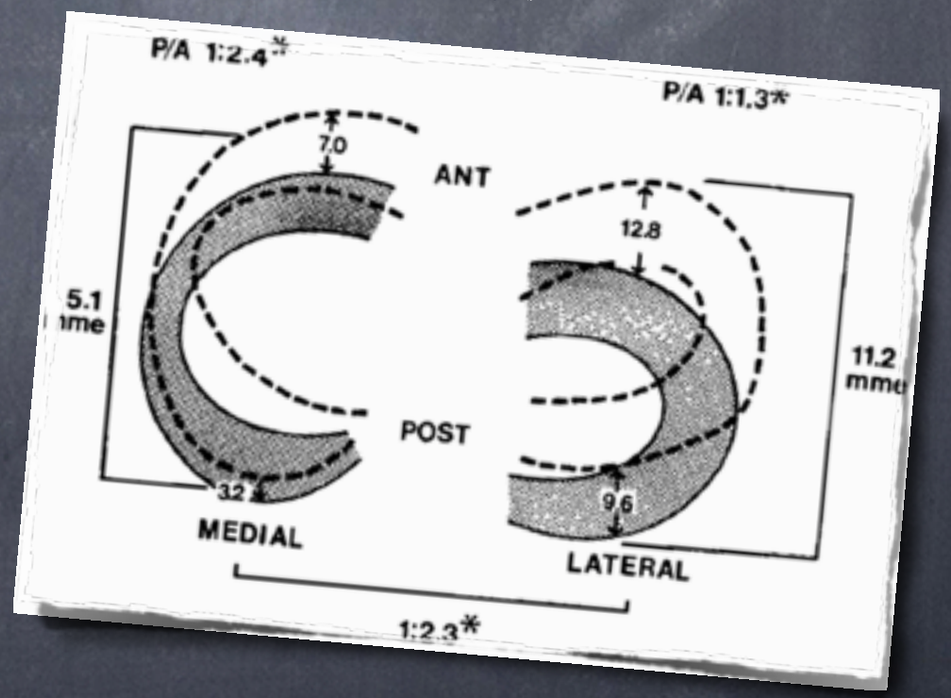
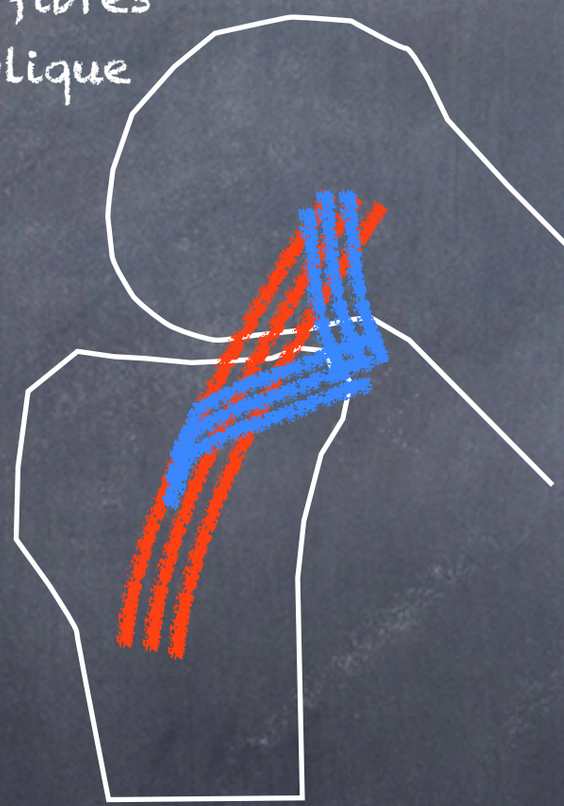
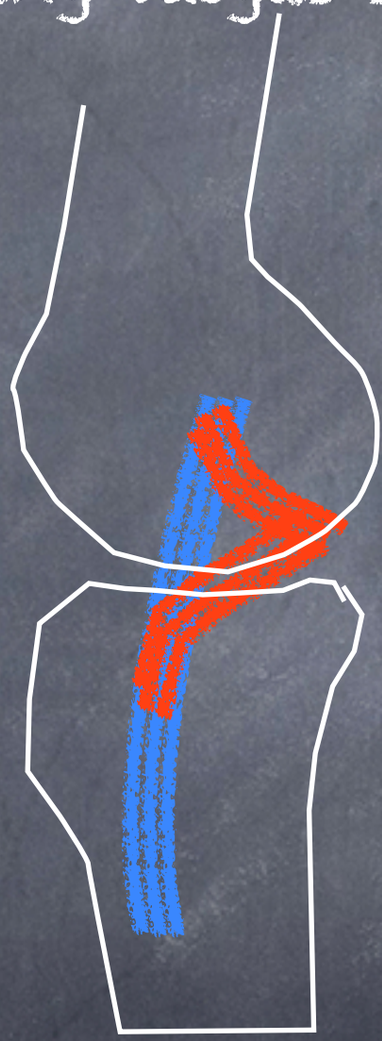


Varus /Valgus motion

- Medial / Lateral Stability achieved through collaterals.
- 2 biomechanically relevant fibre bundles on MCL
- Orientation crucial to withstanding valgus stress

In flexion anterior fibres taut / posterior oblique fibres slack



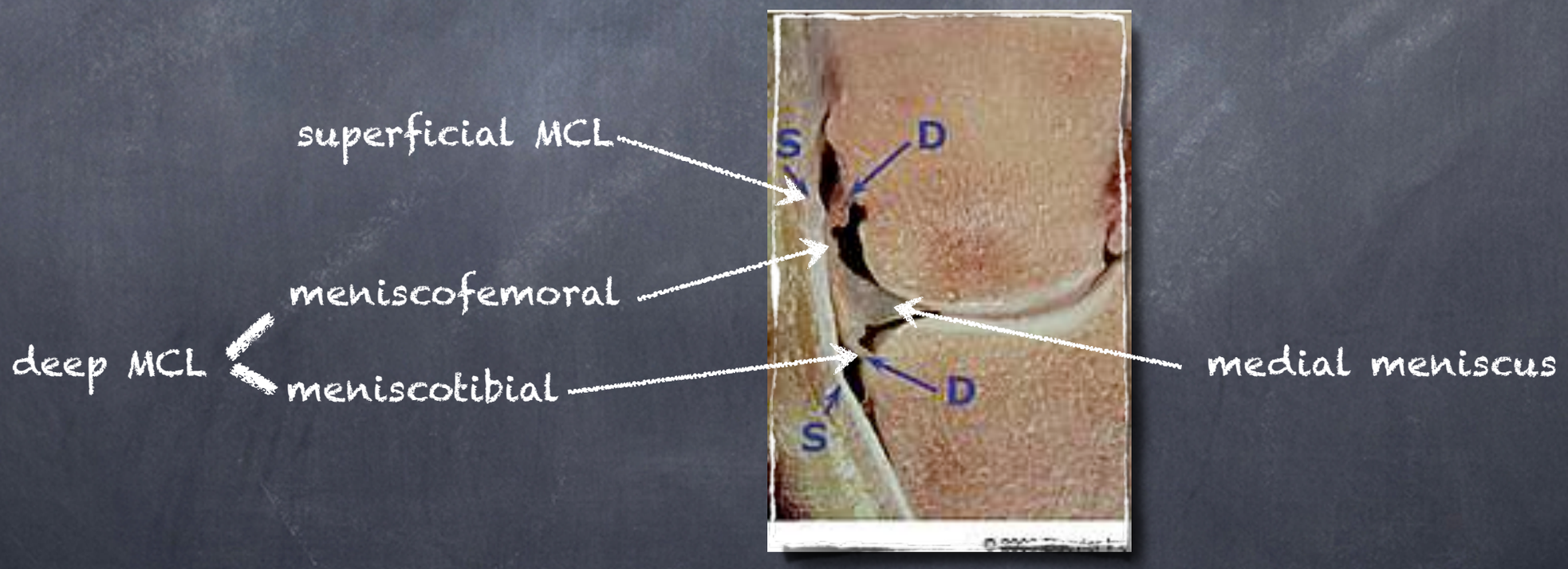


In extension posterior fibres taut / anterior oblique fibres slack

Secondary restraints - ACL, PCL, Posteromedial corner

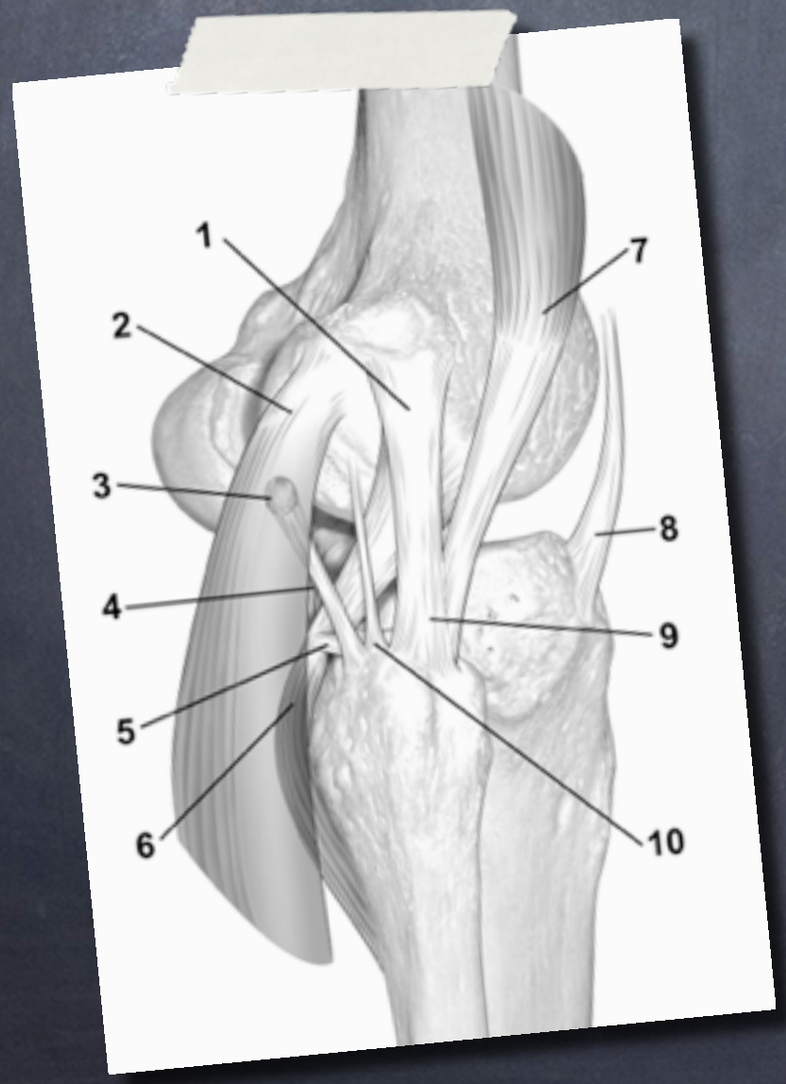
Ligamentous contribution - Valgus

- Superficial MCL - 3° at full extension / 5° at 30° flexion
- Deep MCL - 3° from 15-90° flexion.
- Posteromedial Capsule - significant contribution in the extended knee - 29% at 0°, 14% at 30° and 5% at 90°.
- ACL / PCL secondary restraints.



Ligamentous constraints - Varus

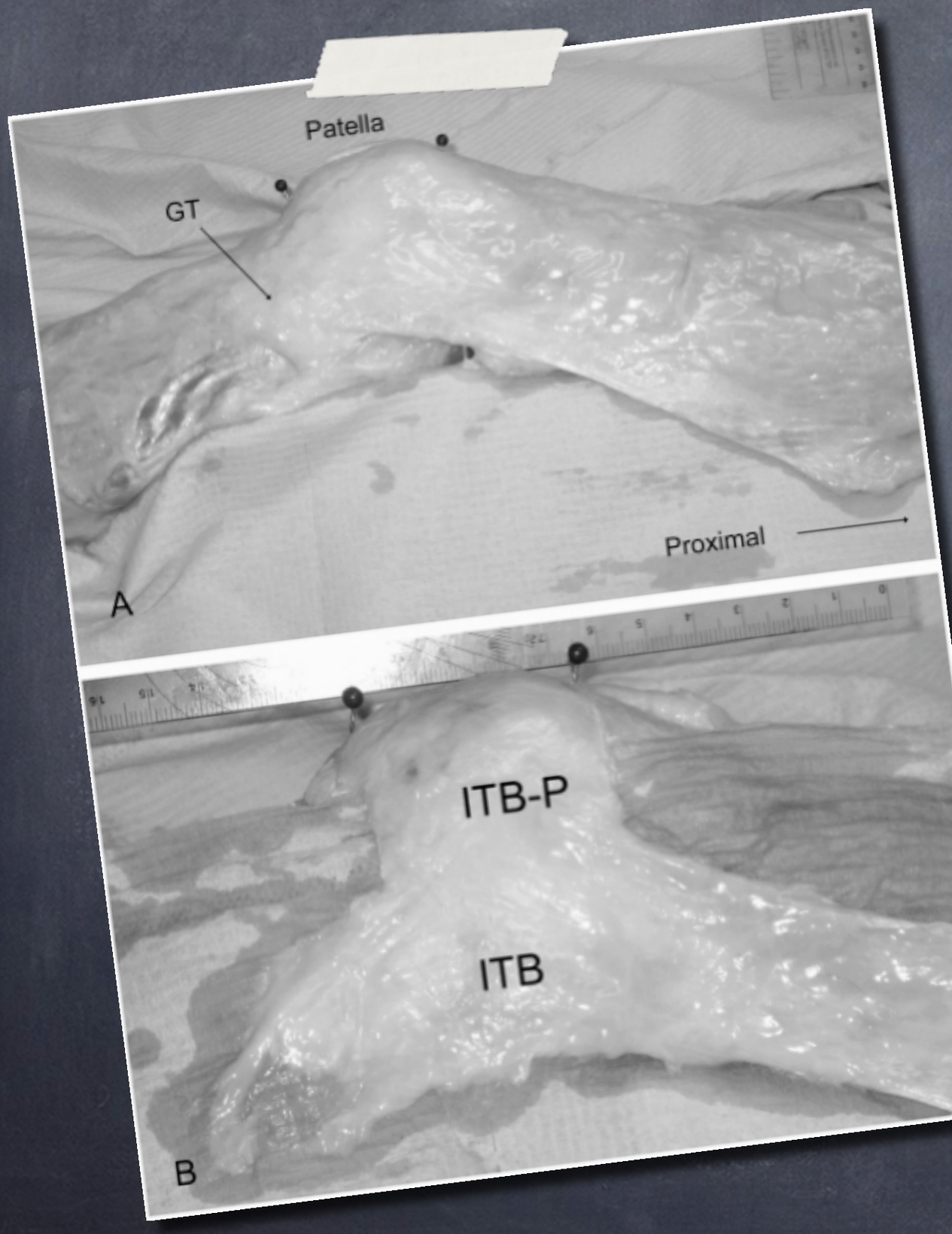
- Lateral Collateral Ligament - 55% at 5° and 69% at 25°
- Arcuate / Fabellofibular - 13% at 5°
- ACL secondary restraint (though stronger ligament, short moment arm)
- ITB and Popliteus have dynamic stabilising role

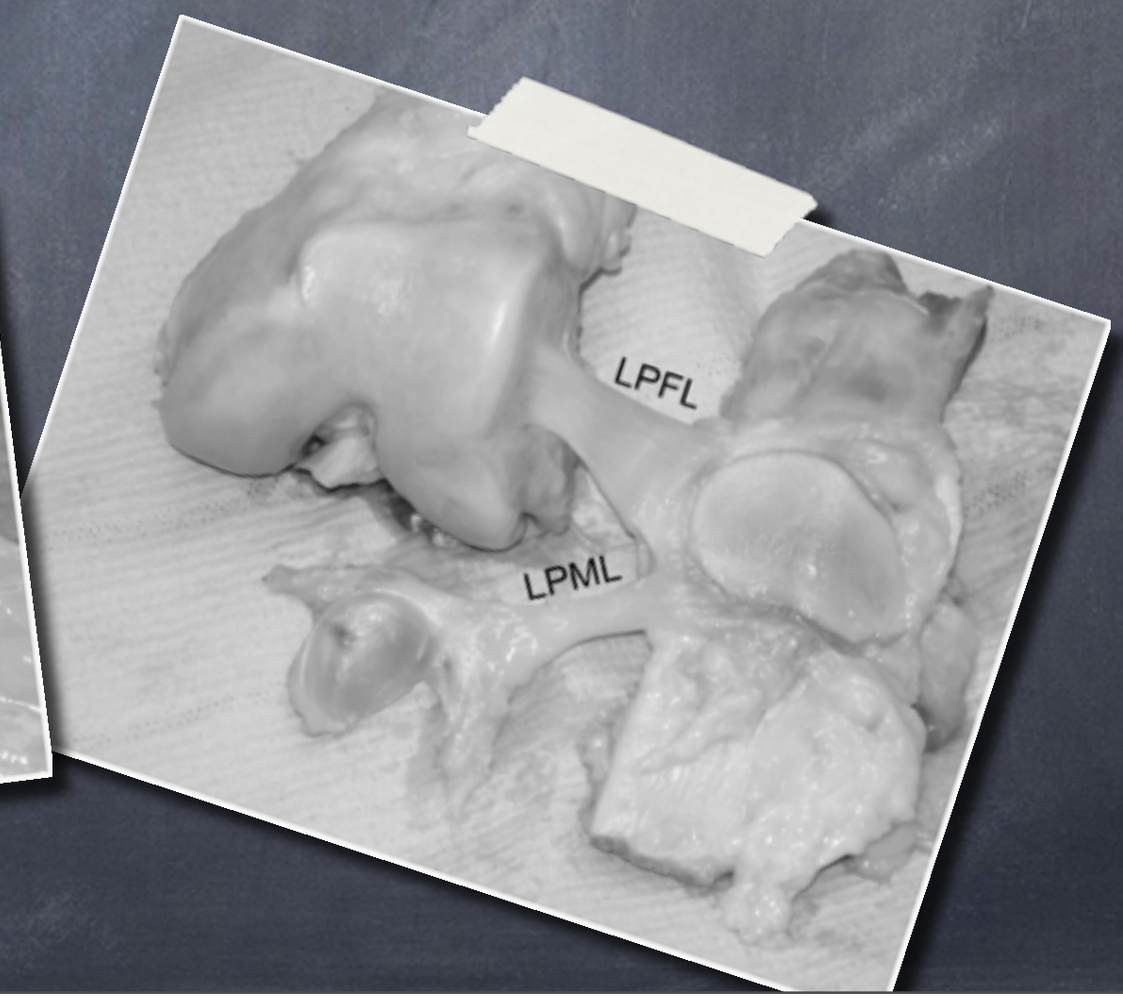


(1) LCL
(2) Lateral Head of Grastrocnemius
(3) Fabella
(4) Fabello Fibular ligament
(5) Poplitio fibular ligament.
(6) Popliteus tendon
(7) Biceps femoris tendon
(8) ITB
(9) Conjoint Tendon
(10)Arcuate ligament.

The Lateral Retinaculum

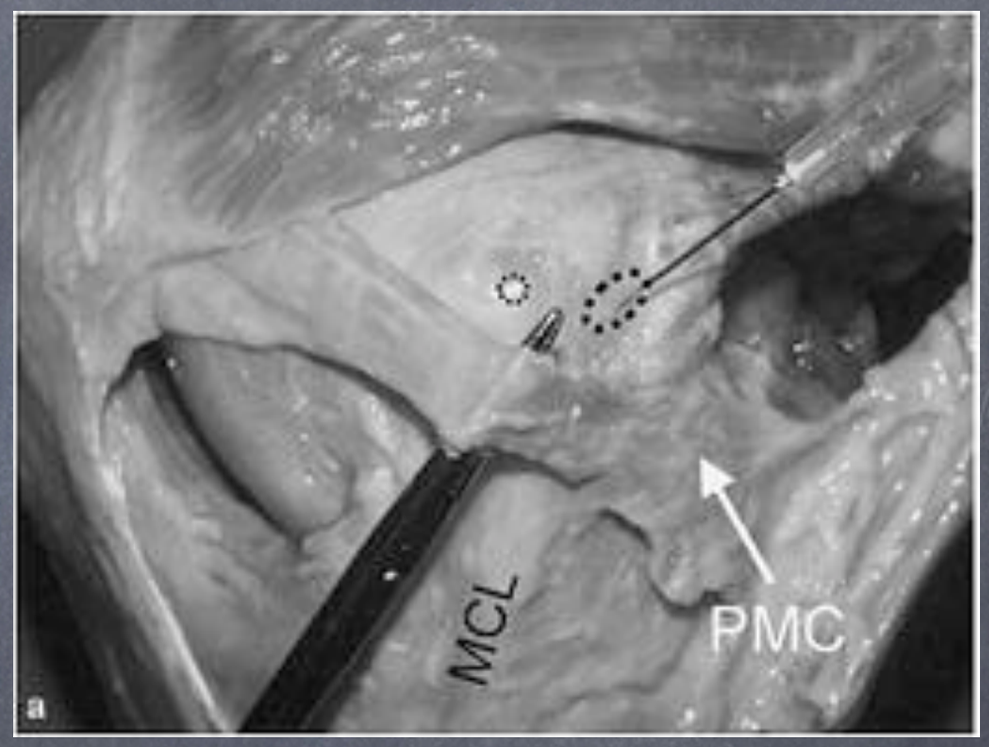
- Specific tissue bands in Lateral retinaculum
- Thick ITB-patellar band (582N)
- Thin Patellofemoral band (172N)
- Thin Patellotibial band (85N)





The Medial Retinaculum

- Thin medial meniscopatellar ligament
- Medial patellofemoral ligament (200N)
- 60% lateral patellar stability in extension
- Not isometric




Thankyou!