ANATOMY

Type of joint
Knee: modified hinge or condyloid
Patello-femor joint: is a saddle joint

Locking mechanism
Rotation pivots on the Lateral condyle and the medial condyle glides backwards it occurs around the ACL
Vastus medialis locks the joint and the popliteus muscle unlocks the knee joint

Movement occurs
Flexion and extension occurs above the meniscus [0-130°]
Rotation of the knee occurs below meniscus

Nerve supply
1. Femoral nerve supplies the knee joint through 3 muscular branches to quadriceps [vastus medialis, intermedius and lateralis]
2. Sciatic nerve through a direct genicular branches
3. Obturator Nerve through it’s posterior division through middle genicular artery
Bursae

4 Anterior bursae

- Suprapatellar bursa
- Prepatellar bursa
- Superficial and deep infrapatellar bursa

2 Medial bursae

- Between MCL and Pes anserinus
- Between MCL and Semimembranous and capsule

2 Lateral bursae

- Between Lateral collateral ligament and biceps tendon
- Between Popliteus and Capsule

4 Posterior bursae

- 2 Between lateral and medial gastrocnemius and joint capsule
- 1 Between Semimembranous and Medial Gastrocnemius
- 1 Popliteus and back of the tibia (synovial extension)
**ACL [Anterior cruciate ligament]**

Intra-articular and extrasynovial ligament

Length and width: 30-40 mm x 11mm  
Fibers rotate by 90° between its attachments

Tibial attachment is anterior and stronger than femoral.  
Femoral attachment is to the medial side of the lateral femoral condyle

Anterior fibres: blend with Anterior horn of the lateral Meniscus

2 bundles  
Anteromedia[nt]l [tight in flexion]  
Posterolater[al] [tight in extension]

When the knee is extended, the ACL is a relatively flat, ribbon-like ligament composed of many parallel fibers.  
Blood Supply  Middle Genicular Artery

Nerve supply  Golgi tendon receptors

Load to failure  1700N  [Normal walking 170N; Running 500N]

**Strain rate plays a role in the location of ligament failure**

High strain rate  Midsubstance tears [common]  
Low strain rate  Avulsion from tibial attachment [seen in children with tibial eminence fracture]

**Tension in cruciate ligament**

Tension is constant in all position. This is due to different fibers in the ACL experience different tension from flexion and extension and the whole ligament is not in constant state of tension.

**Function of ACL**

1. ACL Carries loads throughout flexion  
2. Normally it carries small load ie., 500 N [fails at 2500 N]  
3. Highest loading of ACL is during quadriceps powered extension moving from 40° flexion  
4. Tunes roll back with PCL. 4 bar linkage  
5. Prevents anterior translation  
6. Important for rotational instability
ACL VS MCL

<table>
<thead>
<tr>
<th></th>
<th>MCL</th>
<th>ACL</th>
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<tbody>
<tr>
<td>Macroscopic</td>
<td>Extra-articular; Flat; Flat; uniform</td>
<td>Intra-articular; varied</td>
</tr>
<tr>
<td>Collagen</td>
<td>Fibres are parallel Densely packed</td>
<td>Varied and Nonparallel Less fibers</td>
</tr>
<tr>
<td>Electron Micro</td>
<td>Mean fibril diameter is larger</td>
<td>Is smaller</td>
</tr>
<tr>
<td>Elastic Modulus</td>
<td>2 fold more than ACL</td>
<td>Less than MCL</td>
</tr>
<tr>
<td>Tensile strength</td>
<td>110 MPa</td>
<td>70 MPa (Medial bundle)</td>
</tr>
<tr>
<td>Healing</td>
<td>Heals. No surgery required</td>
<td>Always need surgery</td>
</tr>
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Posterior cruciate ligament [PCL]

Intra-articular and extrasynovial ligament

Its mean length is 38 mm and mean width 13 mm

2 bundles Anterolateral [larger and 85%] Posteromedial bands

Anterolateral band is tight in flexion and lax in extension while the posteromedial bundle is tight in extension and lax in flexion

Division of PCL increases in the Patellofemoral joint forces. This may lead to Patellofemoral arthritis.
**Medial structures of the knee**

3 layers: Superficial, middle and deep layers

Grouped: into anterior, middle and posterio third

<table>
<thead>
<tr>
<th></th>
<th>Anterior</th>
<th>Middle</th>
<th>Posterior</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superficial</td>
<td>Fascia</td>
<td>Fascia</td>
<td>Layer of fascia</td>
</tr>
<tr>
<td>Middle</td>
<td>None</td>
<td>Superficial MCL</td>
<td>Posteromedial capsule</td>
</tr>
<tr>
<td>Deep</td>
<td>None</td>
<td>Deep MCL</td>
<td>Posteromedial capsule</td>
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</table>

**3 important medial ligamentous structure**

1. Superficial MCL

Femur attachment: 1cm anterior and distal to Adductor tubercle
Tibia attachment: Under Pes Anserinus [ 6 cm distal to the joint]

Fibers are grouped into

a. Anterior fibers  Parallel fibers
b. Posterior fibers Oblique
               Posterior oblique ligament

2. Deep MCL

Femur: Femur just below Superficial
Tibia: close to the articular margin

3. Posteromedial capsule

Blending of superficial and deep MCL and Semimbranous extension
Posterior oblique ligament probably not distinct and is as above

Appears to dynamically stabilised by Semimembranos

**Lateral structures of the knee** [Seebacher]

I layer       Biceps Femoris; Iliotibial band
II layer      Quadriceps retinaculum; Patellofemoral ligament
III layer     Superficial: Lateral collateral ligament; Fibulo-fabellar ligament
               Deep: Coronary ligament, Arquate ligament, Popliteo-fibular ligament
Anatomic variation: 67% have both arcuate and Fabello-fibular ligament; 20% only Fabello-fibular ligament; 13% only arcuate.
III. BIOMECHANICS

a. Anatomic and mechanical axis

Mechanical axis: Centre of the hip to the centre of the ankle

Anatomic axis of femur is approx 6 degrees of valgus from mechanical axis or 9 degrees of valgus from vertical axis

Anatomic axis of tibia is 3 degrees of varus from mechanical axis

Lines that intersect the tibia and the femur intersect at knee 6

Posterior slope in the tibial plateau is 9°

2. The “screw home mechanism

Rotation between the tibia and femur occurs automatically between full extension (0°) and 20° of knee flexion. External rotation of the tibia on femur during full extension is Obligatory external rotation

This occurs because of differential radii. Medial femoral larger than lateral (by 17mm). At full extension, medial tibial plateau has to cover more distance and this causes external rotation of the tibia.

This screw home: very stable and both Cruciates are tight and very minimal movement occurs between tibia and femur

1. During knee extension
The tibia glides anteriorly on the femur.

2. During the last 20 degrees of knee extension
Anterior tibial glide persists on the tibia's medial condyle because its articular surface is longer in that dimension than the lateral condyle's.

3. Prolonged anterior glide
On the medial side produces external tibial rotation, the "screw-home" mechanism

c. Sliding and rolling

With 0-15° of flexion: [Rolling prominent]

Sliding::Rolling is 1:2

With 15°-130° of flexion: [Sliding prominent]

Sliding::Rolling is 4:1
From kinematics studies,

Flexion and extension do not occur about a fixed transverse axis of rotation but rather about a constantly changing center of rotation (polycentric rotation).

Motion is therefore achieved by a complex coupled mechanism in which the femoral condyles simultaneously glide and roll back on the tibial plateaus

**D. 4 Bar linkage**

4 Bars  ACL, PCL, Femur: Roof of the intercondylar notch, Tibia intercondylar eminence

![Diagram](image)

(a) Straight leg  (b) 45 degrees bent  (c) 90 degrees bent

**Relation to Femoral link**

Extension: ACL is parallel to the Femoral link
Flexion PCL is parallel to the femoral link.

**Isometry**  Only Some fibers in ACL and PCL is isometric during any ROM.

**With flexion and extension**

None of the length of bars changes with movement but angle between ACL and PCL changes.

**e. Instant centre**

Centre is at the intersection of ACL and PCL. Therefore do not produce moment .

Line from instant centre to tibifemoral contact point forms perpendicular to the tangential to the tibia.
f. Movement

Normal range 0-140°
Function range -3 to 120°

Walk: Heel strike 15° flexion
Sprint: Heel strike 30°
Swing 60°
Getting in and out of chair 115°
Climbing stair 90 to 100°

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g. Primary joint restraints

<table>
<thead>
<tr>
<th></th>
<th>Primary</th>
<th>Secondary</th>
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<tbody>
<tr>
<td>Anterior</td>
<td>ACL</td>
<td>Deep MCL</td>
</tr>
<tr>
<td>Posterior</td>
<td>PCL</td>
<td>Posterolateral complex</td>
</tr>
<tr>
<td>Varus</td>
<td>LCL</td>
<td>Posterolateral complex</td>
</tr>
<tr>
<td>Valgus</td>
<td>MCL</td>
<td>Cruciates</td>
</tr>
<tr>
<td>Internal Rotation</td>
<td>MCL</td>
<td>ACL</td>
</tr>
<tr>
<td>External Rotation</td>
<td>LCL &amp; posterior complex</td>
<td>PCL</td>
</tr>
</tbody>
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H. Posterior roll back

On knee flexion, both femoral condyles roll back. This is due to four bar linkage.

PCL retaining supposed favour normal roll back
Roll back: increases maximum knee flexion.
And it increases patello-femoral moment arm
11. Tibio-femoral force

- Moment: \( F_q \times 2.5 = W \times 7.5 \) ie., \( F_q = 3 \times W \)

- Sum of Forces: \( F_q + F_j + F_w = 0 \)

\( F_q = \) Quadriceps force; \( F_j = \) Joint reaction force