KNEE COMPLEX

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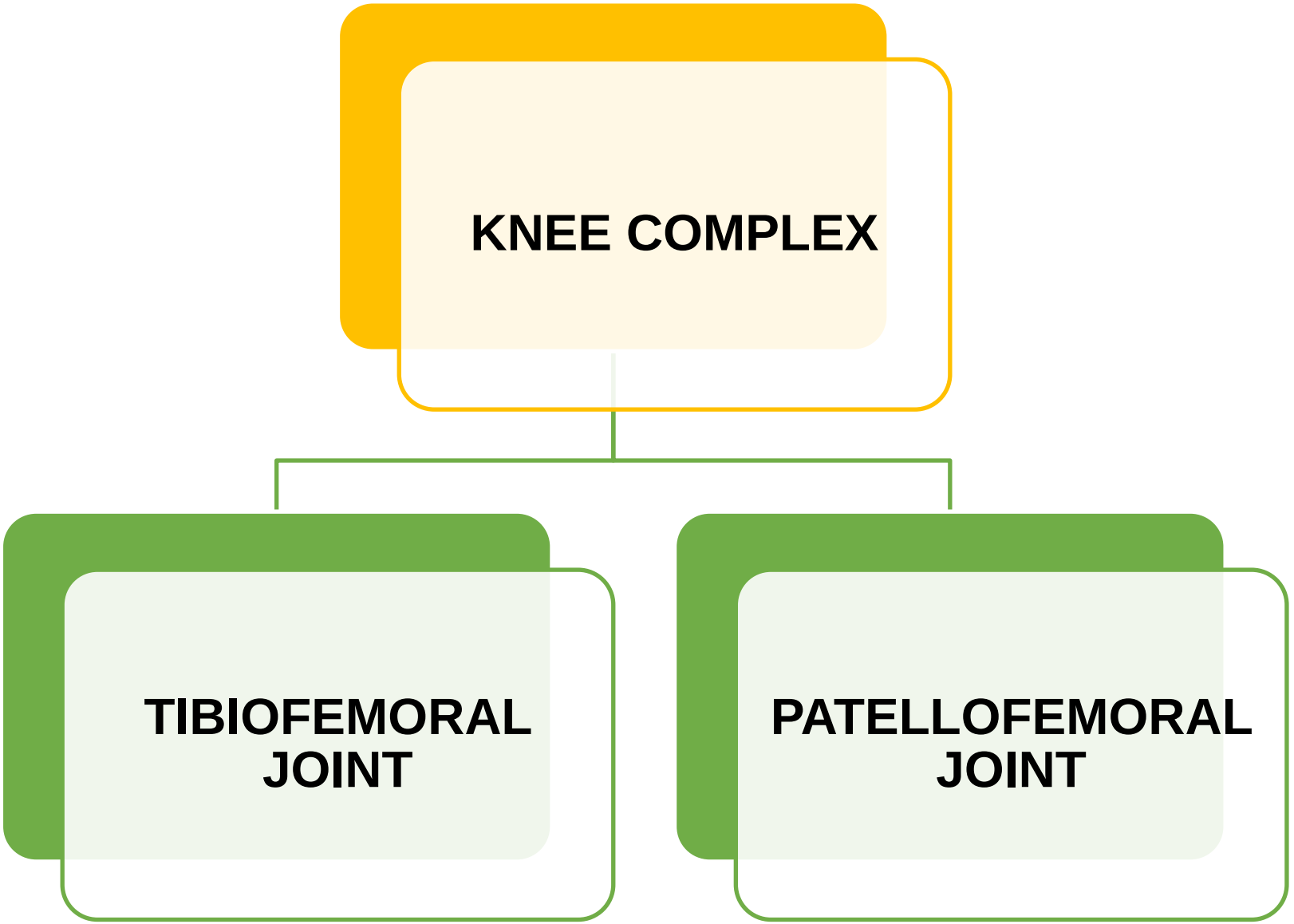
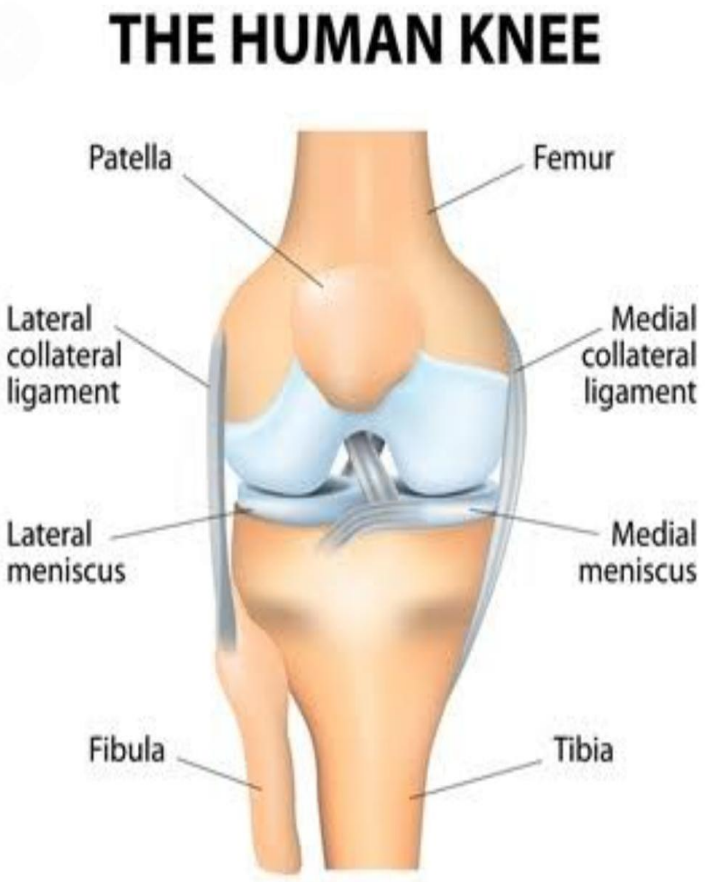

KNEE COMPLEX
TIBIOFEMORAL JOINT
PATELLOFEMORAL JOINT

INTRODUCTION

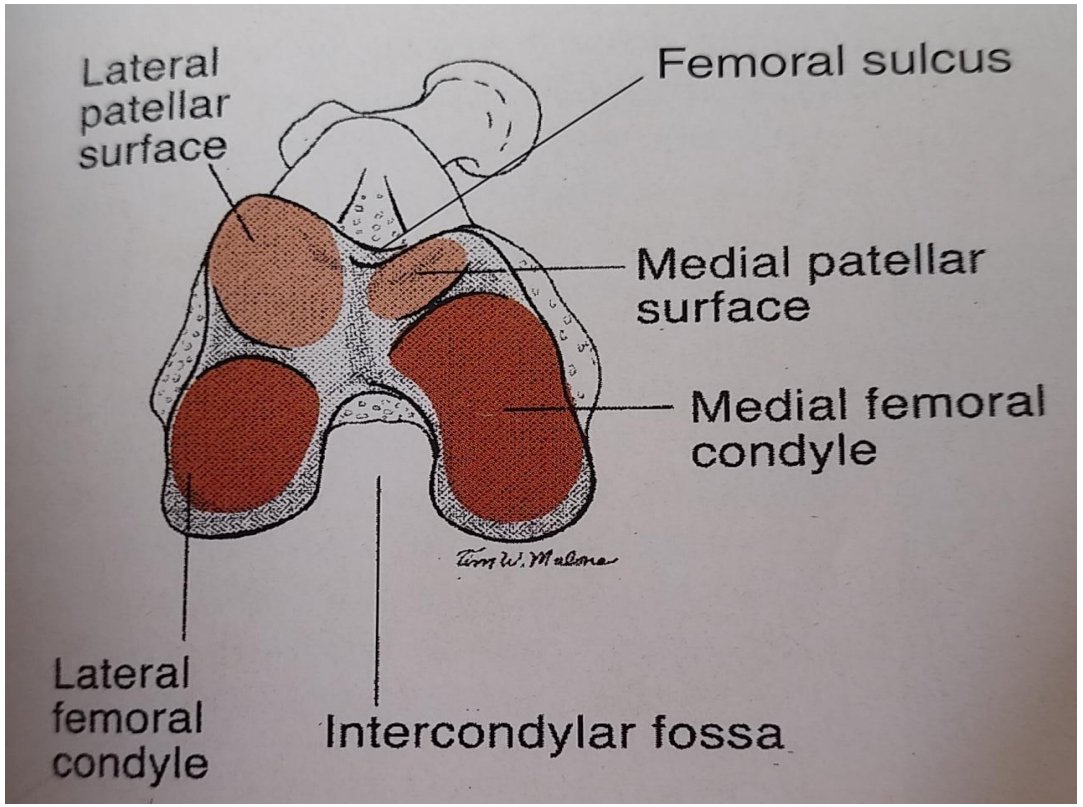
- synovial joint
- It is formed by the articulations between the patella, femur and tibia
- Knee joint works in conjunction with hip and ankle joints to support the body's weight during static erect posture
- Dynamically, the knee complex is responsible for moving and supporting the body during variety of activities



FEMUR

- The proximal articulating surface: Composed of large medial and lateral condyles of distal femur.
- Medial condyle **is larger , with greater radius of curvature and projects distally than lateral condyle.**
- Because of medial obliquity shaft of femur do not lie immediately below the femoral head.(slightly medial).

- Lateral condyle lies more directly in line with the shaft of medial condyle.



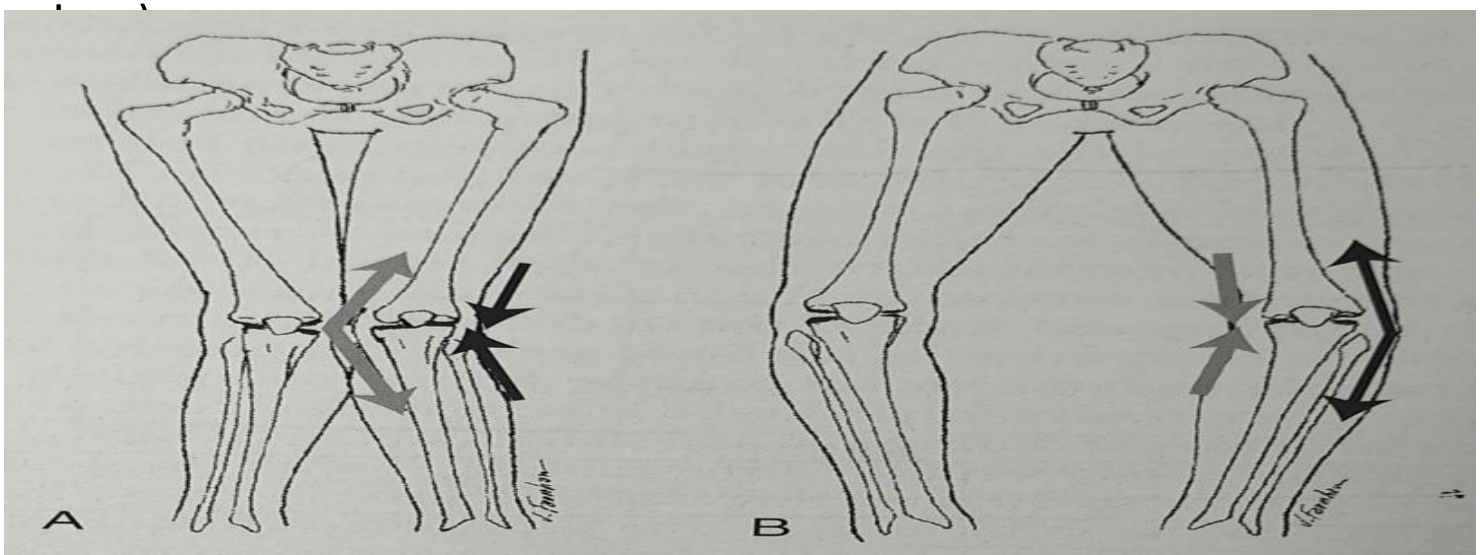
TIBIA

- The large convex femoral condyles sit on relatively flat tibial condyles
- Distal articulating surface: assymetrical medial and lateral tibial condyles or plateaus
- In anteroposterior direction medial tibial plateau is longer than lateral tibial plateau.
- Proximal tibia is larger than tibial shaft .
- The tibial plateau slopes posteriorly approximately **7°-10°,** which is conducive for flexing tibiofemoral joint

- Medial and lateral tibial condyles are seperated by two bony spines- **intercondylar tubercles**
- Intercondylar tubercles become lodged in intercondylar notch of femur during knee extension.
- the joint surface doesn’t provide stability, to improve joint congruency

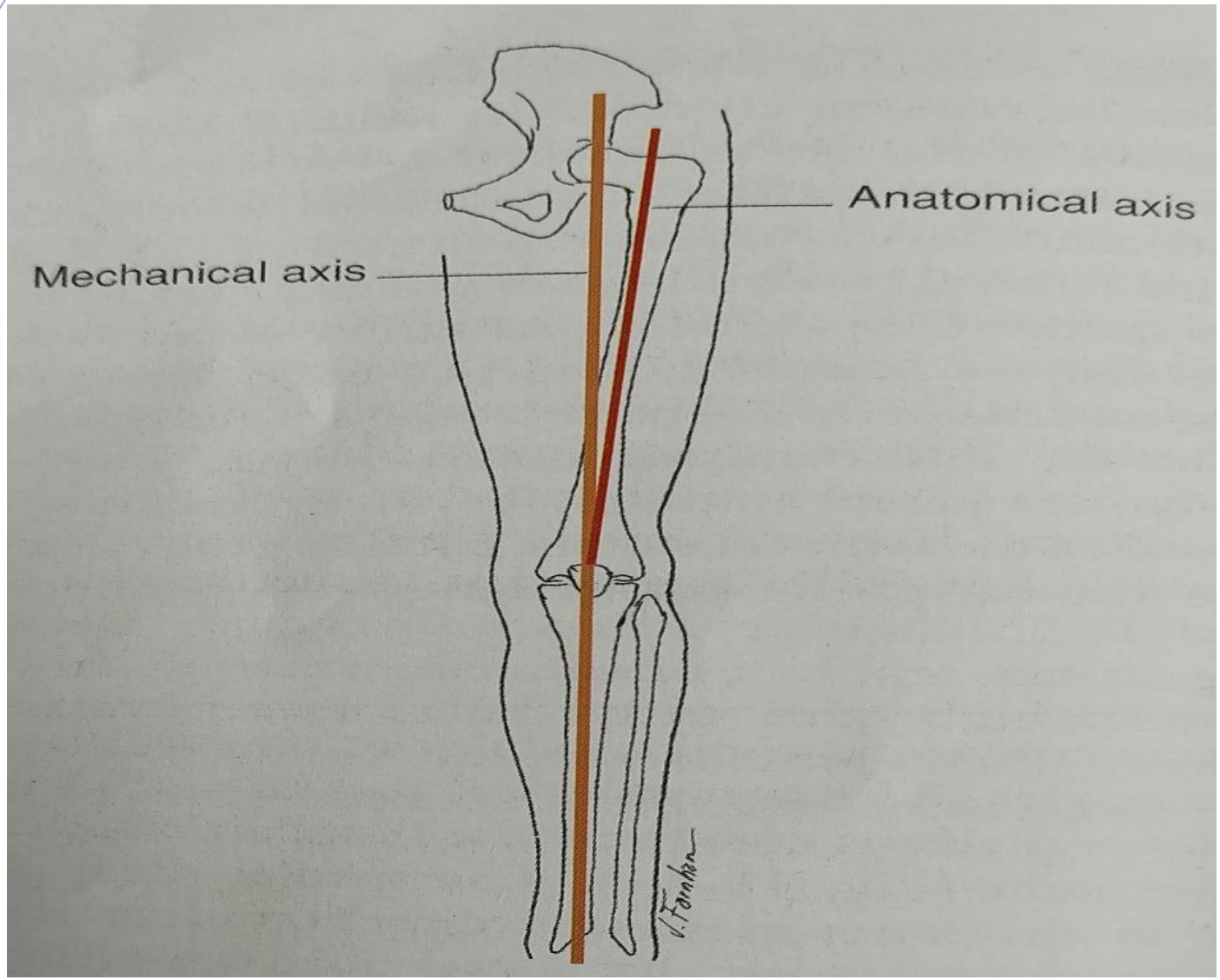
TIBIOFEMORAL ALIGNMENT AND WEIGHT BEARING FORCES

- Normal medial tibiofemoral angle is 180°-185°, that is the femur is angled upto 5° off vertical, creating a slight **physiological (normal) valgus angle** medially at the knee
- If the **medial tibiofemoral angle is greater than 185°=GENU VALGUM** (knock knees)
- If the **medial tibiofemoral angle is 175° or lesser =GENU VARUM** (bow



How to measure tibiofemoral alignment?

- Line from the center of femoral head to the center of head of talus. This line represents the **mechanical axis** or **weight bearing line.**
- In normally aligned knee , it will pass through the center of the joint between the intercondylar tubercles.
- In bilateral stance, the weight bearing stresses on the knee joint are equally distributed between medial and lateral condyles.


Anatomical axis
Mechanical axis

- Unilateral stance- the weight bearing line shifts towards the medial compartment.
- Smaller BOS, below the center of mass.
- This shift increases increases the compressive force on the medial compartment.

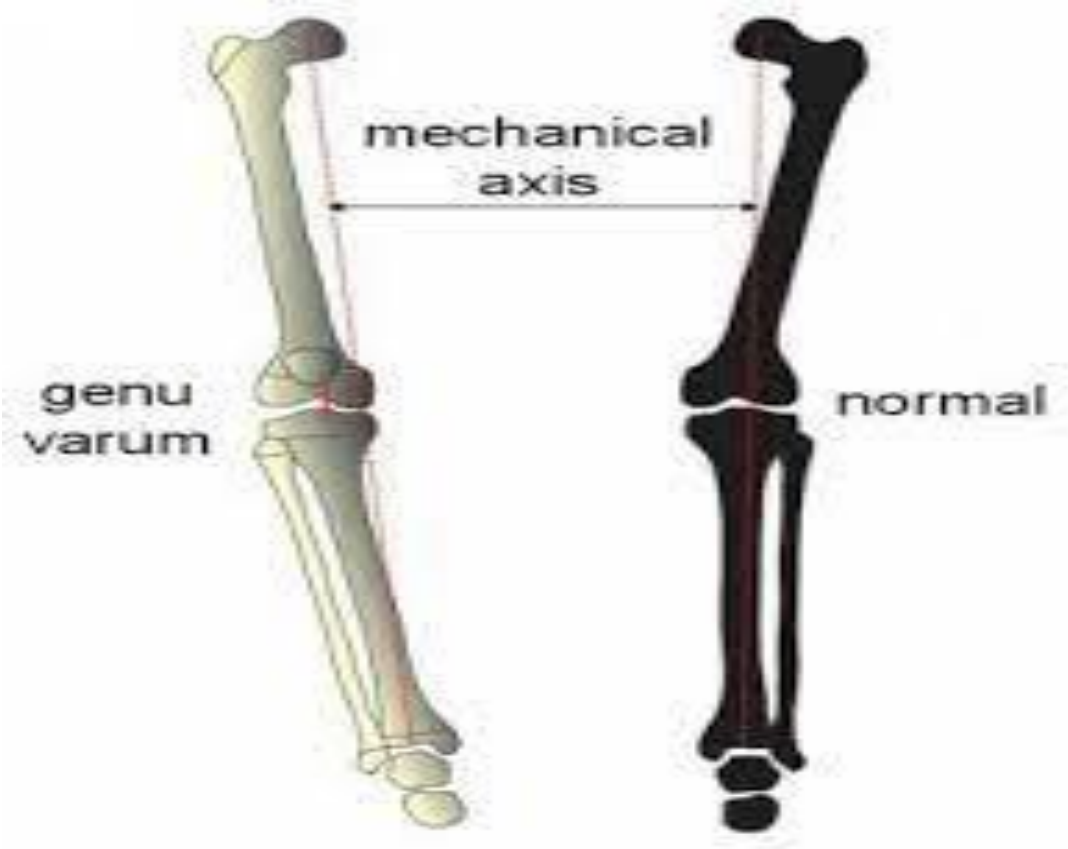
- During dynamic activities such as gait , the lines of forces shifts medialy to the knee joint center.
- This medial shift increases the compressive stresses medialy and increases the tensile stress laterally.

- **Genu valgum :**
- weight bearing line shifted laterally
- Increasing the compressive force on the lateral condyle
- Increasing lateral compressive force

Genu varum:

- Weight bearing line shifted to medially, increasing compressive force on the medial condyle.
- Presence of genu varum or genu valgum creates a constant overload of the lateral or medial articular cartilage which may result in damage to the cartilage and the frontal plane knee laxicity

- Genu varum contributes to the progression of medial compartment knee arthritis and medial joint laxicity.



MENISCI

- Menisci Are fibro cartilaginous discs are located on tibial condyles that enhances the congruence of knee joint

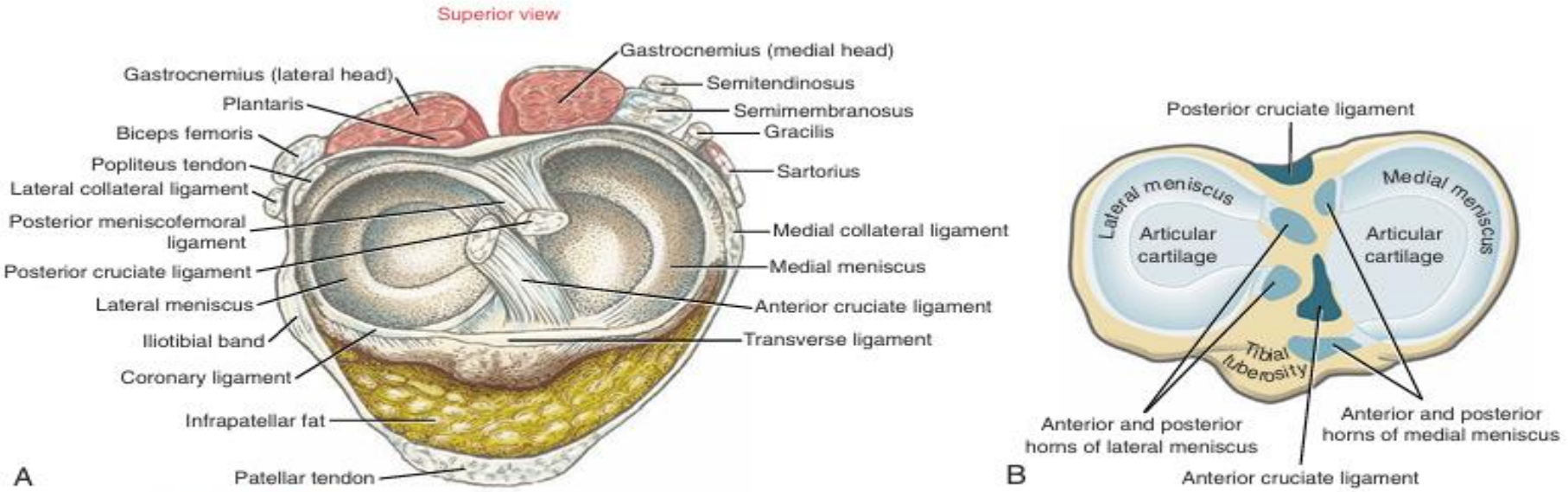
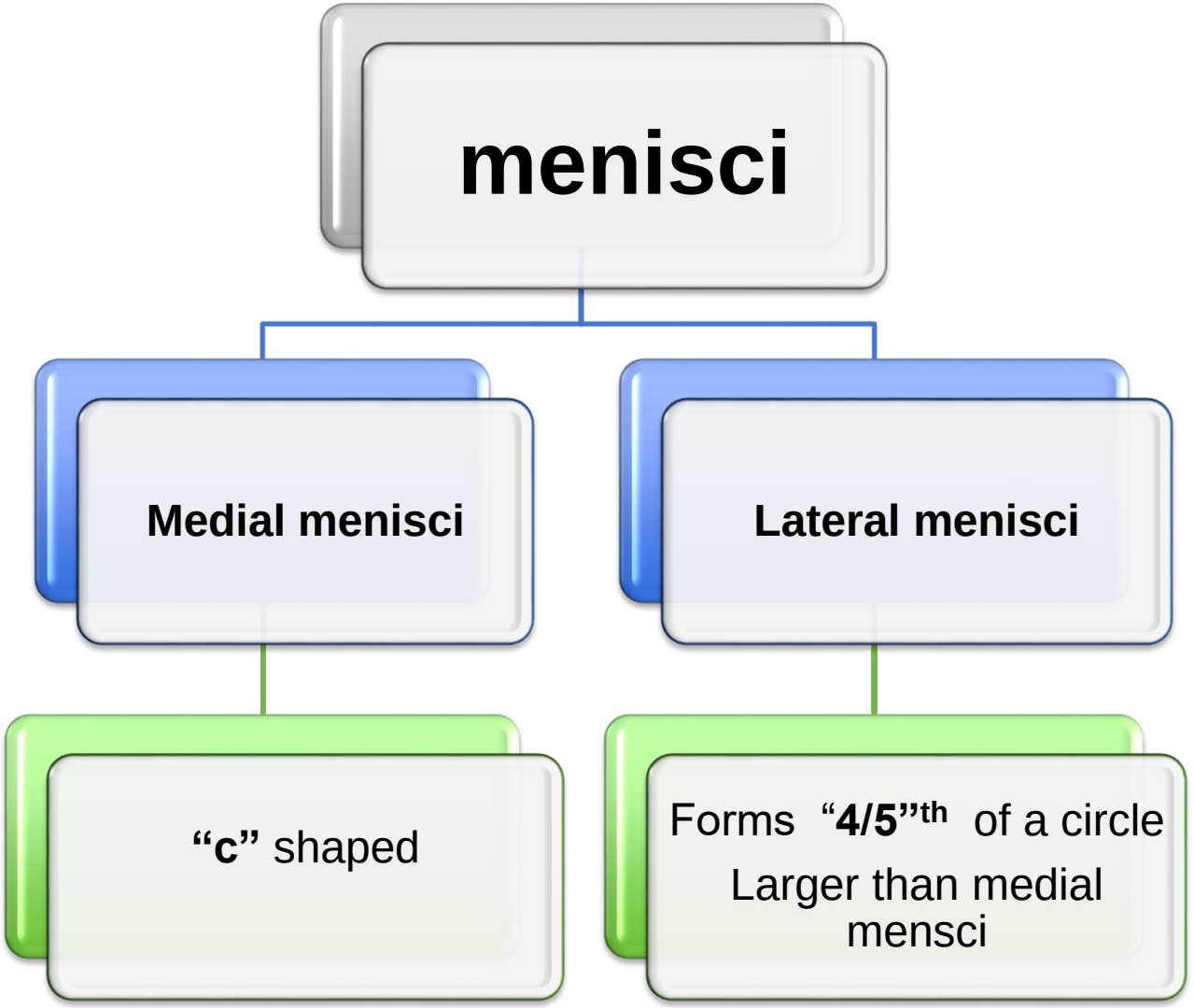
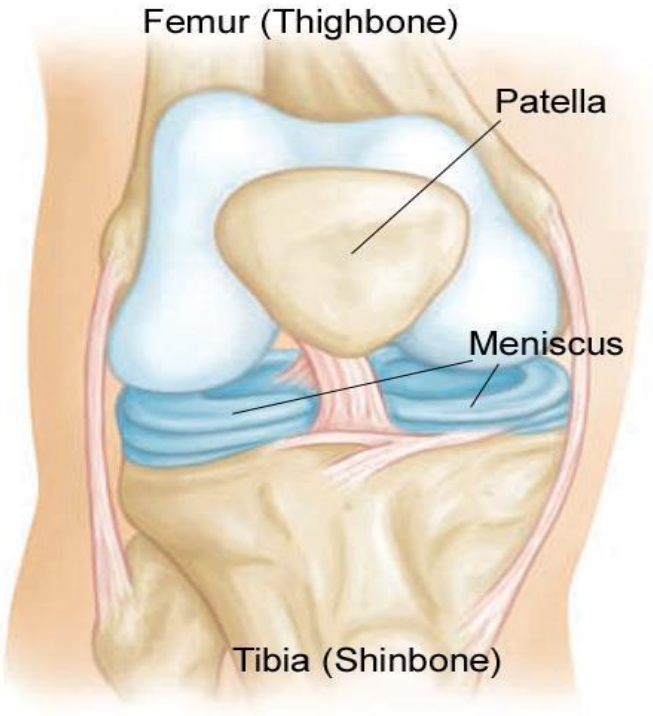


FIGURE 13-11. **A,** The superior surface of the tibia shows the menisci and other cut structures: collateral, cruciate, and posterior meniscofemoral ligaments, as well as muscles and tendons. (This specimen does not have an anterior meniscofemoral ligament.) **B,** The superior view of the right tibia marks the attachment points of the menisci and cruciate ligaments within the intercondylar region.


menisci
Medial menisci
Lateral menisci
“c” shaped
Forms “4/5”th of a circle
Larger than medial mensci

Functions of menisci

- Increases joint congruence
- Distributes weight bearing forces- dissipate the force
- decrease stress on tibiofemoral joint.
- Reduces friction between joints
- Serves as shock absorber



- Both menisci open towards intercondylar area, they are **thick peripherally** and **thin centrally** forming concavities.
- **Medial condyle is more susceptible to injury**
- Greater compressive load pass through medial condyle.
- Greater degree of **genu varum,** greater compression on medial meniscus.

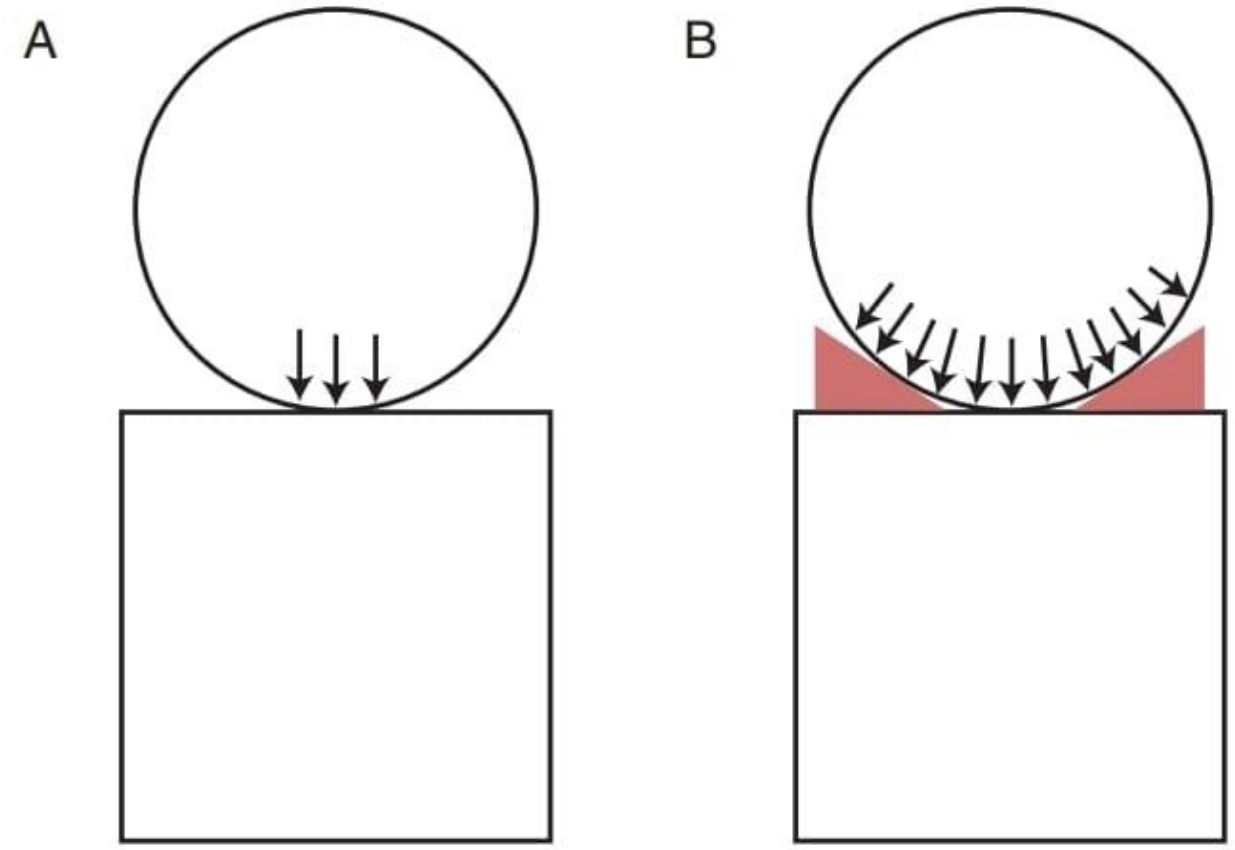
Meniscal attachments

- Medial meniscus has greater ligaments and capsular restraints, that limit translation compared to lateral meniscus.
- The limited mobility of medial meniscus contribute – greater incidence of injury.
- Anterior and posterior ends of menisci are called **anterior and posterior horn.**
- anteriorly menisci are connected each other by **transverse ligament**
- Both menisci are attached to patella- **patellomeniscal ligament.**

- Medial meniscus is attached:
  - medial collateral ligament.
  - ACL, PCL
  - Semimembranosus muscle
- MCL contributes to the restricted motion of the medial meniscus .
- Anterior and posterior portion of medial meniscus attached to the anterior cruciate ligament and Posterier cruciate ligament.

- Lateral meniscus is attached to:
- Popliteus muscle, this attachment controls the motion of lateral meniscus

- Role of menisci :
- Increase the contact area between bony surface.
- If femoral condyles, sits on flat tibial plateau, the stress is high because of the limited contact.
- Removal of menisci **doubles the articular cartilage stress on femur and tibial plateau.**



▲ **Figure 11-11** ■ **A.** If the round block (the femoral condyles) sits on the flat block (the tibial plateau), the stress (force per unit area) is high because of the limited contact. **B.** With the addition of the soft chocks or wedges (menisci), the contact area is increased, and the stress between the blocks (bony surfaces) is reduced.

Total meniscestomy

Increase in joint stress

Degenerative changes in tibial plateau

So total meniscetomy is rarely done. Instead removal of damaged tissue (debridement), repair is done

Body weight on knee joint

Gait	Increases **1-2 times**
Running	**3-4 times** body weight
Landing/ Jumping	**7-8 times** body weight

In this menisci takes **40-50%** of the body weight

When menisci are removed

Load on articular cartilage increases **1-2 times**

Load on tibiofemoral joint increases about **3-4 times**

Menisci vascularity

- In early years of life, before weight bearing ;

Menisci are supplied by rich blood supply.

- When weight bearing is initiated it begins to diminish.
- After 50 years of age ,blood supply only at periphery of menisci.
- At central region it is avascular, however it get nourishment through diffusion from synovial fluid

- Diffusion only happens during loading/ weight bearing.

During peroid of immobilisation → There is no loading → Diffusion doesnot occur → Damage to MENISCI, articular cartilage

Only peripheral vascularised region of meniscus is capable of inflammation, repair, remodeling after a tear/ injury

- Periphery of contains large number of:
  - Nociceptors- sense pain
  - Mechanoreceptors(helps in proprioception)
- When meniscal injury occurs mechanoreceptors get damage, so proprioception (joint position sense) is lost.

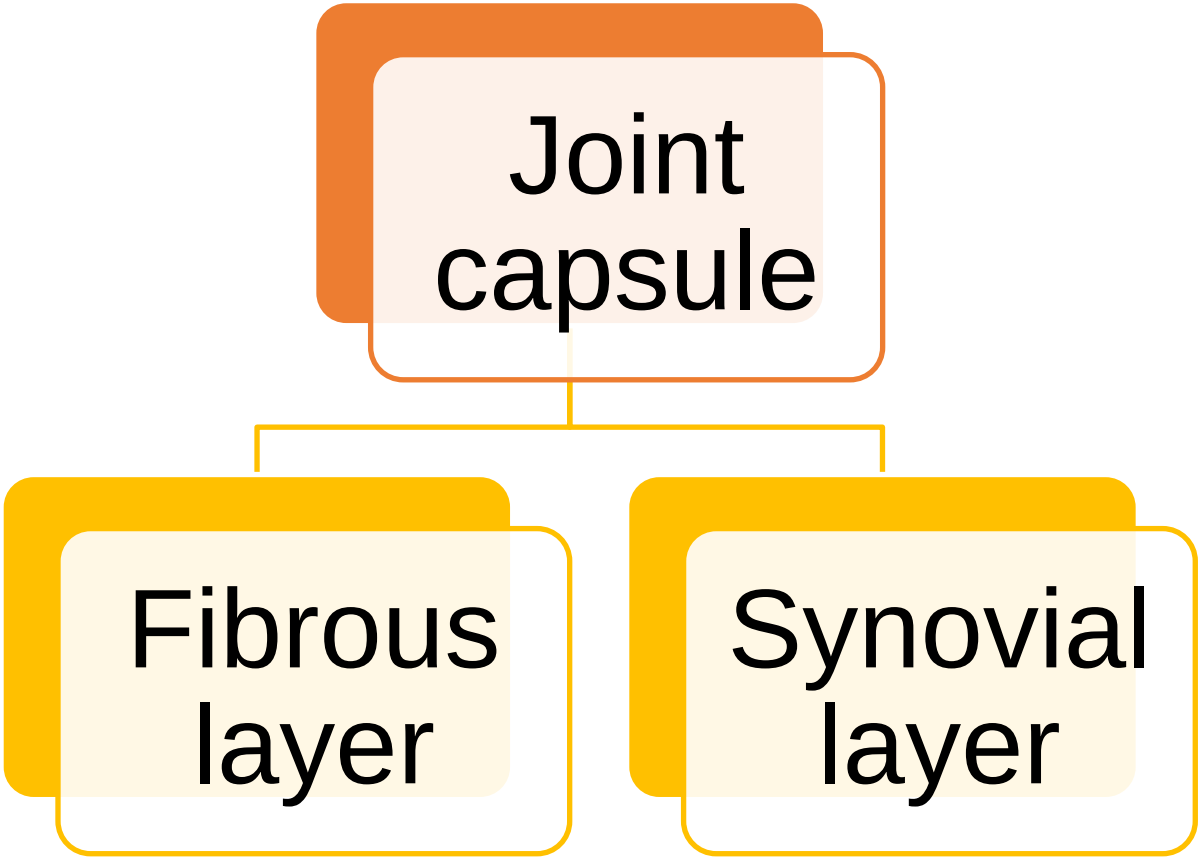
JOINT CAPSULE

- Role:
- Stability
- provides Proprioception and sensory feedback.
- Joint capsule creates a cavity in which synovial fluid is filled.

Joint capsule attachments:

- Joint capsule enclose both tibiofemoral and patellofemoral joint.
- Posteriorly:
  - Proximal attachment: posterior margins of femoral condyles.
  - distally: posterior tibial condyle.
- Anteriorly: patella, quads tendon(superiorly), patellar tendon(inferiorly)

- Anteromedial portion of joint capsule called **Medial patellar retinaculum.**
- Lateral portion called **lateral patellar retinaculum.**


Joint capsule
Fibrous layer
Synovial layer

- **<u>Fibrous layer (outer layer)</u>**:
- Contains extensor retinaculum.
- Quadriceps tendon, patella, patellar tendon , fascia covering patella , quadriceps and patellar tendon together forms extensor retinaculum.
- Medial retinaculum has a thickening that is attached to vastus medialis is called medial patellofemoral ligament.

- Lateral patellofemoral ligament have a thickening called **lateral patellofemoral ligament.**
- **Patella to menisci- medial and lateral patellomeniscal ligament**
- **Patella to tibia- M and L patellotibial ligament**

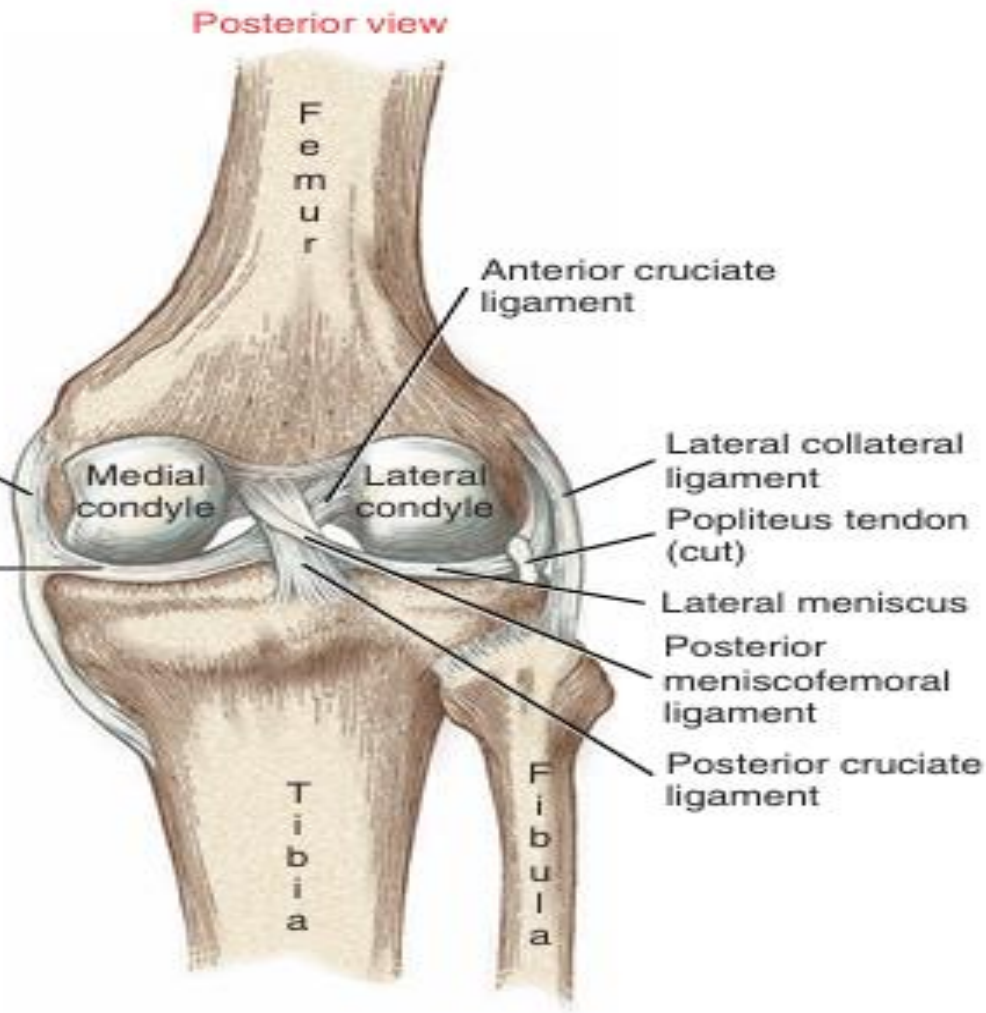
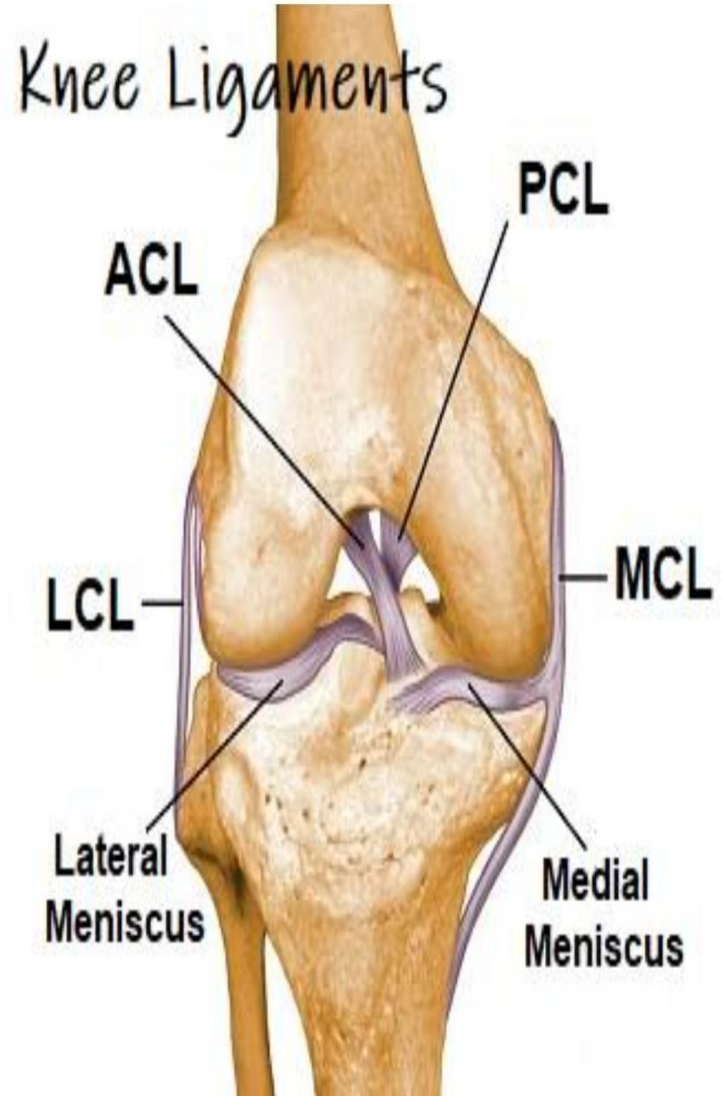


FIGURE 13-12. Posterior view of the deep structures of the right knee after all muscles and the posterior capsule have been removed. Observe the menisci, collateral ligaments, and cruciate ligaments. Note the popliteus tendon, which courses between the lateral meniscus and lateral collateral ligament.

- Synovial layer:
- The role of synovial tissue are to secrete and absorb synovial fluid in to joint capsule.
- Provides lubrication, provide nutrition to avascular structures.

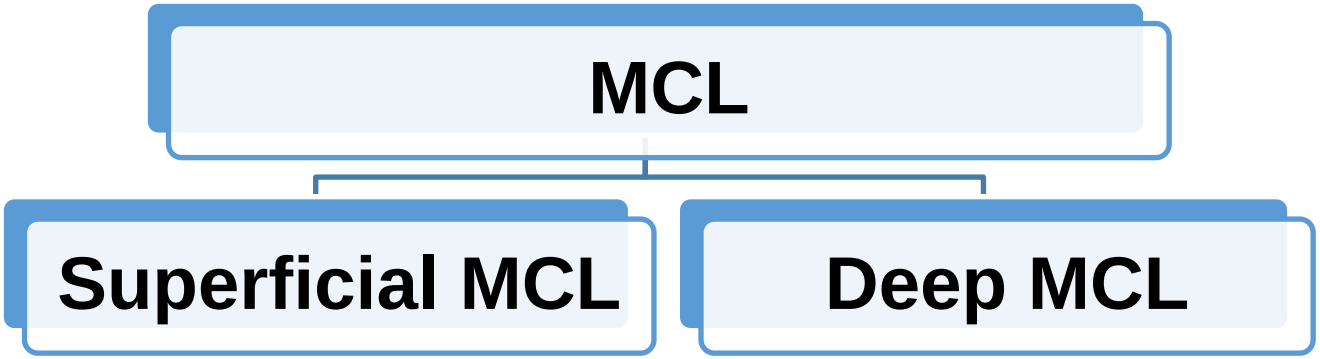
KNEE LIGAMENTS

- Anterior cruciate ligament
- Posterior cruciate ligament
- Medial collateral ligament
- Lateral collateral ligament



MEDIAL COLLATERAL LIGAMENT(MCL)

- MCL is also called tibial collateral ligament
- Arise from medial femoral epicondyle to tibia.



- Superficial MCL arise from medial femoral epicondyle and inserted distal to inserstion of pes anserius muscle.
- Deep fiber arise medial femoral condyle to proximal tibia.

- MCL has a rich blood supply having capacity to heal when ruptured or injured.
- MCL is attached to capsule and meniscus.

LATERAL COLLATERAL LIGAMENT(LCL)

- LCL arises from lateral femoral condyle to fibular head.
- LCL is not attached to capsule , hence it is extracapsular ligament.

Function- MCL

- MCL , the superficial portion, is the **primary restraint to excessive valgus(abduction)** stresses at the knee
- MCL also plays a **secondary role in resisting anterior translation of tibia** on femur.
- Prevents **excessive lateral rotation of tibia**.
- As MCL is taut in **full extension , knee joint is able to resist valgus stress (closed pack position).**
- **In extension: the role of MCL IS 57%.**
- In knee **20-30 knee flexion** MCL is proving **max resistance to valgus stress.**
- **IN 20-30 FLEXION, ROLE OF MCL is 78%.**

Function-LCL

- LCL is responsible for resisting varus stress.
- LCL also limits excessive lateral rotation of tibia as well.

ANTERIOR CRUCIATE LIGAMENT

- Origin: posteromedial aspect of lateral femoral condyle.
- Insertion: distally on tibia on medial intercondylar tibial spine.
- According to insertion ACL is classified as bundles:
- **anteromedial bundle, posterolateral bundle.**

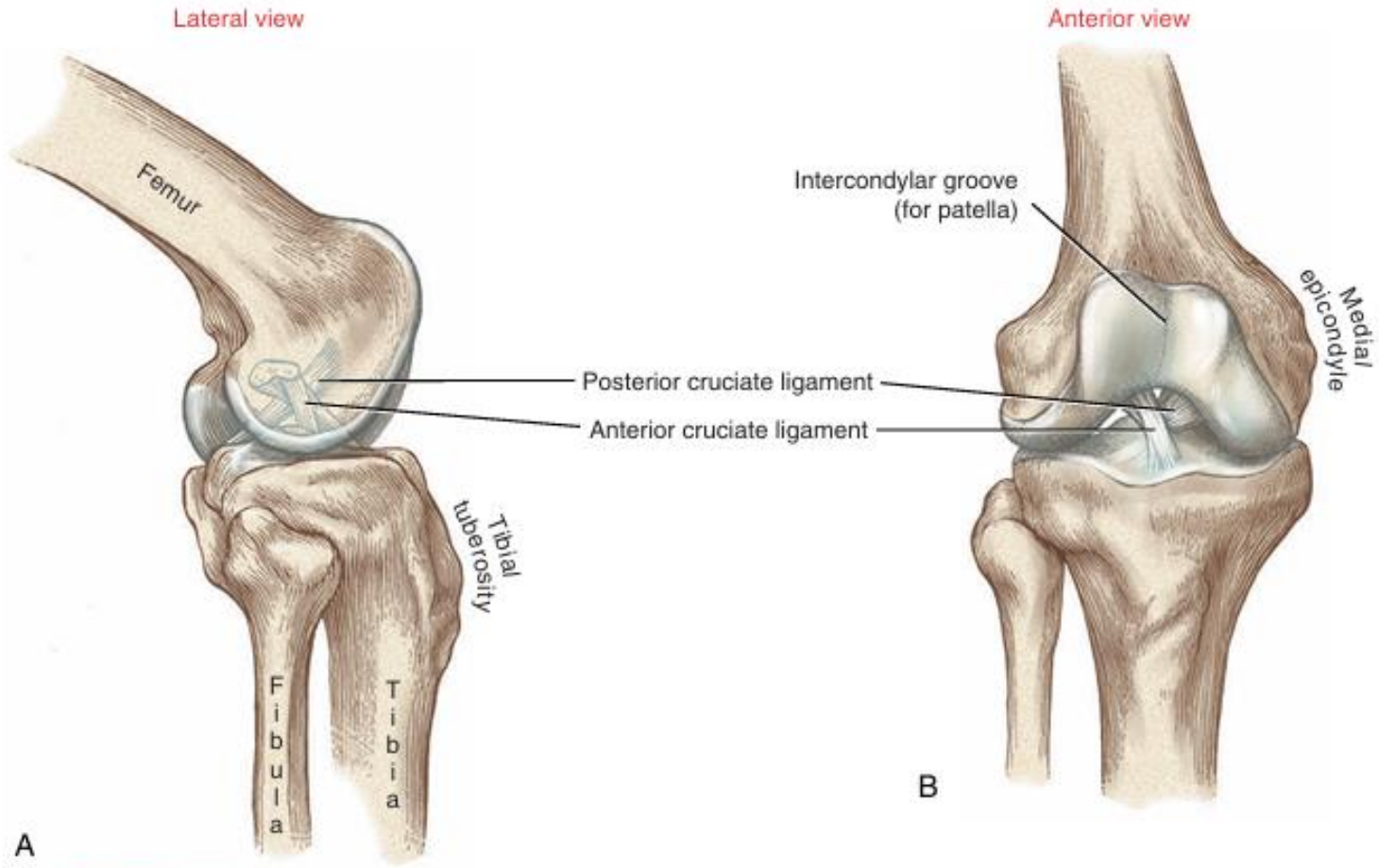


FIGURE 13-19. The anterior and posterior cruciate ligaments. **A,** Lateral view. **B,** Anterior view. The two fiber bundles within the anterior cruciate ligament are evident in **A.**

Functions

1. **ACL functions as the primary restraint against anterior translation of tibia on femur**

- During **extension**, **posterolateral bundle** is active.
- During **flexion , anteromedial bundle** is active.
- When flexion is increasing anteromedial bundle is tight , posterolateral bundle is loose.
- During flexion anteromedial bundle prevents anterior translation and provides stability.

- When extension, posteromedial bundle prevents anterior translation and provides stability
- During **30 degree flexion, anterior translation is maximal** because anteromedial bundle is not that tight.

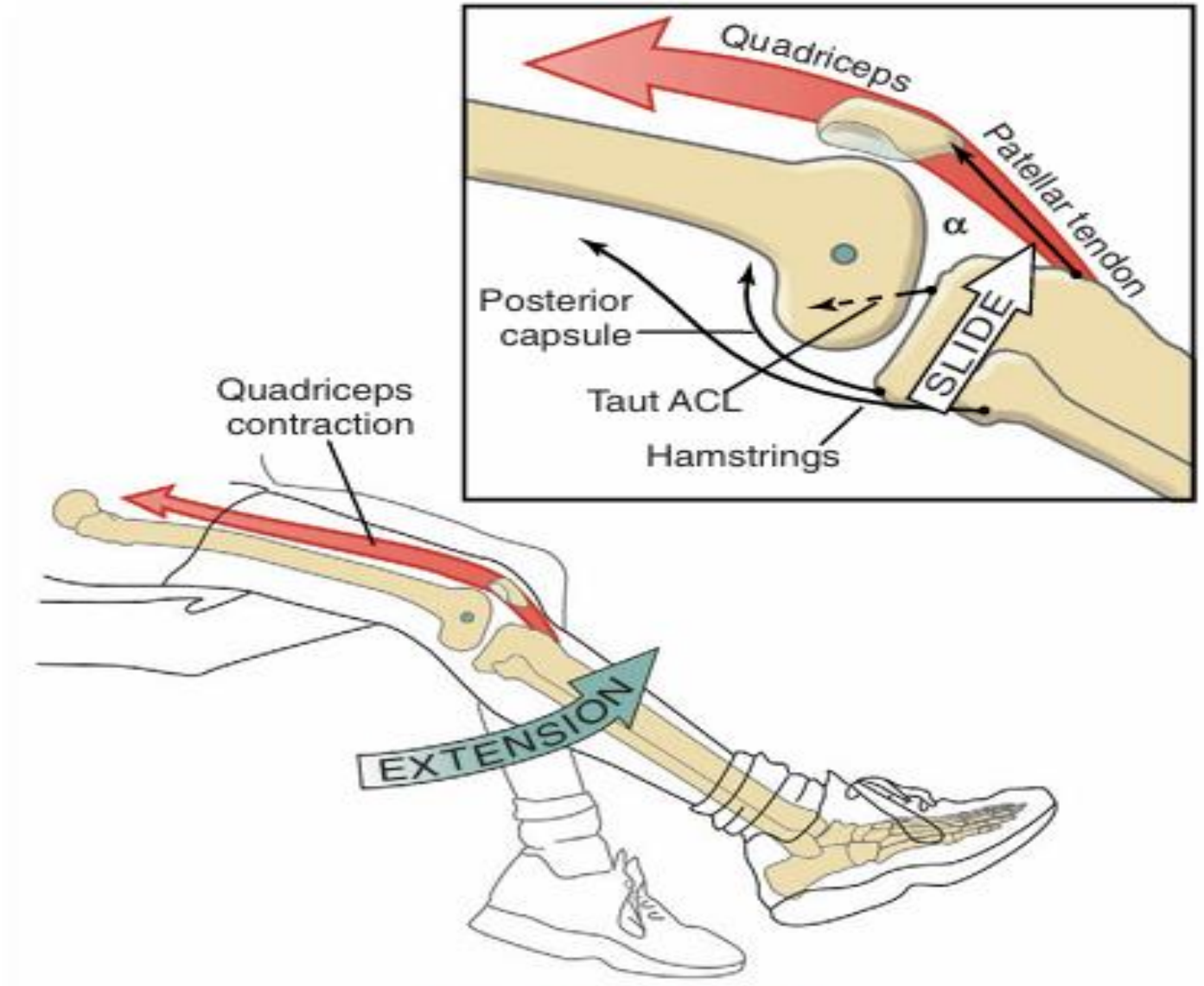
- 2. **ACL is responsible for resisting hyperextension of the knee.**
- Posterolateral bundle resists hyperextension

3. **ACL provides rotary stability of the knee during medial/lateral rotation, varus/valgus stability.**

4. Assist in valgus stability of MCL.

- Injury to MCL increases load on MCL thus increases strain on ACL.

- Quadriceps loading of a ACL deficient knee, results in medial tibial translation, shift the joint loading, results in degenerative changes.
- Isolated quadriceps contraction produce anterior translation of tibia, strains ACL.
- GASTRONEMIUS muscle cause anterior translation of tibia, thus increases strain ACL. Proximal tendon of gastrocnemius wraps around proximal tibia.



A Active knee extension

- Hamstring has the potential to reduce stress on ACL.
- Soleus muscle also cause posterior translation of tibia hence reduce strain on ACL.
- Co-contraction of gastrocnemius and quadriceps increases strain on ACL.
- Quadriceps exercise can only be given with knee flexed beyond 60 degree knee flexion.

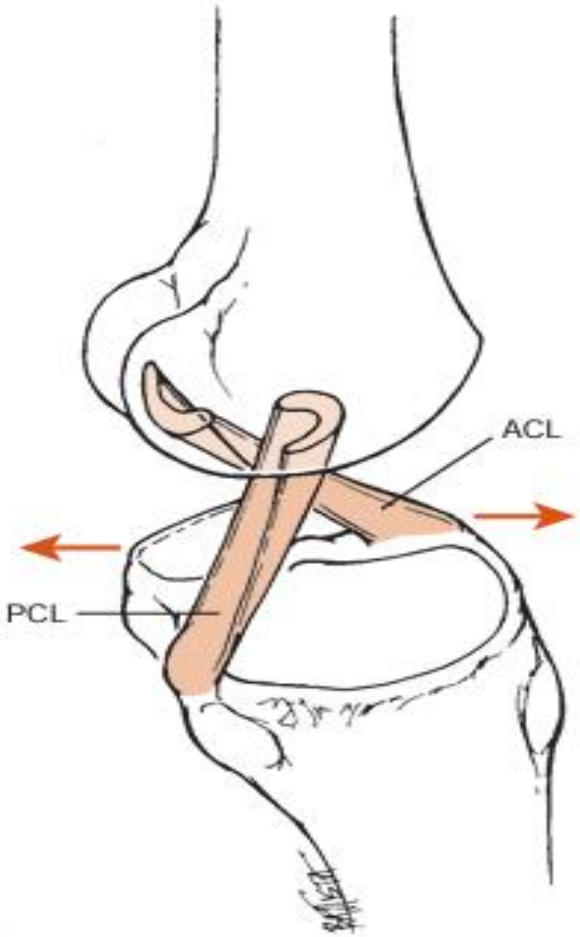


Figure 41.24: The ACL and PCL prevent anterior and posterior glide, respectively, of the tibia on the femur.

POSTERIOR CRUCIATE LIGAMENT(PCL)

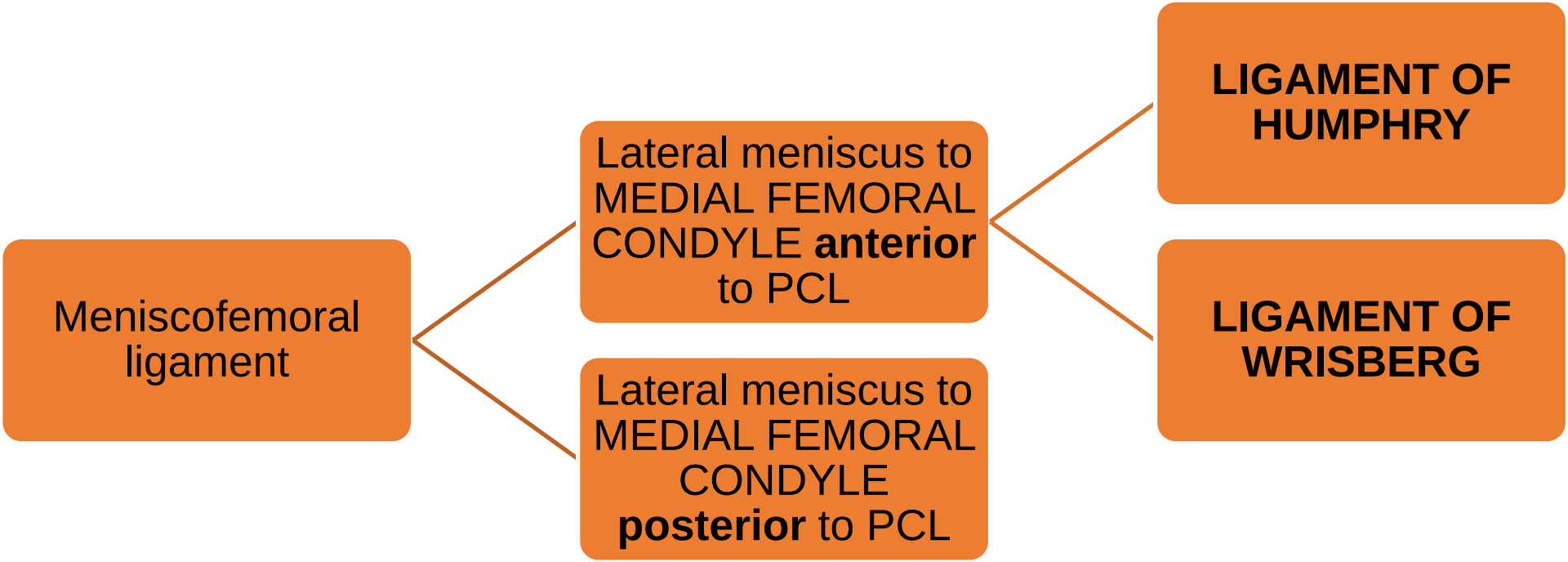
- Origin: Arises from medial femoral epicondyle
- Insertion: to the tibial surface between medial and lateral meniscus.
- PCL is shorter than ACL, Less oblique than ACL.
- **PCSA of PCL is 150% greater** than ACL, So PCL is **stronger** than ACL
- Divided into PMB and ALB.
- In fully extended knee, PCL absorbs **90%** of posterior directed load on tibia.


Back side of the knee
Posterior cruciate ligament
Posterior cruciate rupture

- PCL is the **primary stabilizer** of knee against posterior movement of tibia on femur
- PCL serves as **primary restraint to posterior displacement of tibia** beneath femur
- Is also has a role in restraining varus and valgus stresses at the knee.

- PCL resists medial tibial rotation.
- Popliteus muscle limit the posterior translation of tibia.
- When PCL is damage posterior translation will be prevented by popliteus
- Hamstring and Gastronemius contraction strains PCL
- Quadriceps contraction reduce the strain on PCL.

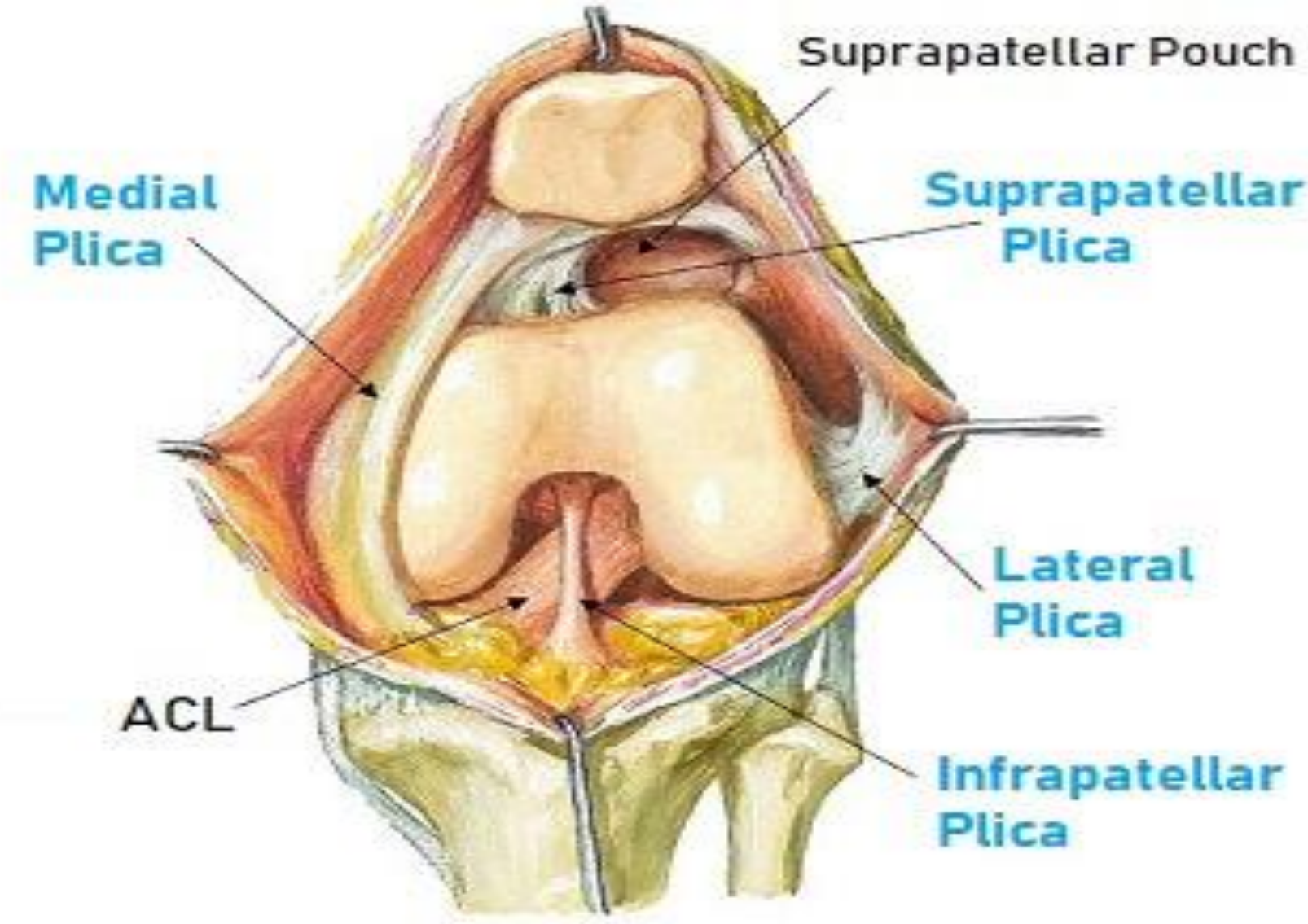
- Oblique popliteal ligament
- Arcuate ligament
- Meniscofemoral ligament:
- Attach from bone to menisci



PLICA

- Remnants of synovial membrane is seen after the birth is known as PLICA.
- Synovial membrane fuse over 12 weeks, but sometimes it fails to fuse and remains as left over, this remnants or folds is called PLICA.

- Most common locations are :
- Inferior- infrapatellar plica
- Superior- suprapatellar plica
- Medial- mediopatellar plica, lateral (rare).
- On occasions plica may become inflamed ,leads to pain, effusion, and changes in joint structure and function called **plica syndrome.**


Suprapatellar Pouch
Medial Plica
Suprapatellar Plica
Lateral Plica
ACL
Infrapatellar Plica

- Plica syndrome most commonly arises from medial/ superior plica.
- Discomfort arises when medial plica is impinged between medial aspect of patella and medial femoral condyle.
- There will be great pain because it has rich supply of pacinian corpuscles and free nerve endings.


Femur
(Thigh Bone)
Patella
(Knee Cap)
Synovial
Plica
Irritation
Tibia
(Shinbone)

Iliotibial band

- The iliotibial band tract or IT band (ITB) is a longitudinal fibrous sheath that runs along the lateral thigh.
- the ITB receives fascial contributions from the deep fascia of the thigh, gluteus maximus, and tensor fascia lata .
- Insertion: anterolateral tibia

(gerdy's tubercle).


Gluteus medius
Gluteus maximus
Tensor fascia latae (TFL)
Vastus lateralis
Iliotibial band
Patella

- Function: **provide lateral stability**.
- In flexed knee IT band tend to **migrate posteriorly**, increasing its ability to **restrict excessive anterior translation of tibia** under femur.
- IT band get tensed during flexion.

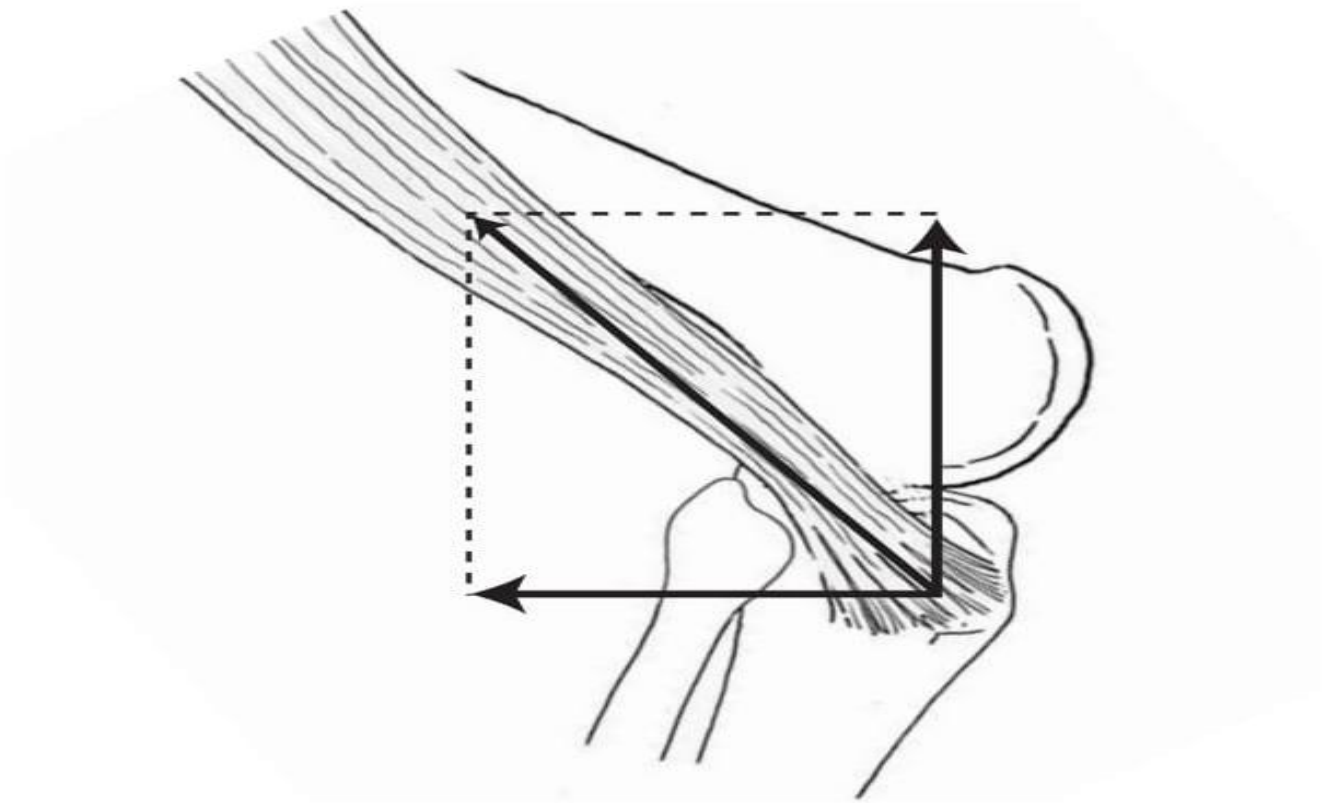


Figure 11–22 ■ The IT band provides lateral support to the knee joint. In the flexed knee, the IT band tends to migrate posteriorly, increasingly its ability to restrict excessive anterior translation of the tibia under the femur.

- Adipose tissue is present between IT band and bony intersurface.
- Adipose tissue is less compressed in full extension.
- **As knee moves from extension to 30 degree flexion compression** of highly vascularised and innervated **adipose tissue increases**.
- Patients with **IT band syndrome** may complains pain at distal insertion of IT band during 30 degree flexion.

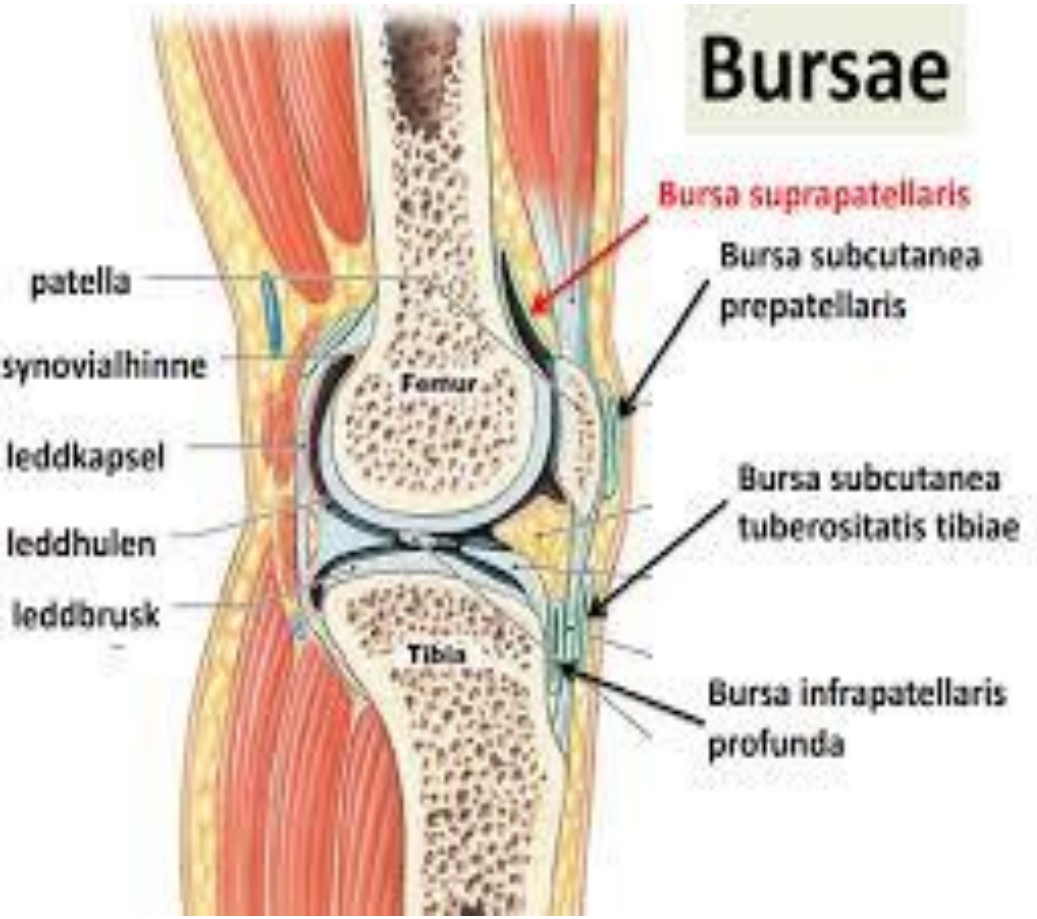
Iliotibial Band Syndrome

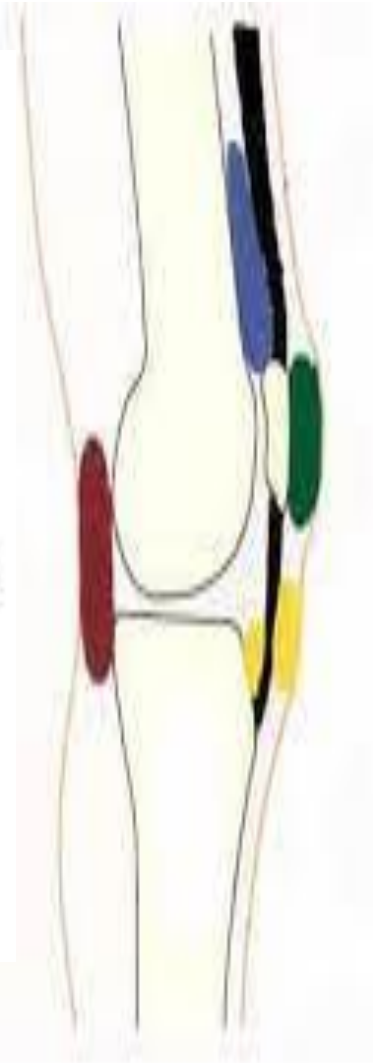
BURSA

- Knee joint contains numerous bursa
- Anteriorly**, suprapatellar bursa** lies between quads tendon and anterior femur,superior to patella.
- Posteriorly, subpopliteal bursa- lies between tendon of popliteus and lateral femoral epicondyle.
- Gastrocnemius bursa lies between tendon of gastrocnemius and medial femoral epicondyle.

- In extension, gastrocnemius and subpopliteal bursa is compressed.
- In flexion suprapatellar bursa is compressed.
- Prepatellar bursa- located between skin and anterior surface of patella.
- Infrapatellar bursa- lies inferior to patella between patellar tendon and skin.

Bursae





Suprapatella bursa

Prepatella bursa

Infrapatella bursae

Semimembranosus bursa

- Both infrapatellar and prepatellar bursa gets inflamed during direct trauma to the front of knee or activities like prolonged kneeling.

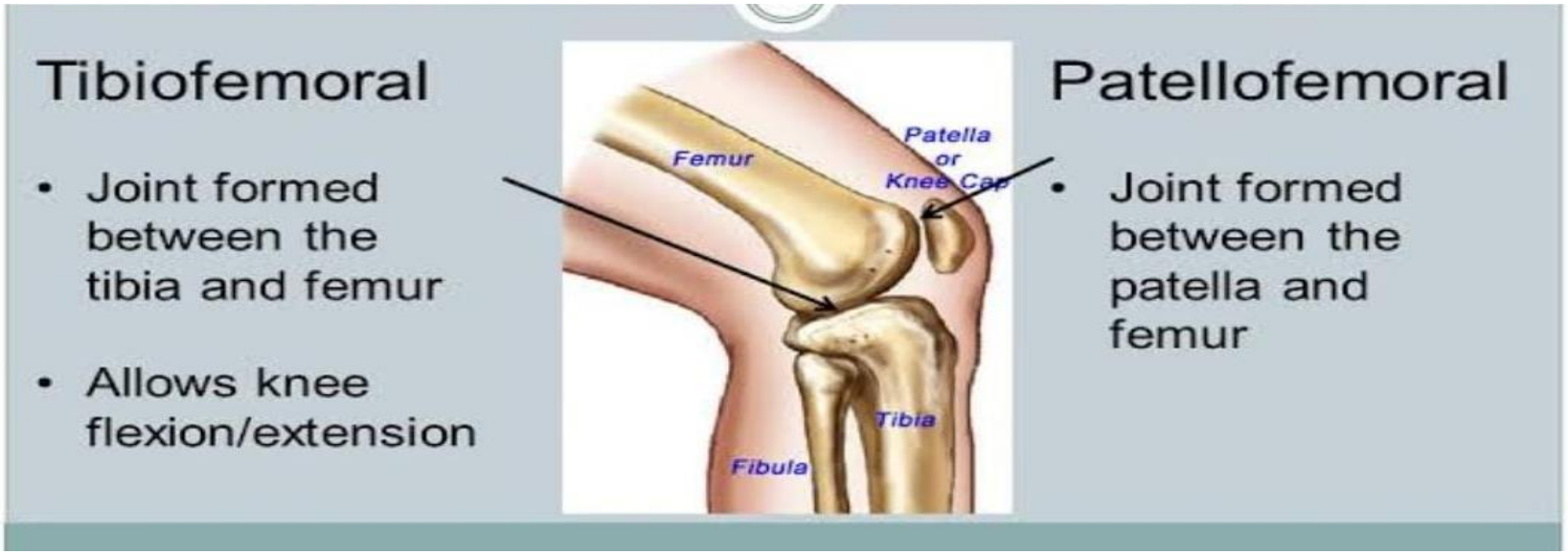
- Infrapatellar bursa is seperated from the synovial cavity by infrapatellar fat pad (Hoffa's pad).


femur
patella
Hoffa's fat pad
tibia
patellar tendon

ARTICULATIONS

- The knee complex is composed of two articulations within a single capsule

1. The tibiofemoral joint



TIBIOFEMORAL JOINT

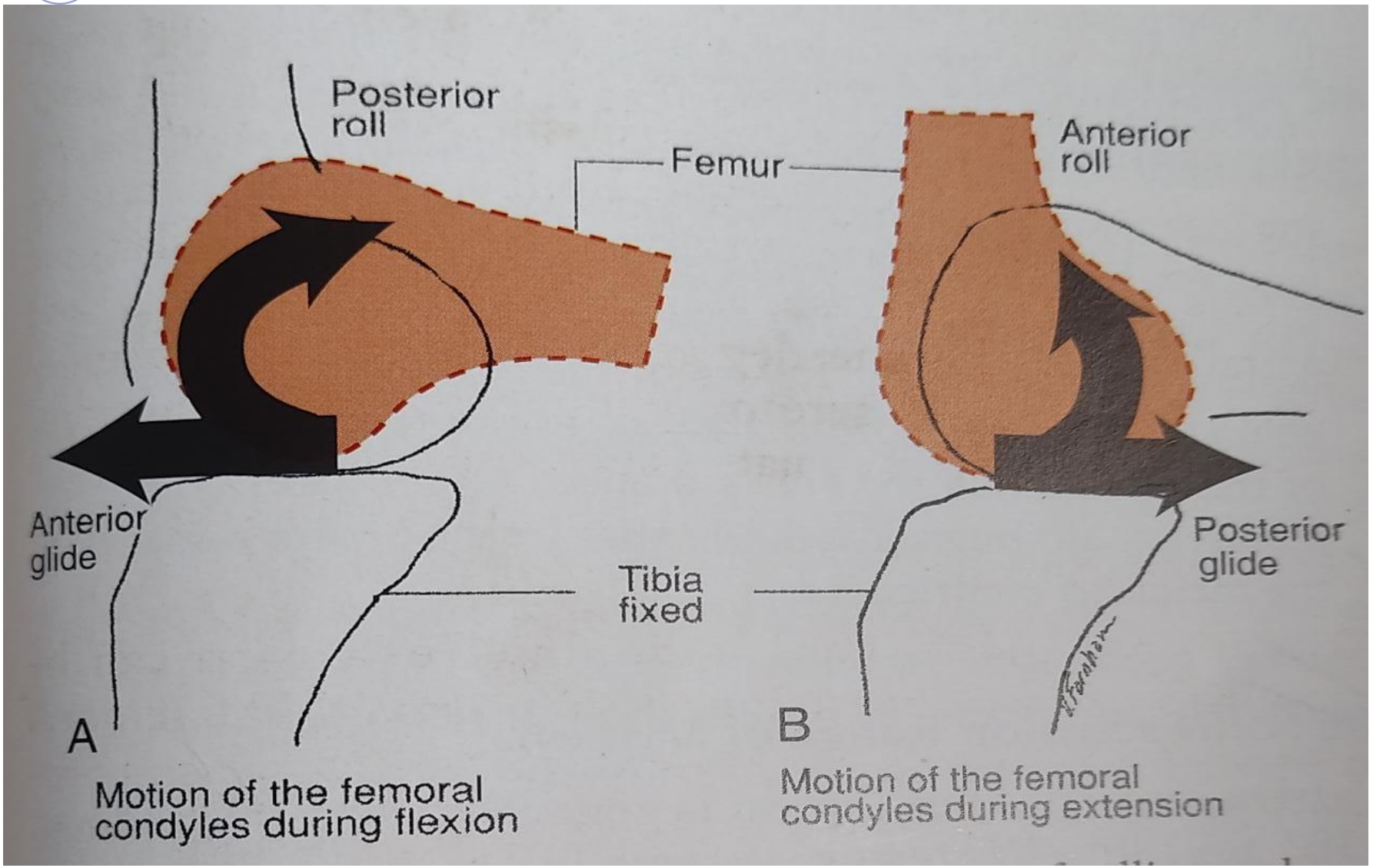
- It is a double condyloid joint
- 3 degrees of freedom:
- FLEXION, EXTENSION
- MEDIAL/ LATERAL ROTATION
- ABDUCTION/ ADDUCTION

- **Axis:**
- for flexion, extension passes through femoral epicondyle- **transepicondylar axis.**

Flexion of femur on fixed tibia

A) Flexion

- Occurs in sagittal plane
- Such as weightbearing activities(squatting).
- **During initiation of knee flexion till (0-25 degree)**
- occurs as posterior rolling of the femoral condyles on the fixed tibia .
- As flexion continues, beyond 25, **posterior rolling of femoral condyle** is accompanied by **anterior gliding of femoral condyle.**


Posterior roll
Femur
Anterior roll
Anterior glide
Tibia fixed
Posterior glide
A
Motion of the femoral condyles during flexion
B
Motion of the femoral condyles during extension

b) Extension of femur on fixed tibia

- Knee extension- **anterior rolling** of femoral condyles on the tibial plateau With **posterior gliding.**

MOTION ON TIBIA ON FIXED FEMUR

- Eg: during seated knee extension or swing phase of gait.
- During extension of tibia on fixed femur, anterior roll and anterior glide takes place.
- When tibia is flexing on femur, the tibia rolls and glides posteriorly.

Flexion and extension range of motion

- Active knee flexion - 130°-140°
- Passive knee flexion -160°
- During gait -60°-70°
- During ascending stairs -80°
- During sitting into and arising from chair -90° or more
- Knee extension /hyperextension -5°
- Beyond 5° of hyperextension –GENU RECURVATUM

B) Medial and lateral rotation

- Occurs in transverse plane.
- longitudinal axis.
- Axis is passing through medial tibial plateau.
- During lateral rotation, lateral tibial condyle move posteriorly, but movement in medial condyle is very minimal.
- During medial rotation, the medial tibial condyle move slight posteriorly ,whereas the lateral condyles moves anteriorly through a larger arc of motion

C) Abduction(valgus) and adduction (varus)

- frontal plane.
- anterioposterior axis
- only 8° abduction/adduction at full extension ,and 13°-20° at knee flexion .
- Excessive frontal plane motion could indicate ligamentous insufficiency

LOCKING AND UNLOCKING MECHANISM OF KNEE

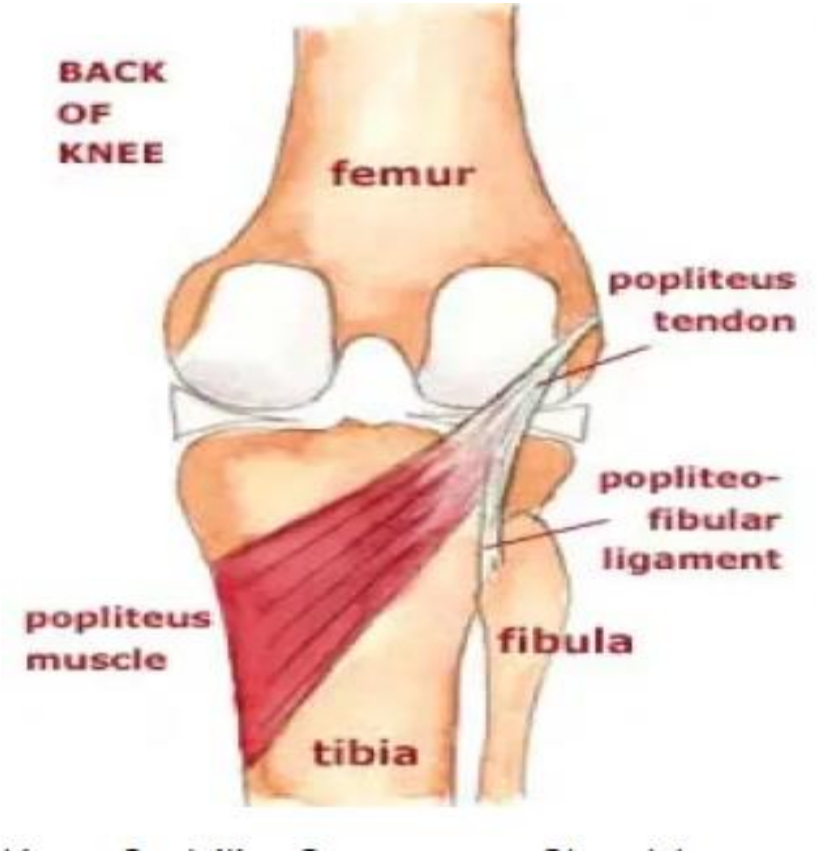
- **NON WEIGHT BEARING**
- The articular surface of Medial femoral condyle and medial tibial plateau is larger than lateral femoral condyle/ plateay.
- **During final stage of knee extension there is a obligatory lateral rotation of tibia.**
- This coupled motion that is lateral rotation with knee extension is known as automatic / terminal rotation.

- During last 30 degree of knee extension the shorter lateral tibial plateau completes its rolling and gliding before medial tibial plateau.
- The longer medial plateau continues to roll and glide anteriorly.
- **This continued anterior motion of medial femoral condyle results in lateral rotation of tibia on femur.**

- This motion is very evident at final 5 degree extension.
- The tibial condyles become lodged in the intercondylar notch, ligaments taut in this position.
- This automatic rotation is known as locking/ **Screw home mechanism.**

Unlocking –Non weight bearing

- To initiate knee flexion from full extension the knee must be unlocked.
- **During initiation of knee flexion from full extension, medial tibial condyle will rotate "medially" . This way knee is unlocked.**
- **The medial rotation occurs by the contraction of popliteus muscle.**
- **Popliteus muscle attaches from the lateral femoral condyle to posteromedial aspect of tibia.**


BACK
OF
KNEE
femur
popliteus
tendon
popliteo-
fibular
ligament
popliteus
muscle
fibula
tibia

Weight bearing

- During last 30 degrees of knee extension the lateral femoral condyle completes its rolling and gliding before medial femoral condyle.
- **Medial femoral condyle** continues to **roll anterior** and **glide posteriorly**.
- Freely moving femur medialy rotates on the fixed tibia during last 30 degree of extension.
- **Unlocking is done by lateral rotation of tibia**

	Non weightbearing	weightbearing
LOCKING	EXTENSION + **LR** FLEXION + MR	EXTENSION + **MR** FLEXION + LR

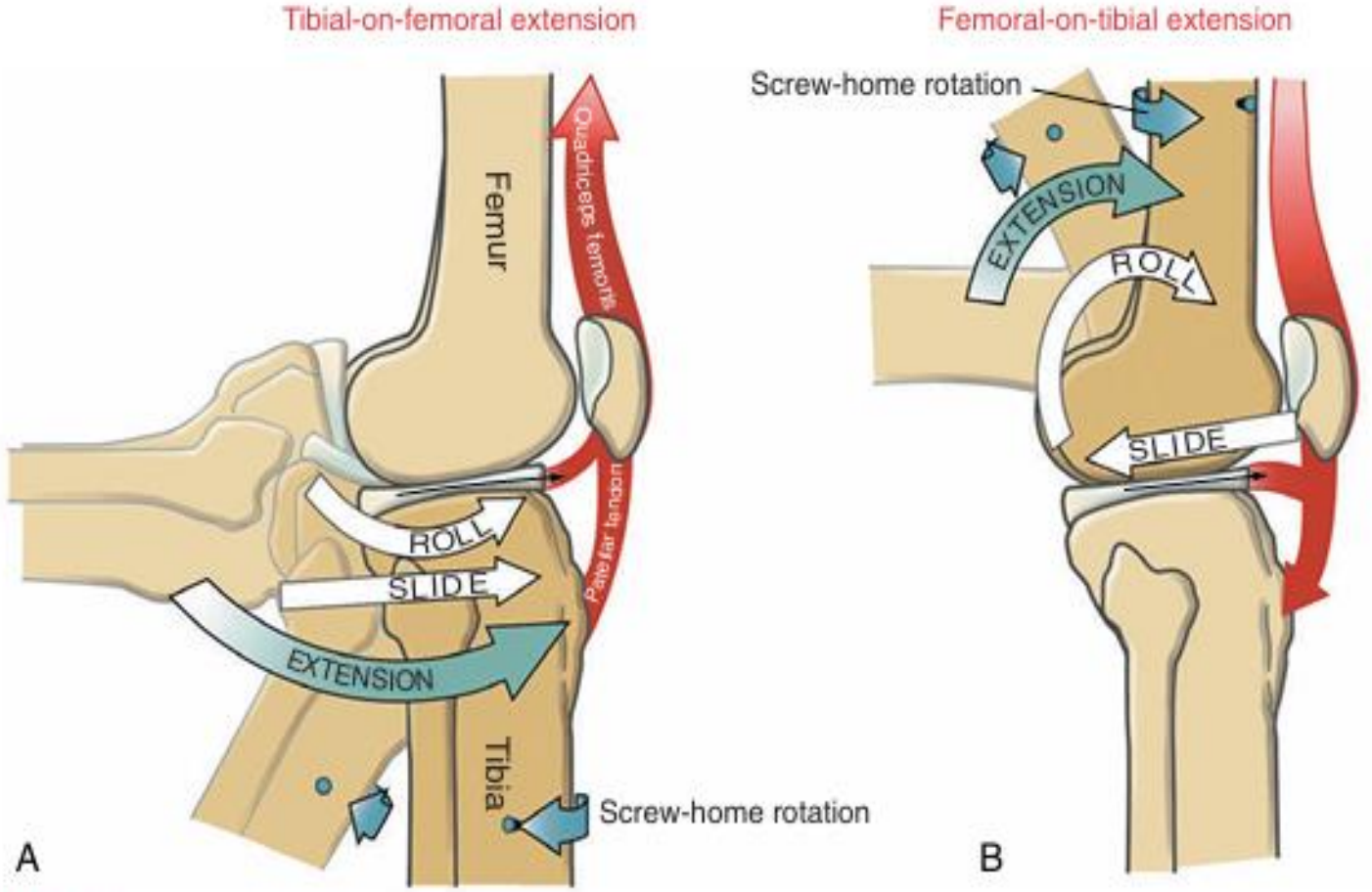
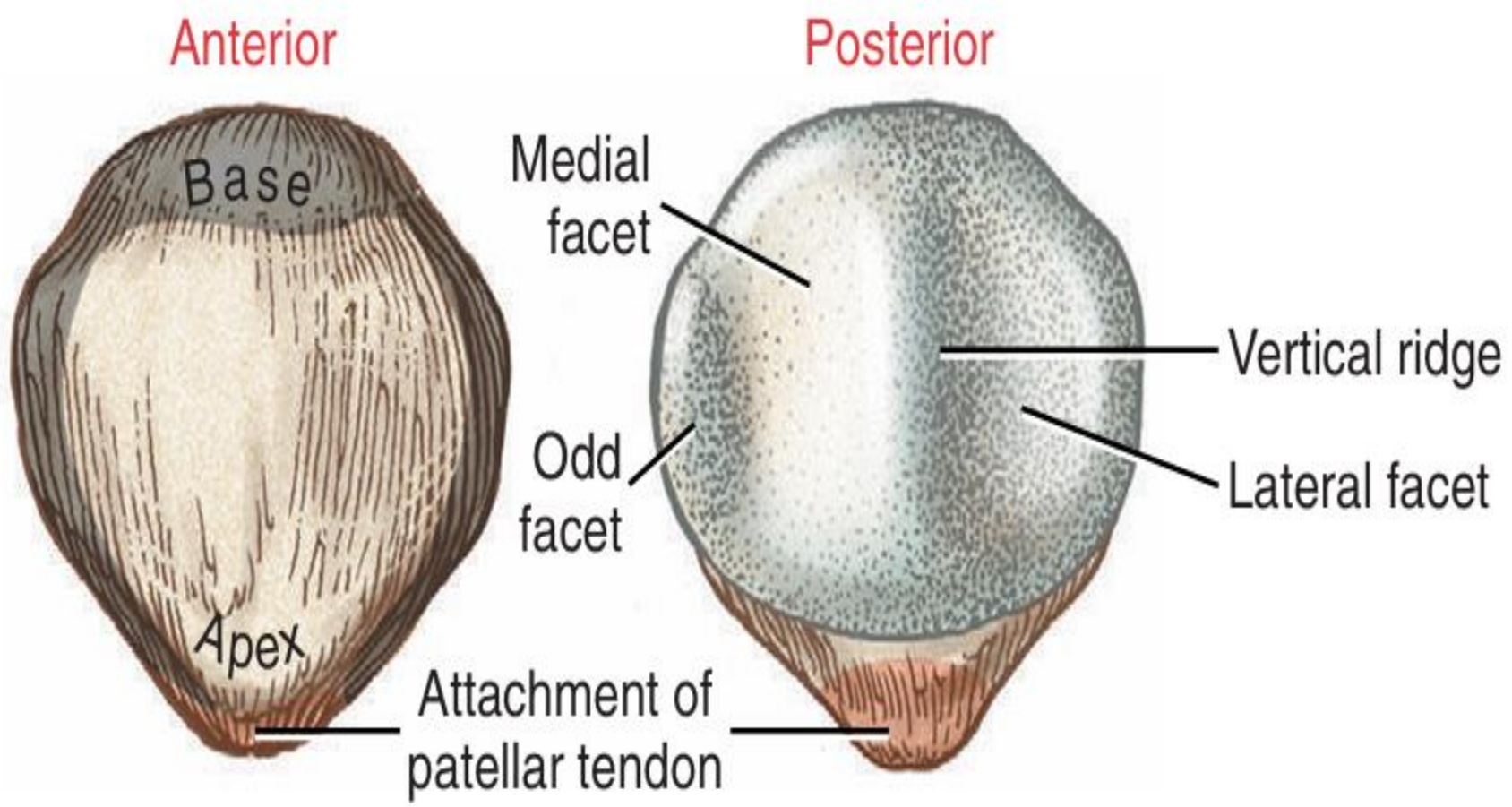


FIGURE 13-16. The active arthrokinematics of knee extension. **A,** Tibial-on-femoral perspective. **B,** Femoral-on-tibial perspective. In both **A** and **B,** the meniscus is pulled toward the contracting quadriceps.

PATELLOFEMORAL JOINT

- The patellofemoral joint is the interface between the articular side of the patella and the intercondylar (trochlear) groove of the femur.
- the flat, triangularly shaped patella is the largest sesamoid bone in the body
- The patella is an inverted triangle with its apex directed inferiorly
- It functions primarily as an anatomical pulley for the quadriceps muscle

- Articulation is provided by the posterior surface.
- Posterior surface is divided by vertical ridge , situated at the center of patella.
- It divides the surface into **medial and lateral facets.**
- There is a second vertical ridge towards the medial border that seperates medial facet from an extreme medial edge known as **odd facet of patella.**


Anterior
Posterior
Base
Apex
Medial facet
Odd facet
Vertical ridge
Lateral facet
Attachment of patellar tendon

- In an extended knee- Posterior surface of patella sits on femoral sulcus.
- Patella is attached to tibial tuberosity by patellar tendon.
- When the position of patella is higher than normal it is called **patella alta.**

- **Ratio of length of patellar tendon to the length of patella is approx 1:1**
- This is referred as **Insal salvati index.**
- A long patella tendon produces abnormaly high position of the patella on the femoral sulcus known as **patella alta**
- It increases patellar instability.

- In patients with patella Alta , the tibiofemoral joint must be flexed more before patella translate inferiorly.

- **Patella baja** (infera) refers to an abnormal inferior location of the patella relative to the femoral trochlea.
- True patella baja occurs due to scarring and shortening of the patellar tendon.

PATELLOFEMORAL JOINT MOTION

A) Patellar flexion and patellar extension

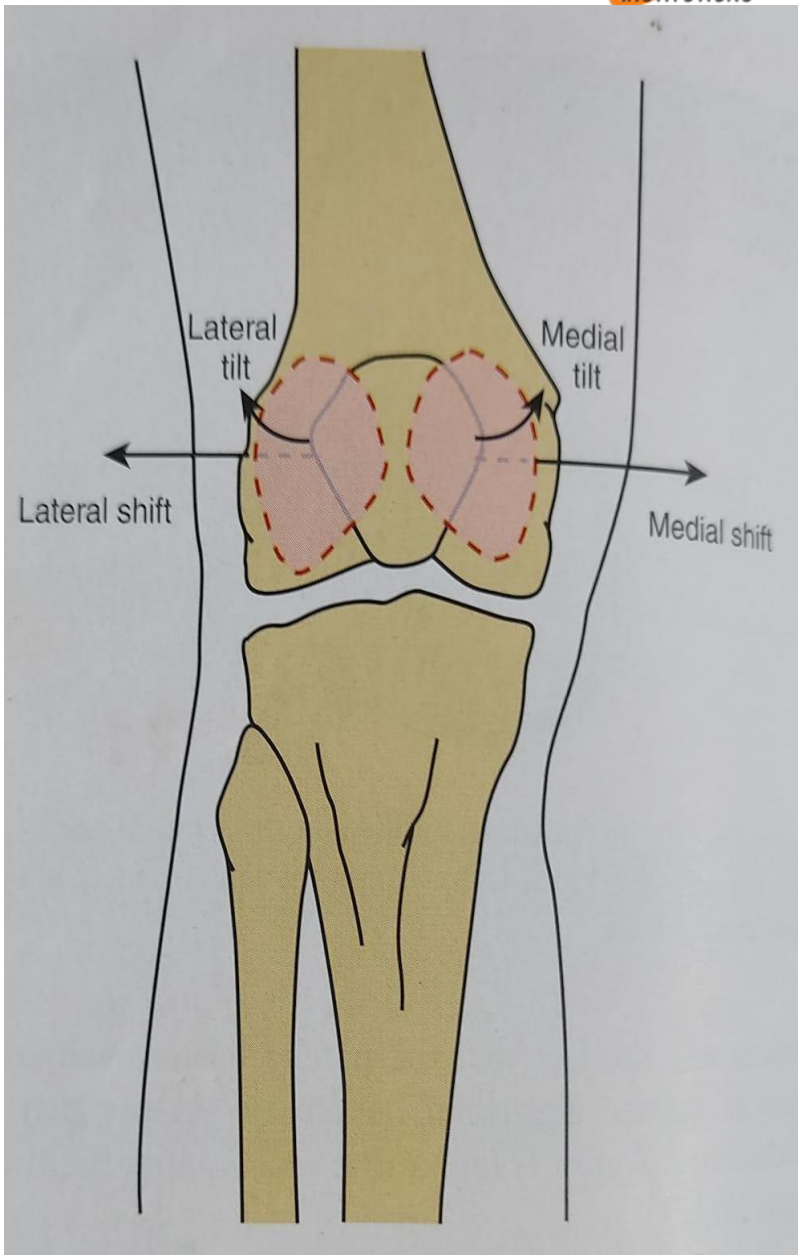
- Patellar flexion: sagittal plane rotation of the patella along with knee flexion as the **patella travels down the intercondylar groove of the femur**
- Patellar extension: brings the patella back to its original position in the femoral sulcus along the knee extension with the apex of the patella pointing inferiorly at the end of the normal range of motion

B) Medial and lateral patellar tilt

- Patella tilts around a longitudinal axis , shifts medially and laterally in the frontal plane.
- Lateral patellar tilt occurs when the lateral edge of the patella approximates the surface of the lateral femoral condyle
- Medial patella tilt occurs when the medial edge of the patella moves toward the medial femoral condyle

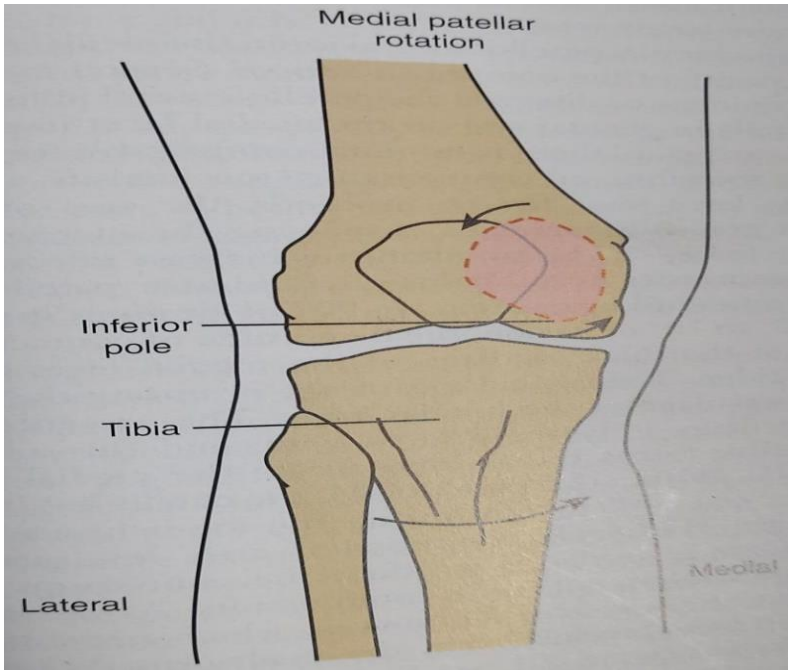
C) Lateral and medial patella shifts

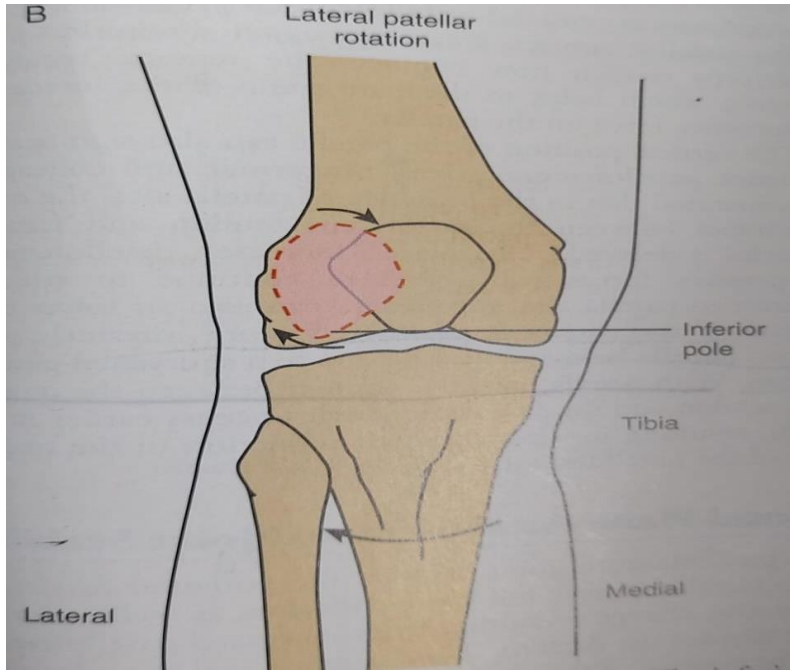
- Shifts occurs in frontal plane along the medial-lateral axis
- A lateral patella shifts is defined as patella moving toward the lateral femoral condyle
- A medial patella shifts is patella moving towards the medial femoral condyle



D) medial and lateral patellar rotation

- Rotation occurs in antero-posterior axis
- Medial rotation occurs when the patella spins around this perpendicular axis with the **apex of the patella pointing towards the medial femoral condyle, and the base of the patella moving closer to the lateral femoral condyle**





Patellar influence on quadriceps muscle function

- Patellar lengthen the moment arm of quadriceps by increasing the distance of quadriceps tendon and patellar tendon from axis of knee joint.
- Patella act as **anatomic pulley-** it deflect the action line of quadriceps away from the joint center

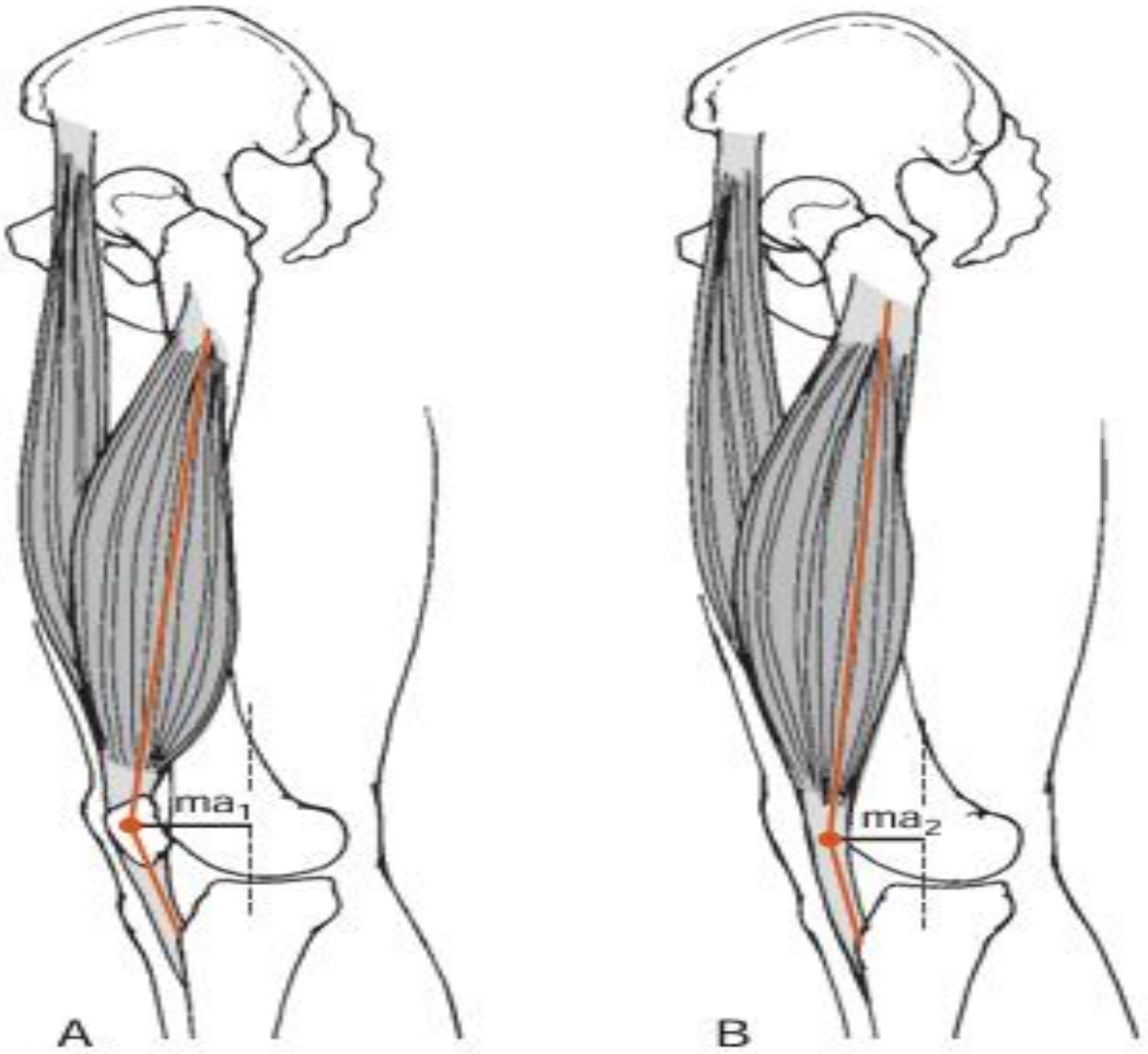


Figure 41.10: **A.** One role of the patella is to lengthen the moment arm (ma_1) of the quadriceps femoris muscle. **B.** Removal of the patella results in a significant reduction of the muscle's moment arm (ma_2), and hence, the moment produced by the muscle.

- **At 135 degrees of flexion**- the patella contacts the femur near **lateral facet** and the **“odd” facet** of the patella
- At this near fully flexed position, the patella rests below the intercondylar groove, bridging the intercondylar notch of the femur.

- **Between 90 and 60 degrees of flexion-** Contact area between the patella and femur is **greatest**.

- As the knee extends through the **last 20 to 30** degrees of flexion- the primary contact point on the **inferior pole of patella**.

- Once in **full extension**, the patella rests completely proximal to the groove and against the **suprapatellar fat pad**.
- In this position, with the quadriceps relaxed, the patella can be moved freely relative to the femur.

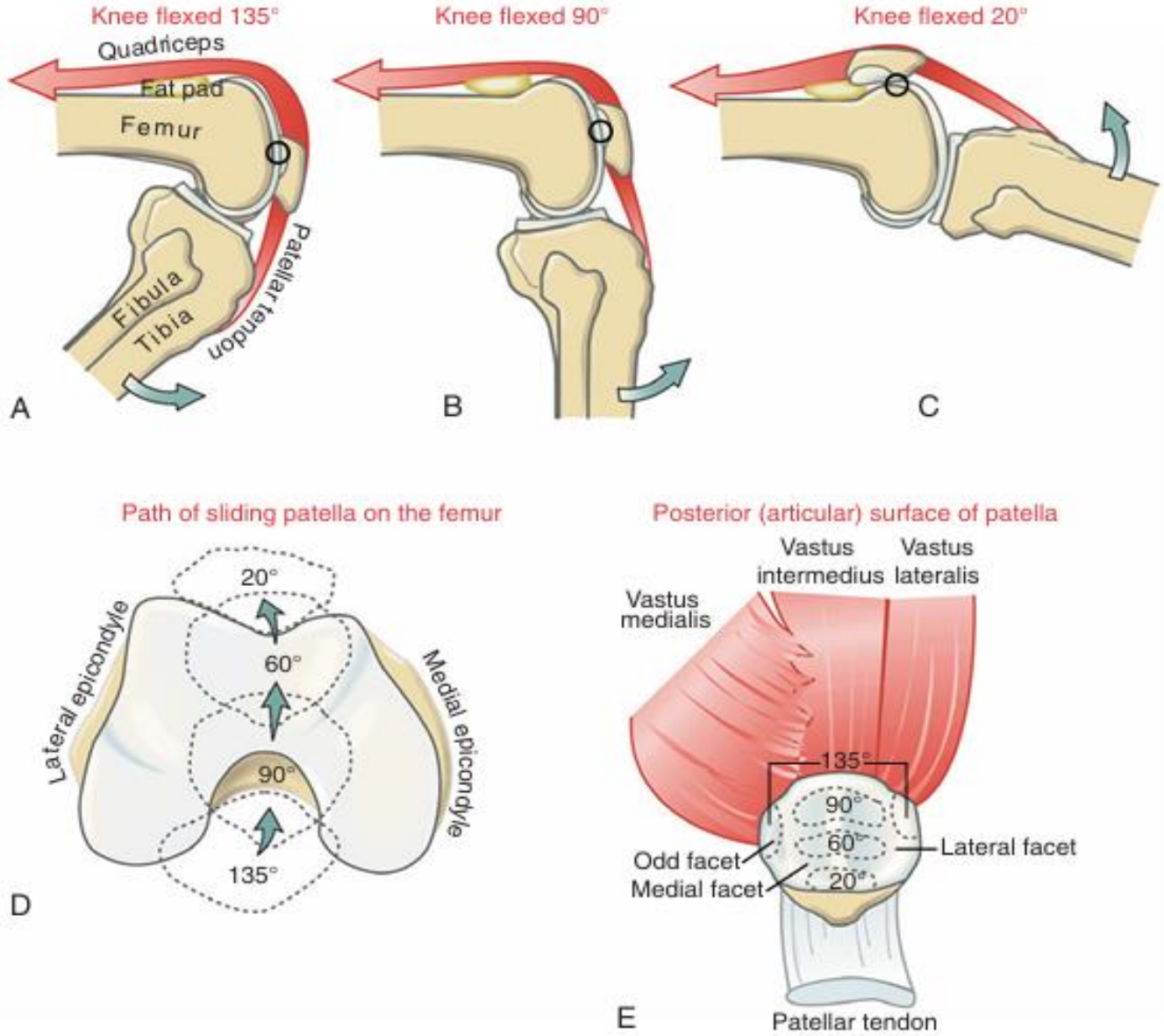
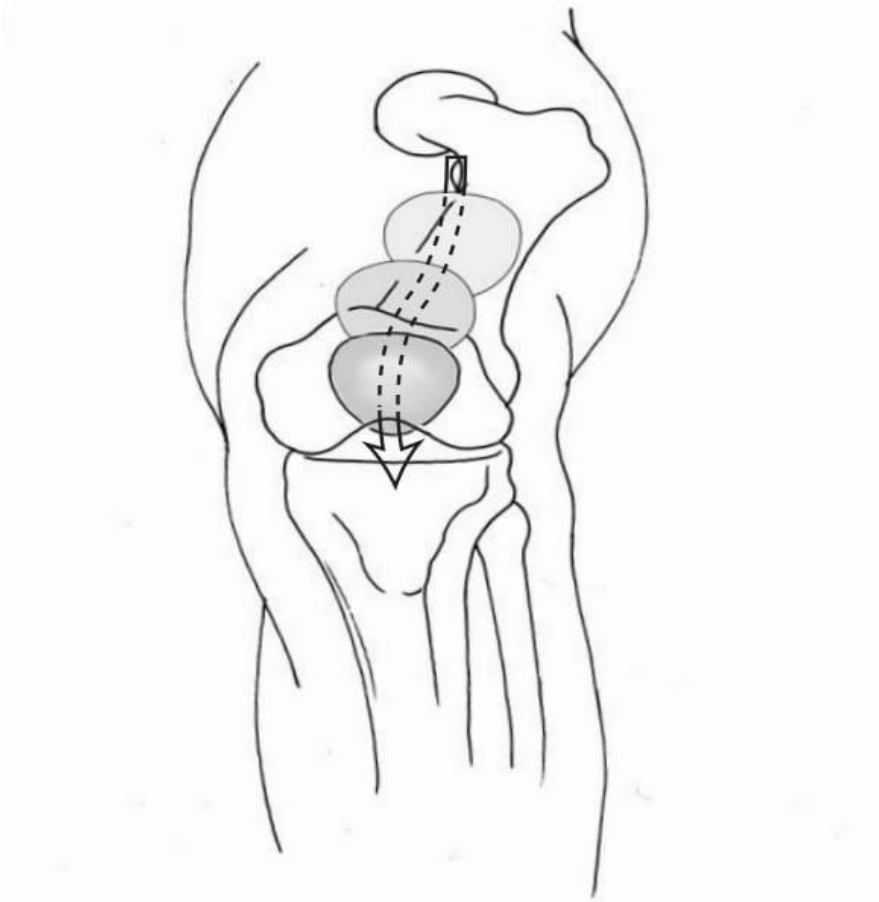


FIGURE 13-23. The kinematics at the patellofemoral joint during active tibial-on-femoral extension. The circle depicted in **A** to **C** indicates the point of maximal contact between the patella and the femur. As the knee extends, the contact point on the patella migrates from its superior pole to its inferior pole. Note the suprapatellar fat pad deep to the quadriceps. **D** and **E** show the path and contact areas of the patella on the intercondylar groove of the femur. The values 135, 90, 60, and 20 degrees indicate flexed positions of the knee.



▲ **Figure 11-44** ■ The patella shifts medially during early flexion and then either remains there or shifts slightly laterally with deeper flexion.

▲ **Fig**
tially exp
ther, the

Patellofemoral joint stress

- As knee flexes and extends, patella is pulled superiorly by quadriceps tendon, inferiorly by patellar tendon.
- These pull produce **posterior compressive force of the patella on femur.**
- **@ full extension** ,patella has less contact area- **less compression**
- As **flexion progresses**, angle of pull of quadriceps and patellar tendon decreases- **greater joint compression**

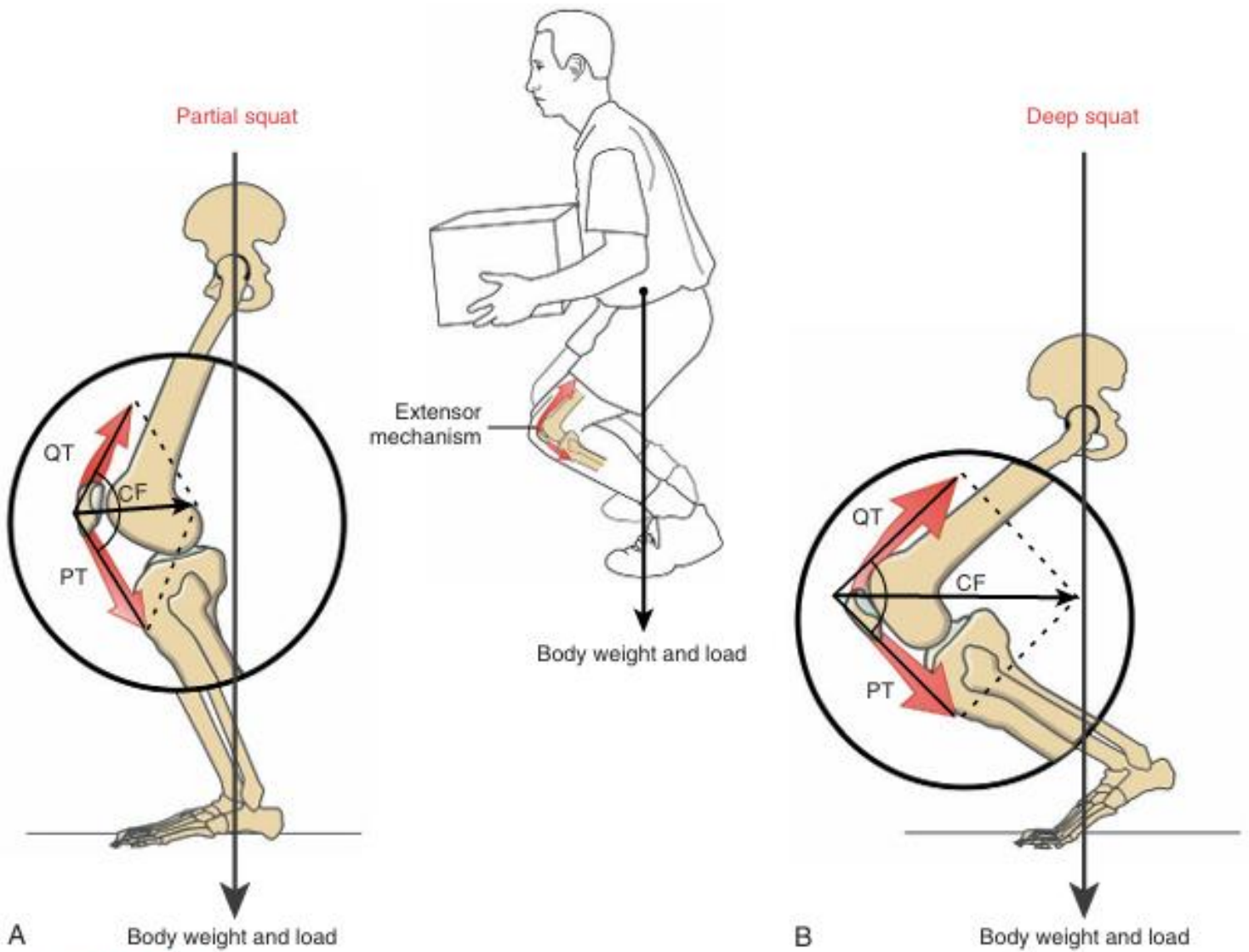
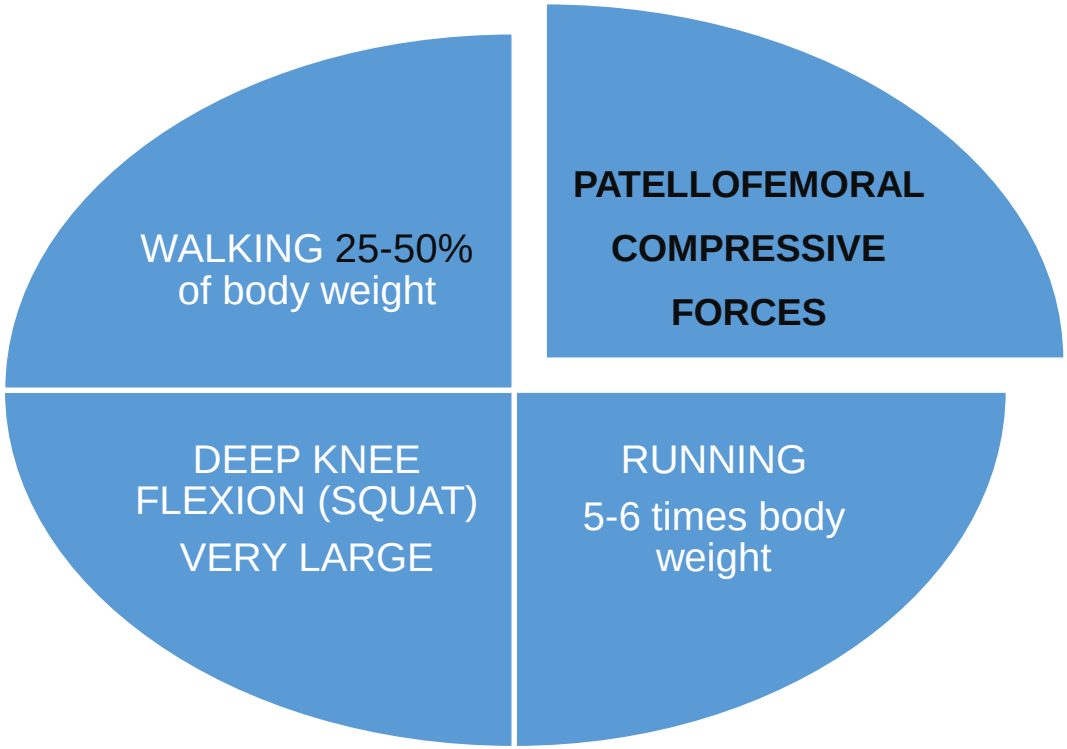


FIGURE 13-28. The relationship between quadriceps activation, depth of a squat position, and the compression force within the patellofemoral joint is shown. **A,** Maintaining a partial squat requires that the quadriceps transmit a force through the quadriceps tendon *(QT)* and the patellar tendon *(PT)*. The vector addition of QT and PT provides an estimation of the patellofemoral joint compression force *(CF)*. **B,** A deeper squat requires greater force from the quadriceps owing to the greater external (flexion) torque on the knee. Furthermore, the greater knee flexion **(B)** decreases the angle between QT and PT and consequently produces a greater joint force between the patella and femur.


WALKING 25-50% of body weight
PATELLOFEMORAL COMPRESSIVE FORCES
DEEP KNEE FLEXION (SQUAT) VERY LARGE
RUNNING 5-6 times body weight

How patellofemoral compressive stress is resisted

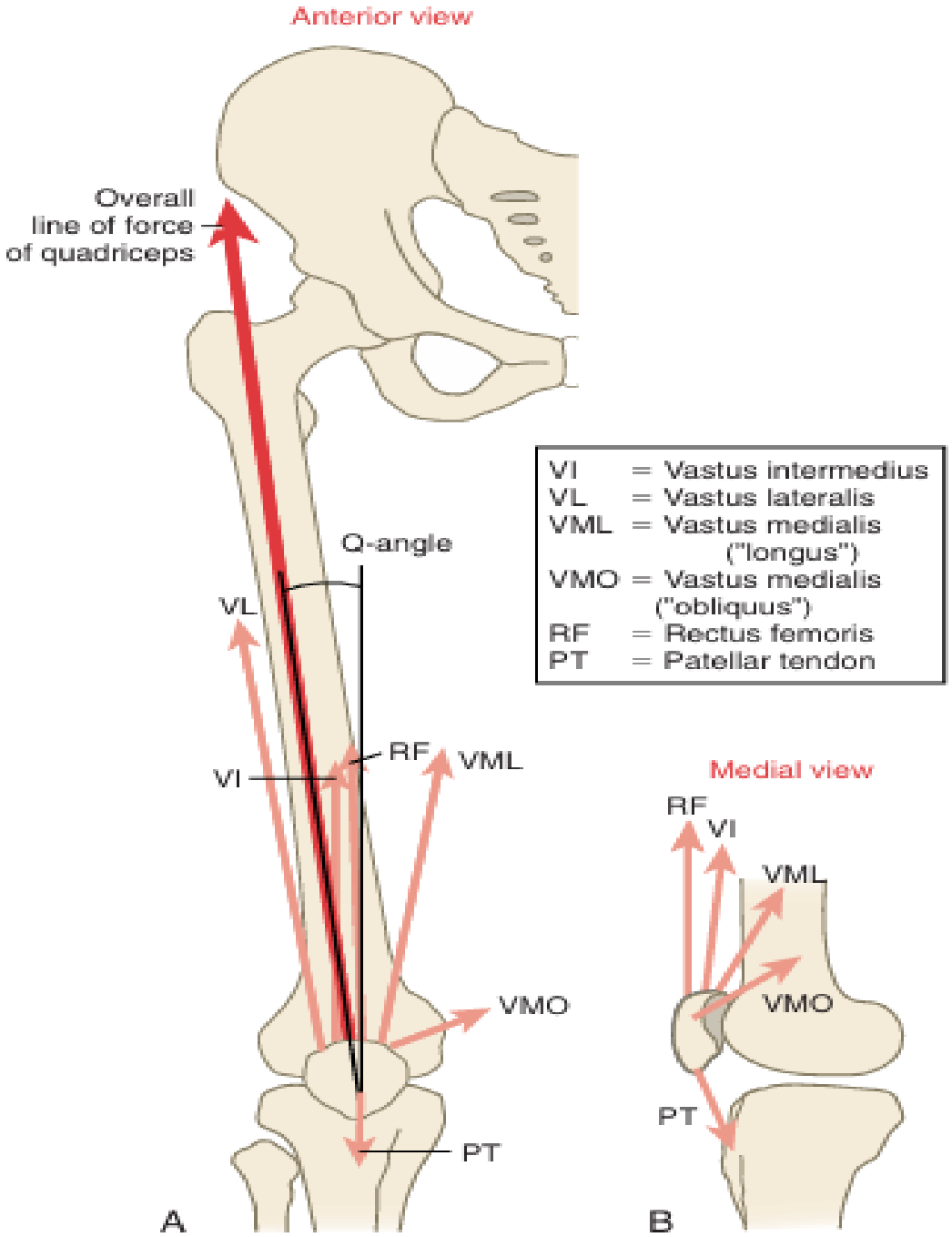
- In full extension, there is less compressive force on patella.
- As flexion progresses 30-70 degree, the area of patellar contact increases, increased compressive force.
- The presence of **thick cartilage** is able to withstand compressive forces transmitted across the medial facet of patella.

- Patella act as anatomic pulley.
- Patella increases the moment arm of quadriceps.
- Large MA , less quadriceps muscle force is required to produce the torque thus reduces joint compression.

- As knee flexion continues beyond 90 degree, patellofemoral stress is increased.
- Quads tendon is contact with the femoral condyles.
- At this time quadriceps tendon helps to dissipate the increased compressive force on the patella.

Q- Angle

- Q- angle:
- Angle formed between a line connecting the ASIS to midpoint of patella and line connecting the tibial tuberosity and the midpoint of patella.
- Normal Qangle- 10-15 degree.


Anterior view
Overall
line of force
of quadriceps
Q-angle
VL
VI
RF
VML
VMO
PT
A
VI = Vastus intermedius
VL = Vastus lateralis
VML = Vastus medialis ("longus")
VMO = Vastus medialis ("obliquus")
RF = Rectus femoris
PT = Patellar tendon
Medial view
RF
VI
VML
VMO
PT
B

When **Q angle increases**

Lateral pull of the patella increases

Patella will displace laterally

Subluxation/ dislocation of patella

Factors increasing Q angle

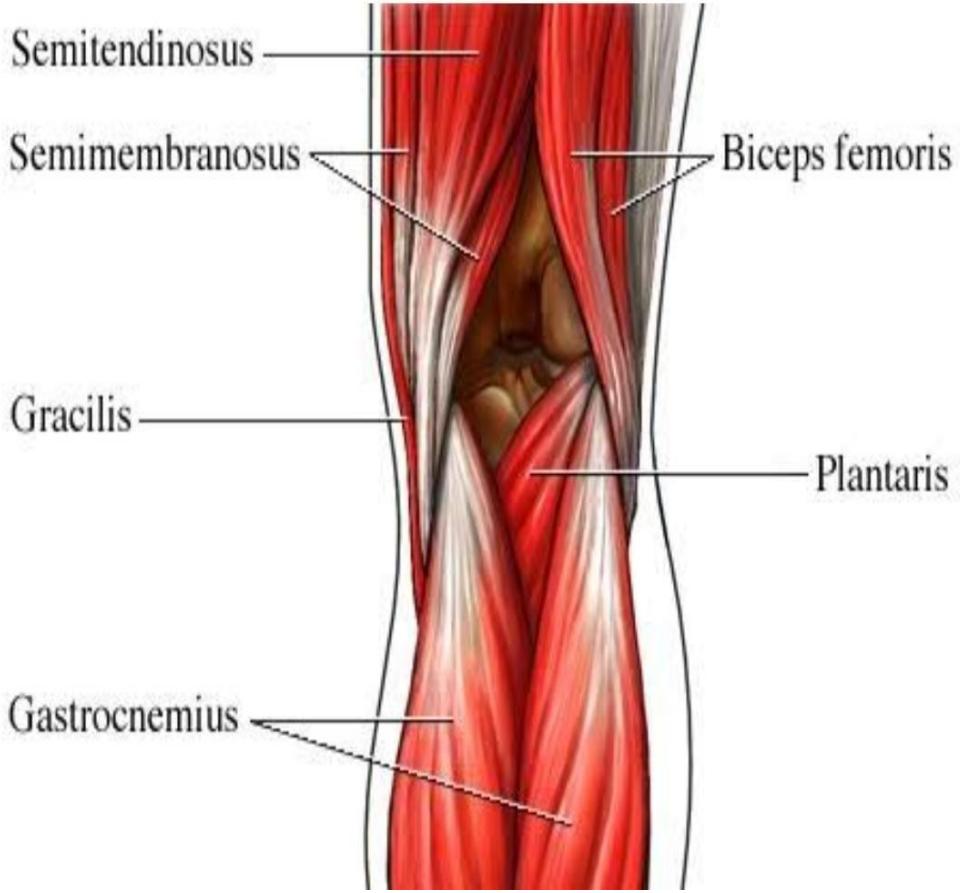
- **1. <u>Imbalance of quadriceps muscle</u>**
- In patients with PFPS , there is delayed onset of activation of vastus medialis muscle.
- There will be imbalance between vastus lateralis and vastus medialis , there is increased lateral pull of muscle, results in lateral pull of patella thus increases the Q angle
- **PFPS- INCREASES Q angle.**

- **IT BAND tightness**
- Tight IT band limit patellas ability to shift medialy during flexion, contributing to increased stress under lateral facet of patella.
- With knee flexion greater lateral pull on patella result in lateral tilting , increasing joint stress.

- **3. genu valgum**
- There is increase Q angle.
- **4. excessive pronation of foot**
- **5. Laxicity of medial patellar retinaculum**
- Increases the lateral pull. Also if lateral retinaculum is tight it increases lateral pull and increase Q angle.

Knee flexors

- Biceps femoris
- Semitendinosus
- Semimembrinosus
- Gastrocnemius
- Plantaris

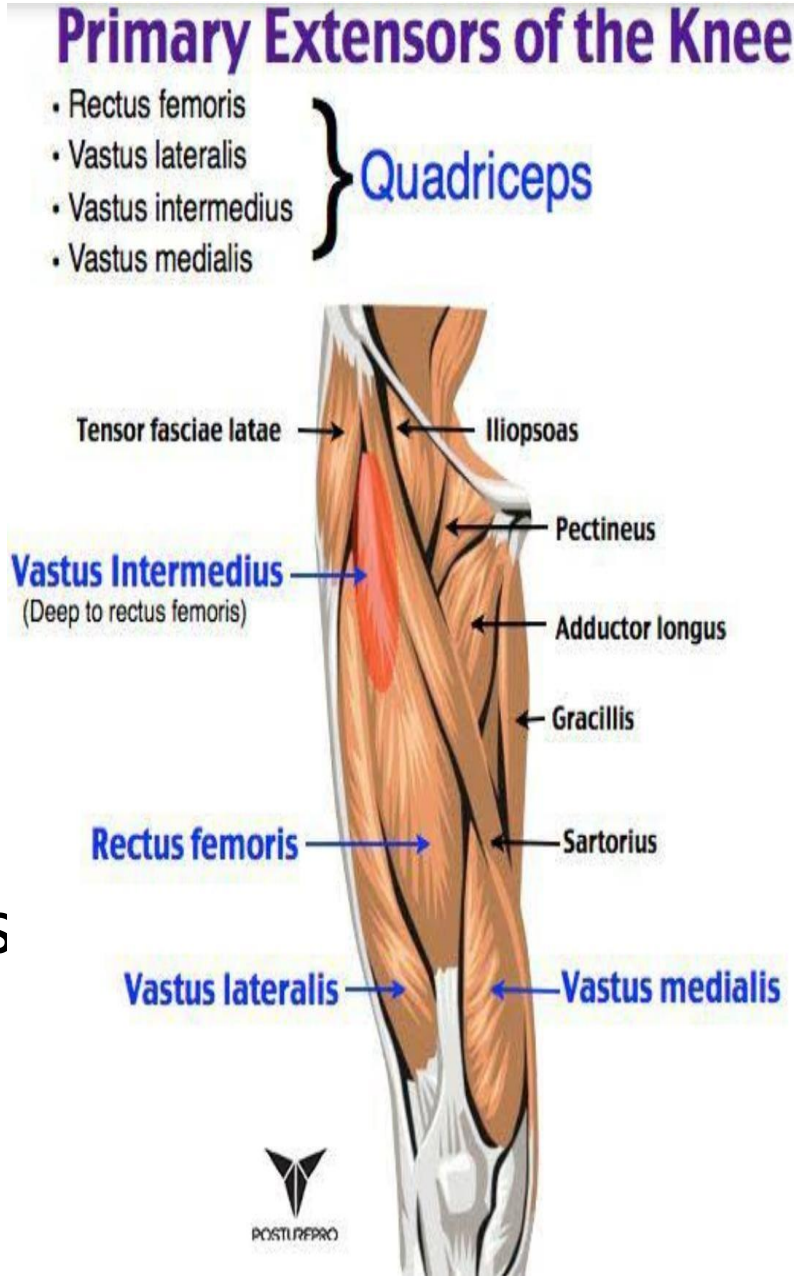


- Popliteus, gracillis, sartorius, semitendinosus, semimembranosus- medialy rotate the tibia on a fixed femur.
- Biceps femoris muscle- lateraly rotate the tibia.

- Greater hamstring force is produced with hip flexed.
- with hip extended, knee flexed 90 or more hamstring are shortened at both joints. (active insufficienciency), Hamstring produce less force in shortened position.
- Pathomechanics:
- Weakness of hamstring reduce knee flexion strength.
- Tightness of hams- knee flexion contracture.

Knee extensors

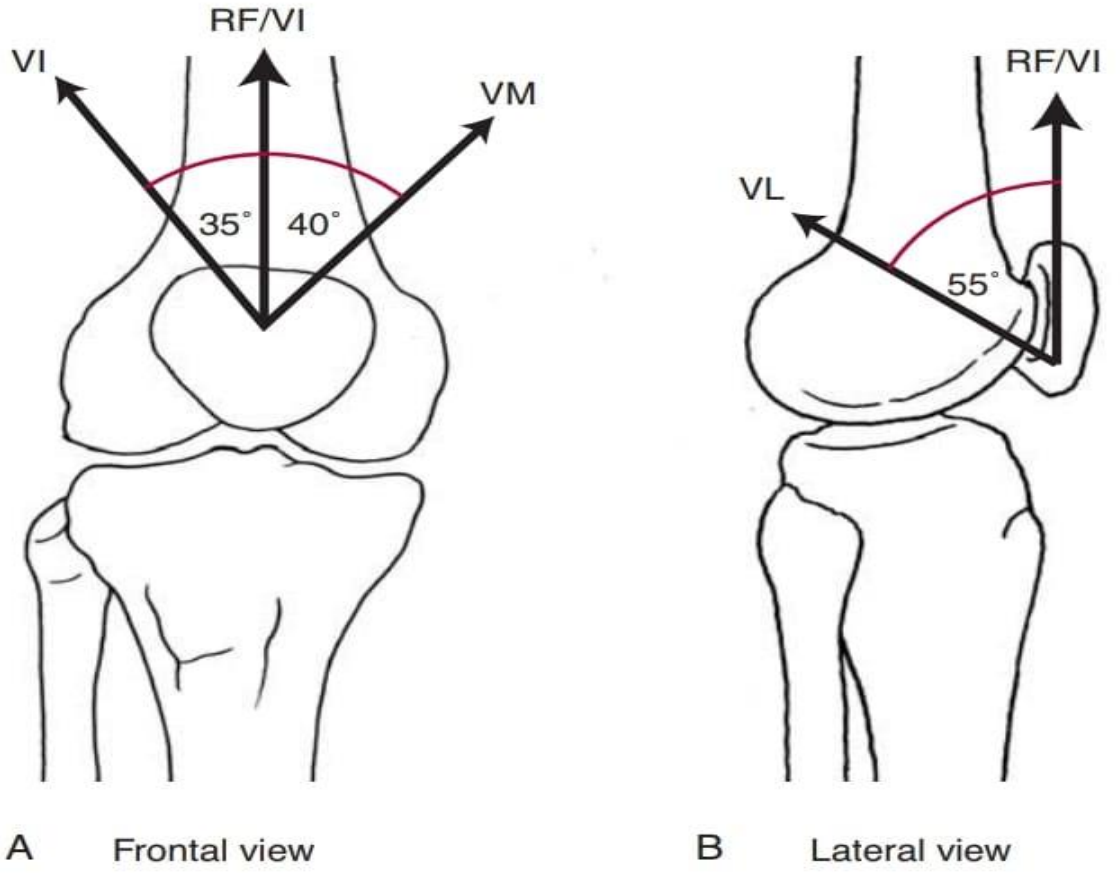
- Rectus femoris
- Vastus medialis
- Vastus lateralis
- Vastus intermedius



- The large vastus group of muscles produces about **80%** of the total extension torque at the knee,
- The rectus femoris produces about **20%**.
- Contraction of the vastus muscles extends the knee only.
- Contraction of the rectus femoris, causes hip flexion and knee extension.
- Resultant pull of vastus lateralis -**35 degree laterally**.

- The vastus medialis consists of fibers that form two distinct fiber directions.
- The distal oblique fibers- (the vastus medialis “obliquus”) approach the patella at 50 to 55 degrees medial to the quadriceps tendon .
- The longitudinal fibers (the vastus medialis “longus”) approach the patella at 15 to 18 degrees medial to the quadriceps tendon.

- Resultant pull of vastus medialis- 40 degree medially.
- The oblique fibers account for only 30% of the cross-sectional area of the vastus medialis muscle, the oblique pull on the patella has important implications for the stabilization and orientation of the patella as it slides (tracks) through the intercondylar groove of the femur
- In patients with patellofemoral pain syndrome clinician try to recruit VMO to maximize the medial pull of patella.



▲ **Figure 11–34** ■ With the data from Powers et al.,[104] the orientation of the four components of the quadriceps muscle are shown (**A**), and the posteriorly directed vector of the VL and VM were found to result in net compression of the patella against the tibia even in full extension (**B**).

Quadriceps lag

- When there is quadriceps weakness or patella is removed, the quadriceps cannot able to produce adequate torque to complete **last 15 degree of non weightbearing knee extension.**
- This is clinically termed as **quadriceps lag/ extension lag.**

- Patient will have difficulty to maintain full knee extension while performing a straight leg raise.
- The patient **will not have a quadriceps lag in weight bearing** because the soleus and gluteus maximus assist in knee extension when the foot is fixed.

- Sartorius is active only during swing phase.
- Sartorius along with semimembranosus and gracilis insert to a common tendon-**pes Anserinus**.
- **Pes anserinus function to resist valgus force and provide dynamic stability.**
- Popliteus muscle – required to unlock the knee.
- It has attachment to lateral meniscus ,helps meniscus to displace posteriorly during knee flexion.

- The knee extensor muscles produce a torque about two thirds greater than that produced by the knee flexor muscles.
- **Isometric activation**, the quadriceps - stabilizes and helps to protect the knee.
- **Eccentric activation**, the quadriceps - controls the rate of descent of the body's center of mass, such as during sitting or squatting.

- At the heel contact phase of walking, the knee flexes slightly in response to the ground reaction force.
- Eccentrically active quadriceps controls the extent of the knee flexion.

Effects of injury and disease

- **Tibiofemoral joint injury:**
- Activities that involve jumping , pivoting etc increases risk of injury in meniscus, ligaments, bones, bursa and musculotendinous structures.
- **Meniscal injury-** most common mechanism of injury is **sudden rotation of femur on fixed tibia when knee is flexed.**

- Excessive forces on joint result in **ligamentous injury.**
- After ligament injury/ reconstruction the tissue must be protected from excessive stress for healing.
- **Osteoarthritis**- commonly seen in older adults.
- Especially in women.
- Causes- previous traumatic injury, obesity, mal alignment, instability or quadriceps weakness

- **Bursitis** is common after trauma or repetative compressive compressions.
- Common location of injury is:
  - pre patellar bursa, infrapatellar bursa
- Inflammation of infrapatellar bursa is known as **housemaid's knee**

- **Patellar plica syndrome**
- Any irritation of patellar plica cause pain in prolonged standing, stair climbing, resisted extension exercises.

- **Patellofemoral joint injury**
- **Patellofemoral pain syndrome**
- Causes:
- Increased lateral patellar compression – tight IT band, large Q angle, genu valgum. Vastus medialis weakness
- **Patellar hypomobility**
- **Patellar hypermobility**: increased risk of patella subluxation or dislocation.

- Medial retinaculum get stretched after patellar dislocation.
- **Chrondromalacia patella**- softening of cartilage.

THANK YOU