Knee Complex

Introduction:

* The knee complex provide mobility.
* Support body during dynamic & static activity.
* The knee complex is composed of 2 articulation within a single capsule.
  - => Tibiofemoral Joint
  - => Patellofemoral Joint

Tibiofemoral Joint:

It is a double condyloid joint with medial & lateral articular surface. Three degrees of freedom (rotatory).

Flexion, Extension -> Sagittal plane

Abduction, Adduction -> Frontal plane

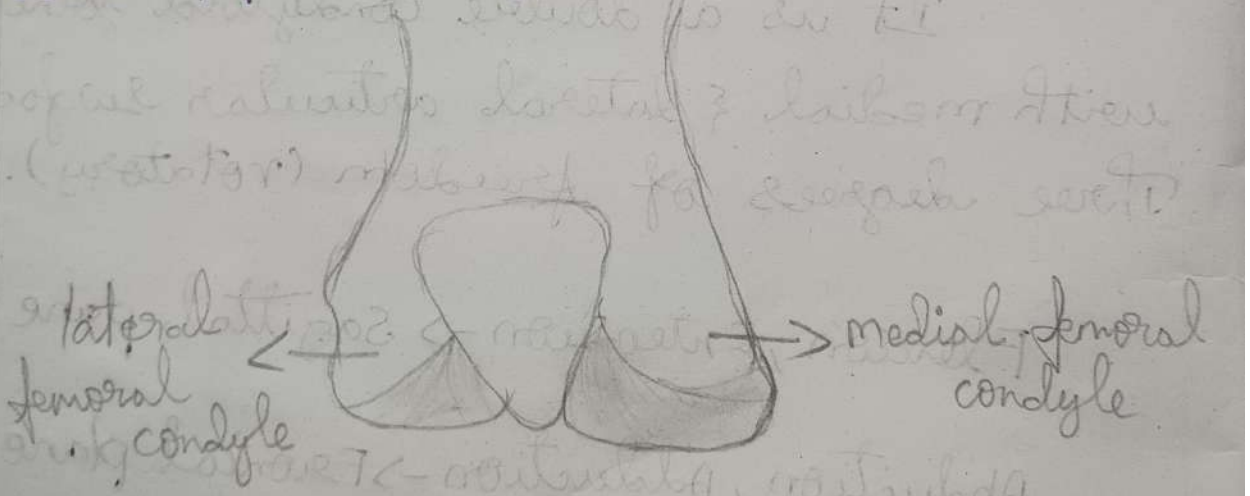
medial, lateral rotation -> Transverse plane

=> The double condyloid knee joint is defined by the medial & lateral articular surfaces also referred to as the medial & lateral compartments of the knee.

Structure:

Femur: The proximal articular surface of the knee joint is composed of the large medial & lateral condyles of the distal femur.

* The medial condyle is larger than the lateral condyle.
* The two condyles are separated inferiorly by Intercondylar notch.
* shallow groove called the femoral sulcus, patellar groove (or) patellar surface.



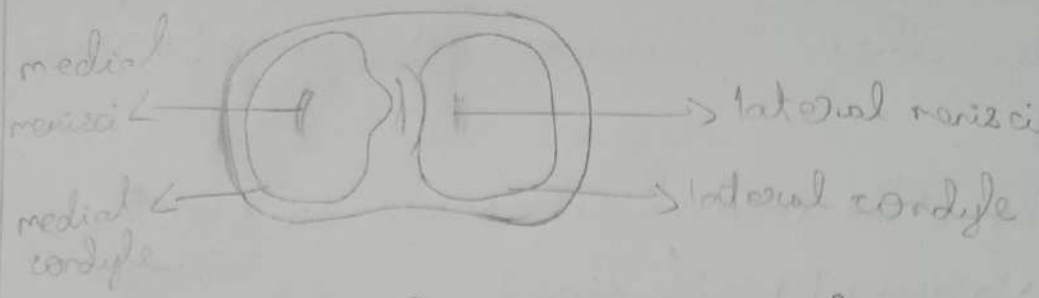
Tibia:

This is correspond to femoral articular surface.

There are 2 concave medial & lateral plateau present on the tibia.

medial condyle is 50% larger than lateral condyle.

Saper view of tibia



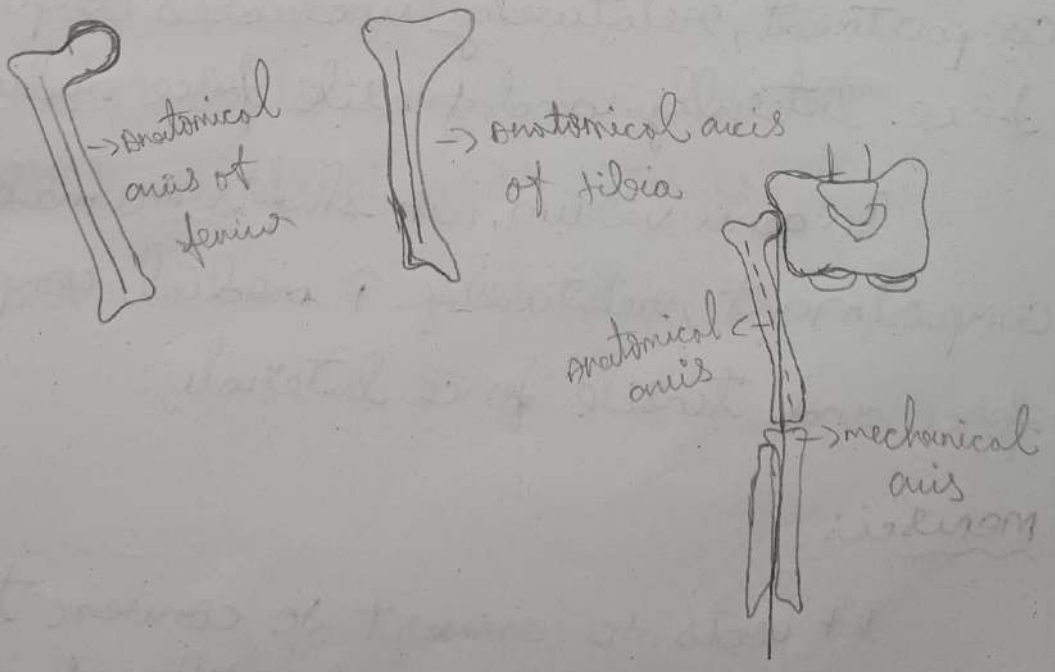
IF alignment and weight bearing forces:

Anatomical axis of femur is oblique, directed inferiorly & medially from its proximal to distal end.

Anatomical axis of tibia is directed vertical

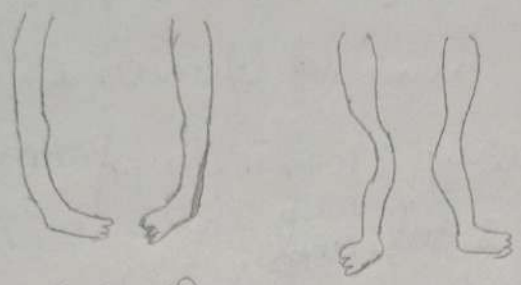
The femoral and tibial longitudinal axis normally form an angle medially at knee joint of 180-185°.

The femur is angle of up to 5° of vertical creating a physiological valgus angle at the knee.



If the medial tibiofemoral angle is greater than 185° is genu valgum [knock knee]

If the medial TF angle is $\leq 175°$ is genu varum [bowl legs].



Genu varum

Genu valgum

In bilateral stance, wb stress on knee joint are equally distributed b/w the medial & lateral condyles.

In unilateral stance, wb stress on knee joint shifts to medial compartment.

In genu valgum, wb shifts to lateral compartment, relatively increases compressive force laterally and tensile force medially.

In genu varum, wb shifts to medial compartment, relatively ↑ medial compressive force and tensile force laterally.

Menisci:

It acts to convert to convex tibial plateu into concavities for the femoral condyles.

- 2 types of menisci
  => lateral menisci
  => medial menisci

Role of menisci:

With intact menisci,

-> contact area at TF ↑ & Joint stress reduced.

Removal of menisci,

-> contact area in the TF ↓ & Joint stress increases.

↓

-> Damage articular cartilage

↓

-> Degenerative changes

Uses: -> ↑ Joint congurence
-> Distribute weight bearing force
-> Reduces friction blw Joints
-> Serve as a shock absorbers.

=> Intercondylar tubercle of tibia
=> Tibial condyle -> coronary ligament
=> patella -> patellomeniscal &
patellofemoral ligament
=> Transverse ligament
=> ACL

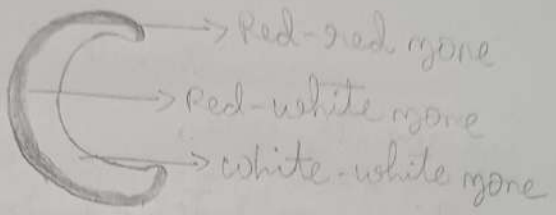
ii) Medial menisci attachment
=> MCL
=> Semimembranous muscle

iii) Lateral menisci attachment
=> Ant & post meniscofemoral ligament
=> PCL
=> popliteus muscle

Blood supply:
=> 25% of blood supply is by capillary from joint capsule & synovial membrane.
=> There are two zones present in the menisci.
They are, Red - red zone
Red - white zone

Red-white zone: It is the border of the vascular area contain chondrocyte like cells.

White-white zone: A vascular receives nourishment from synovial fluid.



Any pathological problem in the menisci leads to menisci injury.

Test:

=> Apley's grid test

Mc Murrey's test

Joint capsule:

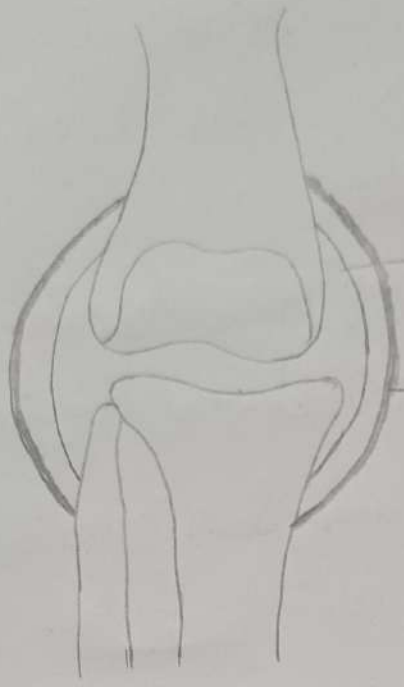
It is to maintain the joint integrity & normal joint function.

It encloses TF & PF joint.

There are two layer present in joint capsule.

They are,

=> Fibrous - superficial layer



Ligaments:

main ligaments are,

=> medial collateral ligaments

=> lateral collateral ligaments

=> Anterior cruciate ligament

=> posterior cruciate ligament

medial collateral ligament:

=> Flat, broad ligament located on the inside of the knee.

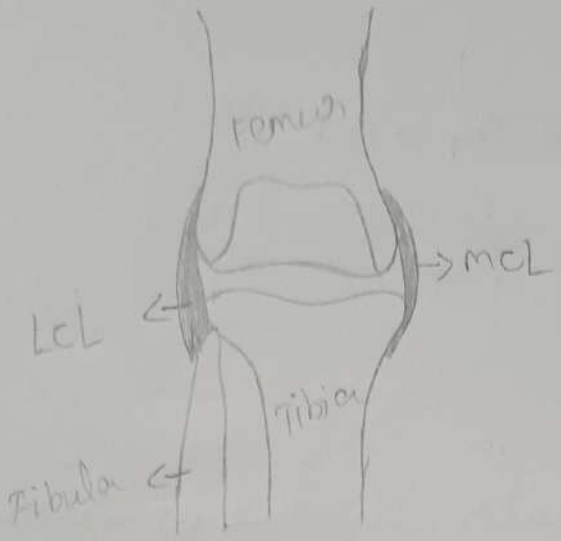
=> It has superficial and deep layers.

=> MCL arises from the medial femoral condyles of femur.

=> Inserted on to the proximal aspect of medial tibial plateau.

=> It prevents from valgus stress on the knee.

=> part of MCL is attach to the medial menisci.



Lateral collateral ligament:

=> cordlike ligament located on the outside of the knee.

=> It arises from proximal lateral femoral condyle.

=> Inserted on to the distal aspect of fibular head.

=> It can prevent from varus stress on the knee.

Anterior cruciate ligament:

=> Anterior medial tibial to posterior lateral femur

=> It prevents from anterior displacement on femur

=> Secondly, it may prevents hyper(or)extension, varus & valgus stresses.

Attachment:

Origin- from ante surface of tibia in the intercondylar area just medial to medial meniscus.

Insertion - to posteriorly on lateral condyle of femur.

2 Bands: ACL is divided into 2 bands

* Antero - medial band
* Postero - lateral band

Functions:

It tightens during extension, preventing excessive hyperextension of knee.

check tibia medial rotation by twisting around PCL.

ACL injury is common when knee is in flexed & tibia rotated in either direction

Posterior cruciate ligament:

Attachment:

origin - From posterior tibia in intercondylar area & run in a superior & anterior direction on medial side of ACL.

Insertion - To anterior femur on the medial condyle.

Band:

There are 2 band present in PCL.

- Antero medial band
- postero medial band

Functions:

It check from being displaced anteriorly on the tibia.

It tightens during flexion & is injured much less frequently than ACL.

PCL play a role in both. restraining & producing rotation of tibia.

Posterior capsule ligaments:

Several structure reinforce the corners of the posterior knee joint capsule.

The posteromedial corner of the capsule is reinforced by the semimembranous ⓜ, by its tendinous expansion called the

oblique popliteal ligament.

The posterior oblique ligament originates from posterior to the adductor tubercle & anterior to the gastronemius tubercle on the femur.

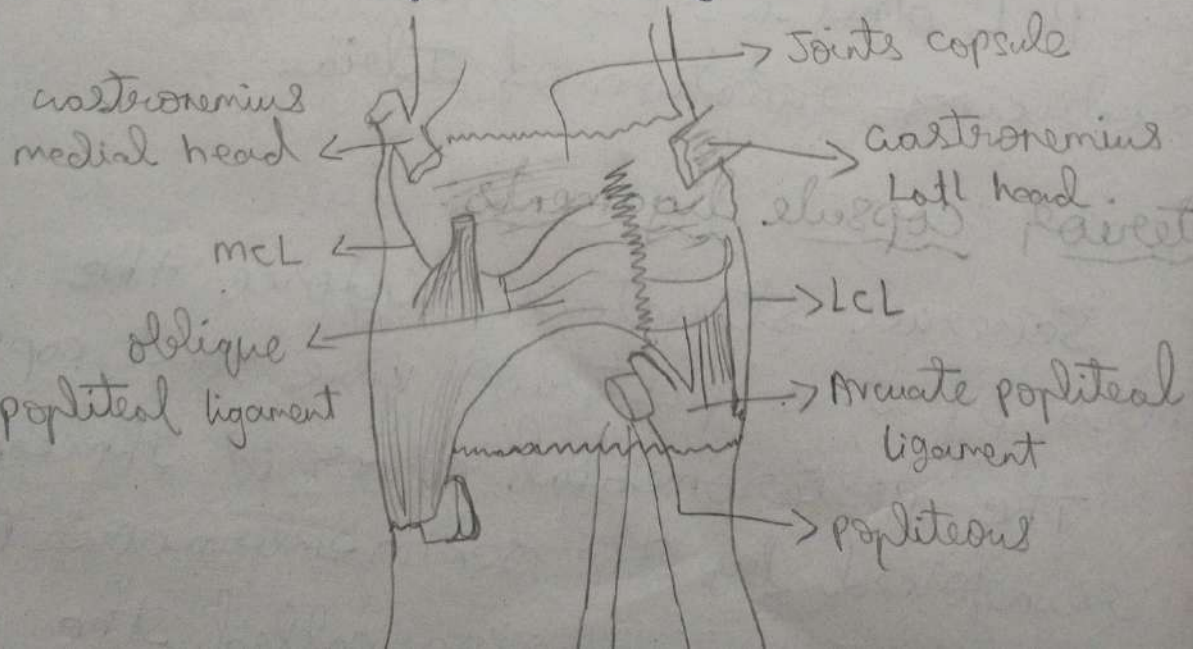
Functions:

The posteromedial complex, specifically the posterior oblique ligament is taut in full extension & assist in checking posterior tibial translation & Valgus force.

These are a important stabilizers against posterior, tibial translation & valgus load.

other ligament present in posterior aspect;

=> Arcuate ligament
=> popliteofibular ligament
=> patellofibular ligament



Ligament of Humphry:

The meniscofemoral ligaments originates from posterior horn of the lat. meniscus & insert on the lat. aspect of medial femoral condyle either ant. to the post. cruciate ligament.

origin - post. to post. cruciate ligament

"Ligament of wrisberg".

Bursa:

Bursa is a fluid filled sac that reduced friction b/w moving parts of the body joints.

some of the bursa present in TFJ:-

=> Suprapatellar
=> Subpopliteus
=> Gastrocnemious
=> prepatellar bursal
=> Infrapatellar
=> Deep infrapatellar

Function -> TO reduce friction

Kinematics of Knee Joints:

The primary angular motion of the TFJ is flexion / extension.

Small amount of both medial / lateral rotation & varus / valgus (abduction / adduction)

i) Flexion

Axis -> Transverse

Rom -> (0° - (130° - 140°))

Arthrokinematics:

i) Femur flexing on fixed tibia

eg -> squating

Rolling -> posterior

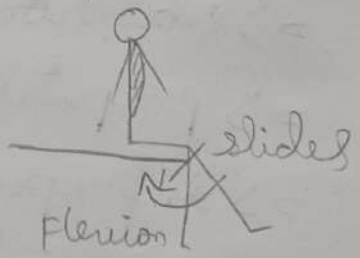
Gliding -> Anterior

ii) Tibia flexing on fixed femur

eg -> sitting

Rolling -> posterior

Gliding -> posterior



ii) Extension

Axis -> Transverse

Rom -> 130° - 0°

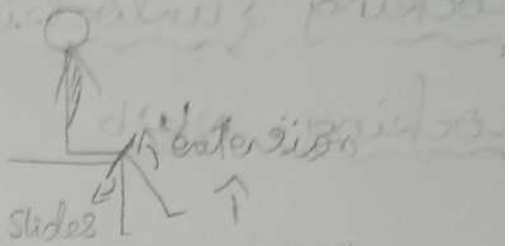
Arthrokinematics:

i) Femur flexed on fixed tibia

eg -> Squating

Rolling -> anterior
Gliding -> posterior

ii) Tibia flexing on fixed femur
eg -> sitting
Rolling -> Anterior
Gliding -> Anterior



iii) medial rotation:
Axis -> longitudinal axis
ROM -> 0-15°

Arthrokinematics:
-> medial tibial condyle moves posteriorly
-> lateral tibial condyle moves anteriorly

iv) lateral rotation:
Axis -> longitudinal axis
ROM -> 0-20°

Arthrokinematics:
-> medial tibial condyle moves anteriorly
-> lateral tibial condyle moves posteriorly

Screw-home movement:
There is a compulsory lateral rotation of tibia that accompanied final stage of knee extension.

This motion is called automatic (or) terminal rotation (or) locking (or) screw home movement.

Locking & unlocking of Knee Joint

Locking: NWB

medial articular surface is longer

↓

During last 30° of non-weight bearing Knee extension

↓

Later tibial plateau & femoral condyle completes rolling & sliding before the medial surface do

↓

medial surface continues to roll & slide anteriorly after the lat surface stopped to move.

↓

This result in lateral rotation of tibia on femur (end 5° extension)

↓

↑ tension in the knee Joint

↓

Bringing Knee Joint into closed pack (or) closed position

↓

Tibial tubercle have now become lodged in the intercondylar notch

menisci are tightly interposed b/w the tibial & femoral condyle

↓

so the ligaments are taut

↓

this is known as locking

unlocking:

Extension to flexion

A flexion force

↓

medial rotation of tibia

↓

Larger medial side will move first than the shorter side

↓

This medial rotation of tibia leads to unlocking (If there is lateral rotation first during unlocking -> the joint surface, ligament & menisci will be damage).

In weight bearing:

During last 30° of extension

↓

Femur medially rotates on fixed tibia (locking)

↓

During flexion there is a lateral rotation of tibia (unlocking).

Clinical test for screw home:

Helfet test:

=) patient sits with knee flexed at 90° & leg hanging free.

=) medial and lateral borders of patella are marked on skin.

=) Tibial tuberosity & midline of patella are designed.

=) Rotation of knee may not rotate during extension.

Knee muscles: [Extension]

Rectus femoris
Vastus medialis
Vastus lateralis
Vastus intermedius

[Flexion]

Biceps femoris
Semitendinosus
Semimembranous
Gastrocnemius
plantaris

[medial rotators]

Sartorius
Gracilis
popliteus
Pes anserius

[lateral rotators]

Tensor fascia lata

Patellofemoral Joint:

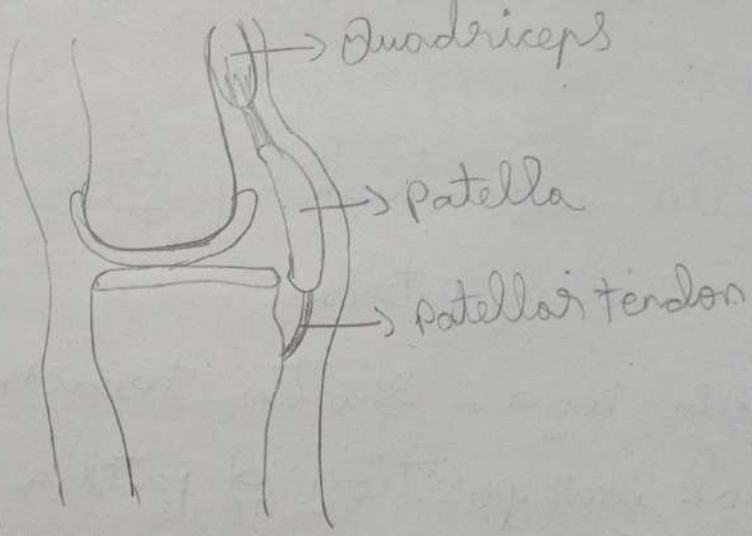
=> patella is a true sesamoid bone

=> posterior surface of the patella is covered with thick hyaline cartilage.

=> The patella slides within the trochlear groove.

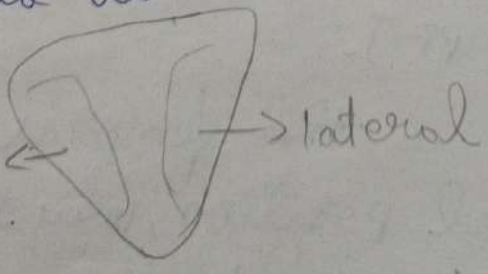
=> patella is a flat, triangular shaped bone embedded with in the quadriceps tendon.

=> It is an inverted triangular shape.

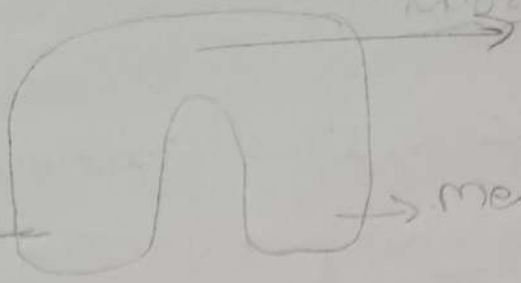


Articular Surface:

- Patella - Posterior aspect
- Femur - condyles - b/w the medial & lateral facet area called patellar groove.
- Patella is an anatomical pulley.



Posterior view of Patella



vertical position of patella

Insall Salvati Index

The ratio of the length of the patella tendon to the diagonal length of patella is refered as Insall-Salvati index.

The ratio is 1:1

Variations:

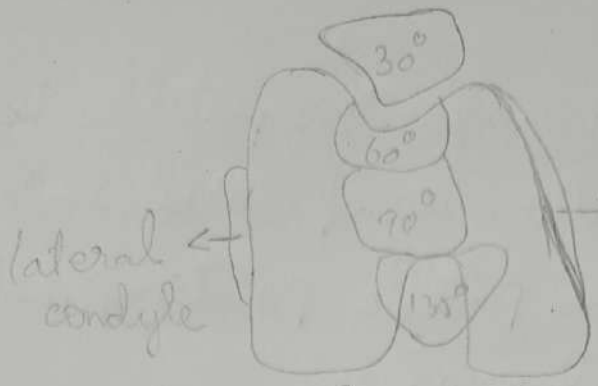
Patella alta - higher position of patella or high-riding patella.

Patella baja - shorten tendon produce an abnormal low position of patella on the femoral sulcus.

PFJ congurence:

The contact blw the patella & femur changes throughout the knees ROM because of congurence of PF-J.

Patella sits in the femoral sulcus in the knee extended position, only the inferior pole of patella is contact with the femur, ↑ the contact area.



motions of patella:

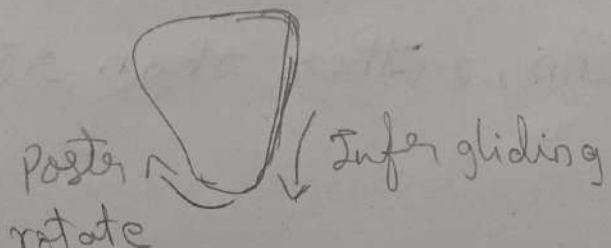
1. Patellar flexion -> sagittal plane
2. Patellar extension -> sagittal plane
3. Patellar lat/med tilt -> longitudinal axis
4. lat/med patellar shifts -> rather than rotation around the axis (Ant-post axis)
5. patellar rotation -> Anteroposterior axis

Patellar flexion:

-> patella travels down to the intercondylar groove of femur is termed as patellar flexion

-> when the femur is flexed & the knee is flexed, the patella pulled down by the tibia.

sliding -> inferior
Rolling -> posterior



Patellar extension:

Knee extension brings the patella back to the original position in femoral sulcus.

The apex of the patella pointing inferly at the end of normal ROM

gliding -> sup

rotating -> up

lat / medial patellar tilt:

In addition to patellar flexion & extens the patella tilt around a longitudinal axis

shifts medially & laterally around frontal plane.

rotates around -> ap axis

Patellar tilt - [medial
Lateral

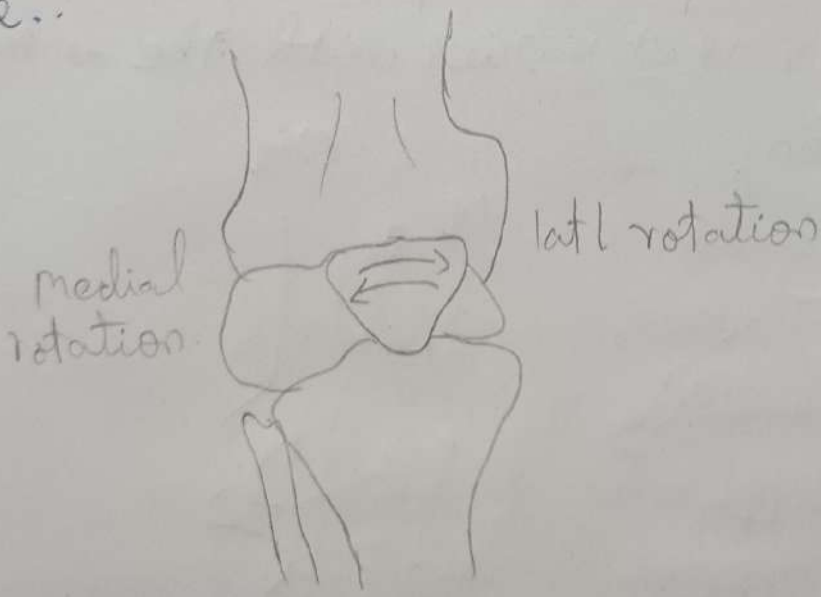
lat / medial patellar shifts:

They are translations that occur in a plane of motion, rather than rotation around an axis.

Patellar rotation:

Rotation of patella is about an AP axis is referred by the movement of distal apex of the patella.

medial rotation occur when the patella spin around the AP axis with apex (bottom) patella pointing towards the medial femoral condyle..



Patellofemoral stress:

The PFJ experiences very high stresses during typical activities of daily living.

Due to this, degenerative changes { OA are occur.

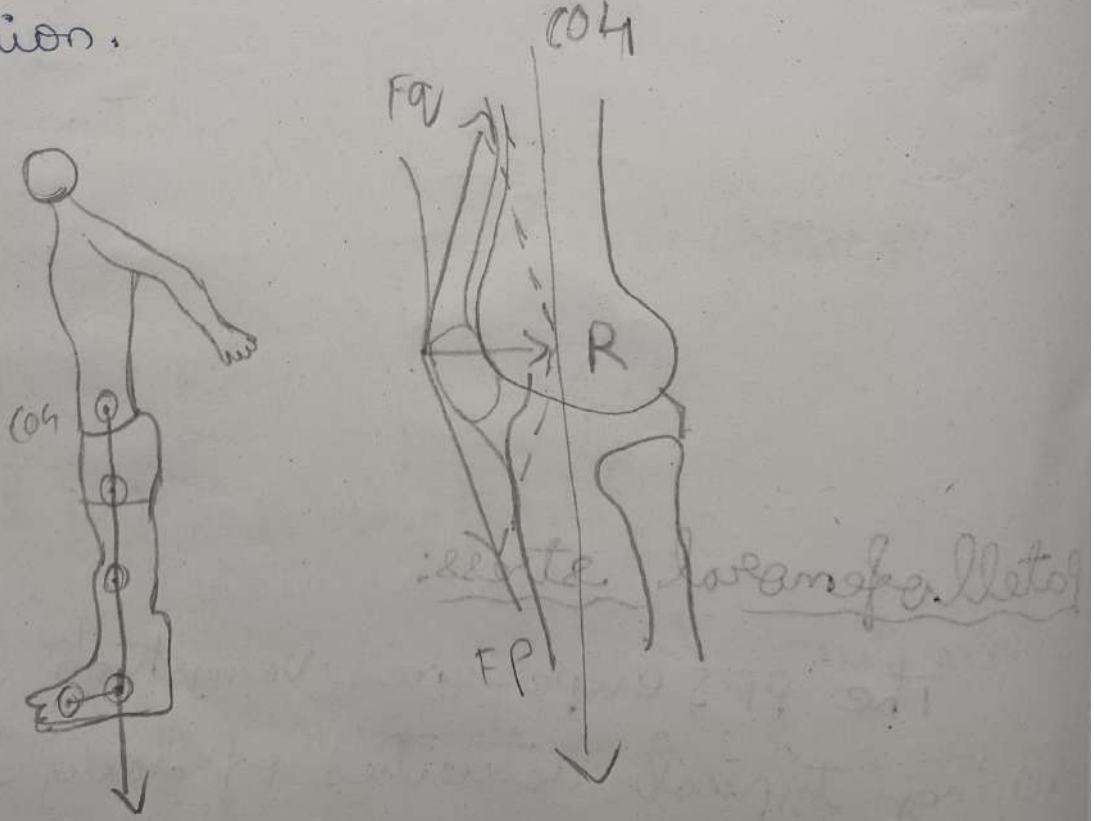
Joint stress can be influenced by alternating either Joint stress force / Joint surface contact area.

Patellofemoral reaction force:

The PFJ reaction force is influenced by both the magnitude of the quadriceps force & the knee angles.

As Quadriceps contract, the patella is pulled superiorly by the quadriceps tendon, with the pull resisted inferiorly by the patella tendon.

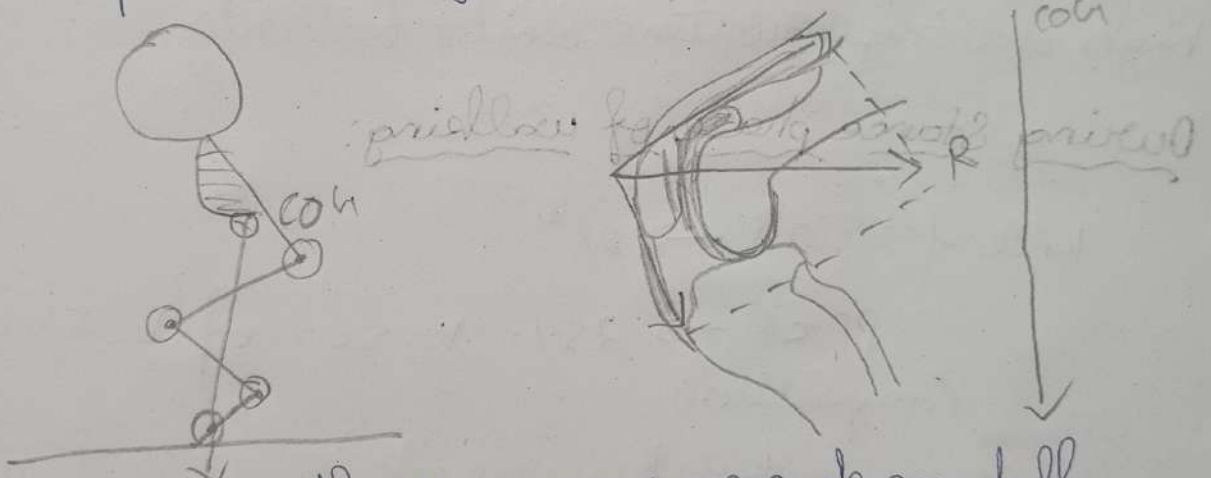
The combination of these pull produce a posterior compression force of the patella on the femur that varies with the amount of knee flexion.



At full extension the quadriceps posterior compressive force on the patella is minimized due to the origin of vastus medialis & lateralis @ on posterior femur.

Despite the small contact area blw the patella & the femur in full extension, this minimal posterior compressive force allows for low PFJ stress with knee at full extension.

These low joint stress levels provide rationale for the use of straight-leg-raising exercises as a way of improving quadriceps @ strength without creating PF pain.



As knee flexion progresses from full extension, the z^{re} of pull blw the quadriceps tendon & patellar tendon ↓, which ↑ the joint reaction force & in turn produces greater PFJ compressive forces.

The ↑ compression occur whether the quadriceps @ is active or passive during knee flexion.

If the quadriceps is inactive, then elastic tension is ↑ within the quadriceps & patellar tendon as knee joint flexion ↑.

If the quadriceps is active, then both the active & passive tension will contribute to ↑ to joint compressive force.

The total joint reaction force is therefore influenced by the magnitude of active & passive pull of the quadriceps & also by the angle of knee flexion.

The PFJ reaction force can become very high during routine daily activity.

<u>During stance phase of walking:</u>

Knee flexion → 20°

PFCF → 25% to 50% of body weight (compressive force)

<u>During running:</u>

The knee flexion & activity the PFCF have been reached over 10 times the body weight.

The vertical position of the patella can also significantly influence PFJ stress. Singerman & colleagues demonstrated

presence of patella alta.

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Sirgerman & colleagues demonstrated the presence of patella alta.

At flexion ↑, PFCF will ↑ continuously.

In contrast with patella baja, the femoral contact b/w the quadriceps tendon & femoral condyle occur earlier in the range & reduction in PF contact force.

Asymmetry of PF Stabilization:

The orientation of the quadriceps resultant pull with respect to the pull of the patellar tendon provides information about the net force on the patellar in frontal plane.

The net effect of the pull of the quadriceps & the patellar tendon can be assessed clinically using a measurement called the Q-angle.

Q-angle:

It is an angle formed b/w a line connecting the anterior superior iliac spine to the mid point of patella & a line connecting the tibial tuberosity & the mid point of the patella.

Normal ∠ie $10^{\circ}-15^{\circ}$

Pathology of knee complex:

i) TFJ injury:

main risk to menisci, ligament, bursa, bone & musculotendinous structure.

a) menisci Injury:

It is common & usually occur as a result of sudden rotation of femur on the fixed tibia, when the knee is in flexion.

It is more prevalent than lateral meniscus injury,

Because the pivot joint during axial rotation in the flexed knee occur through the medial meniscus.

Because more rigidity attached medial meniscus makes more stable during sudden load.

cause the joint to exceed its normal rom.

causes:
- ligamentous tear
- lower-energy force
- ligament weaker due to aging
- any disease
- immobilization
- use of steroids
- vascular insufficiency

c) Bony & cartilogenous disease:

The bony & cartilogenous disease may be injured either by applying large direct force.

Such force are, twist or fall
repetitive load to bone
↑ force

Knee osteoarthritis:

It is a degenerative condition happen by erosion of bone.

common for older adults & womens.

causes: obesity

Knee Osteoporosis:

The osteoporosis is a condition characterised by loss of bone density mass

d) Injuries to cruciate ligament:

They are more common

The anterior cruciate ligament is more commonly damaged than the posterior.

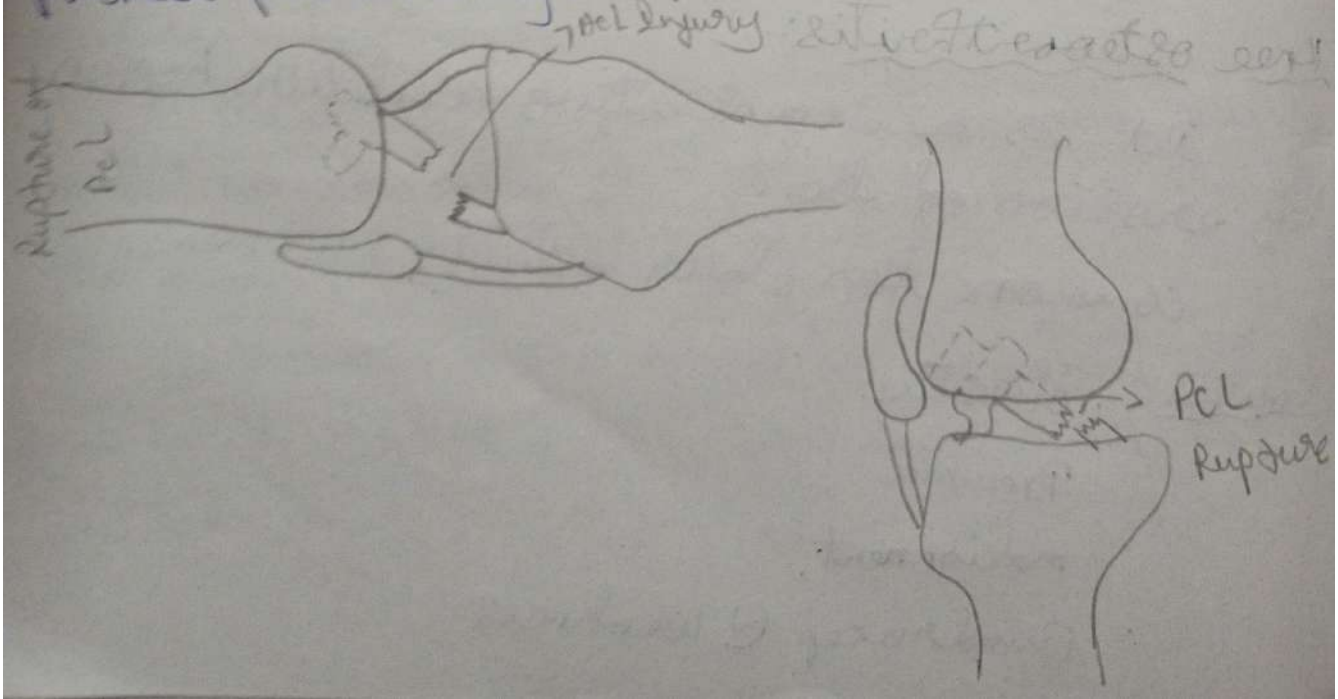
It may be injured in violent hyperextension of knee (or) anterior dislocation of tibia.

The posterior ligament is injured in posteriordislocation of tibia.

The injury may vary from simple sprain to complete tear.

Tear of the ligament leads to abnormal anteroposterior mobility.

The Tear of ACL, tibia is pushed anteriorly while in tear of PCL it is pushed posteriorly.



e) Injuries to collateral ligaments:

These are less common & may be produced by severe abduction & adduction strains.

f) Bursa injuries:

i) Bursitis:

Inflammation of the bursa called Bursitis.

ii) Housemaid's knee:

The prepatellar bursa, the superficial infrapatellar bursa are inflamed.

They are said to be known as housemaid's & clergyman's knee.

PFJ injury:

Patellofemoral dysfunction such as

-> excessive pressure on lateral facets of the patella.

-> lateral subluxation

-> lateral dislocation

chondromalacia patella:

cartilaginous changes seen on the lateral patellar facet were once considered to be diagnostic of PF dysfunction {term as chondromalacia patella.

Malignment of patella:

Ideally the patella is resting in the centre of the width of femur in relaxed standing position.

The patellar position may be altered congenitally or due to tightness of surrounding structures which may lead to painful condition of PFJ

Patellofemoral arthralgia:

- It is also known as patellofemoral pain syndrome or runner's knee.
- It is a common cause of pain in front of knee, particularly around the kneecap.

Patella plica: [medial patella plica]

- common cause of plica syndrome, a condition characterized by pain in the front & in side of knee.

Plica - normal folds of tissue with knee joint synovial membrane, which lines the joint.