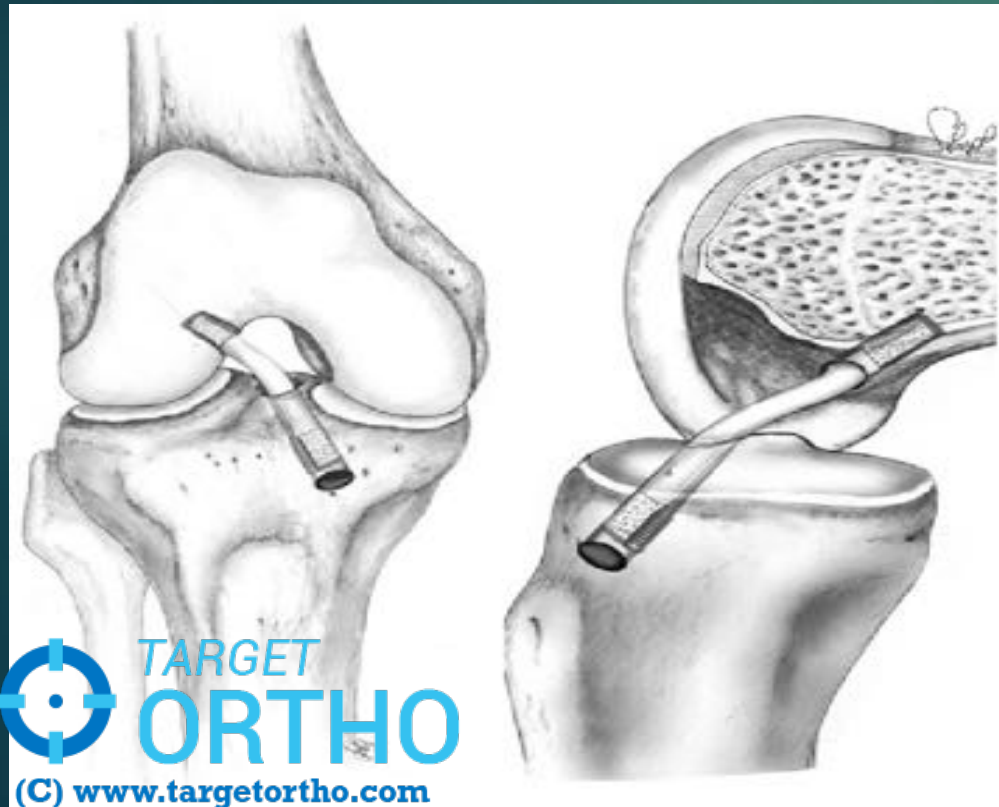
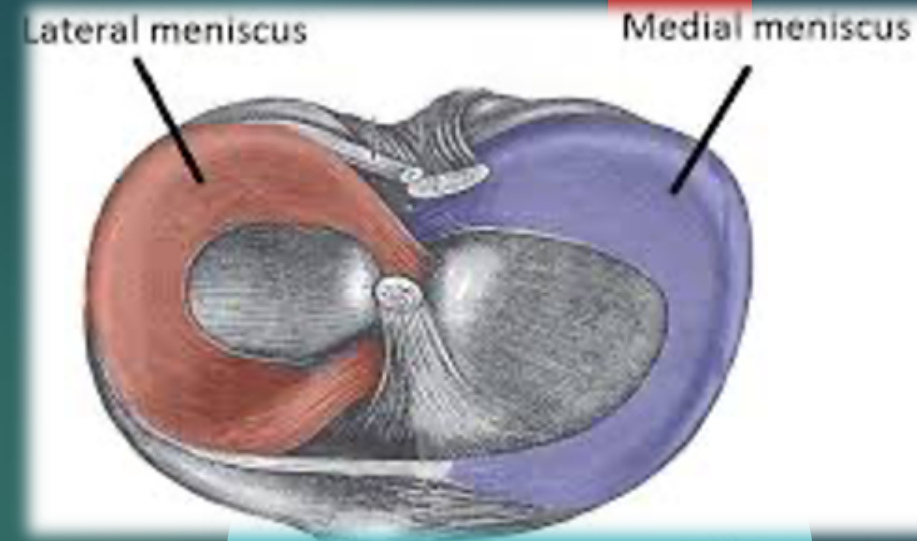
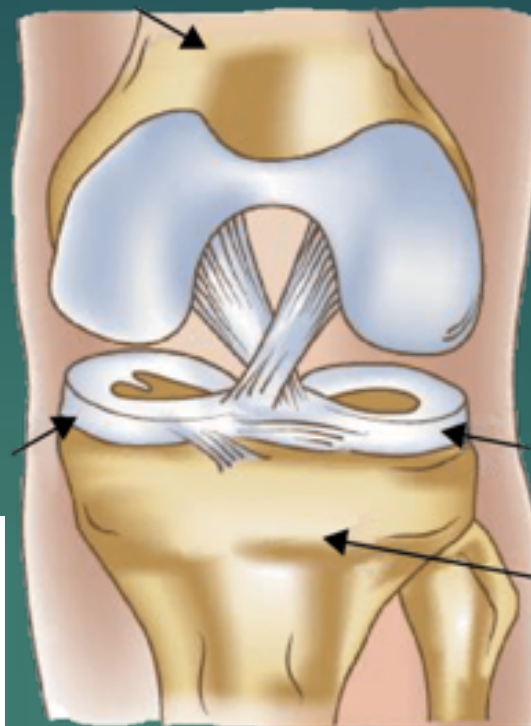
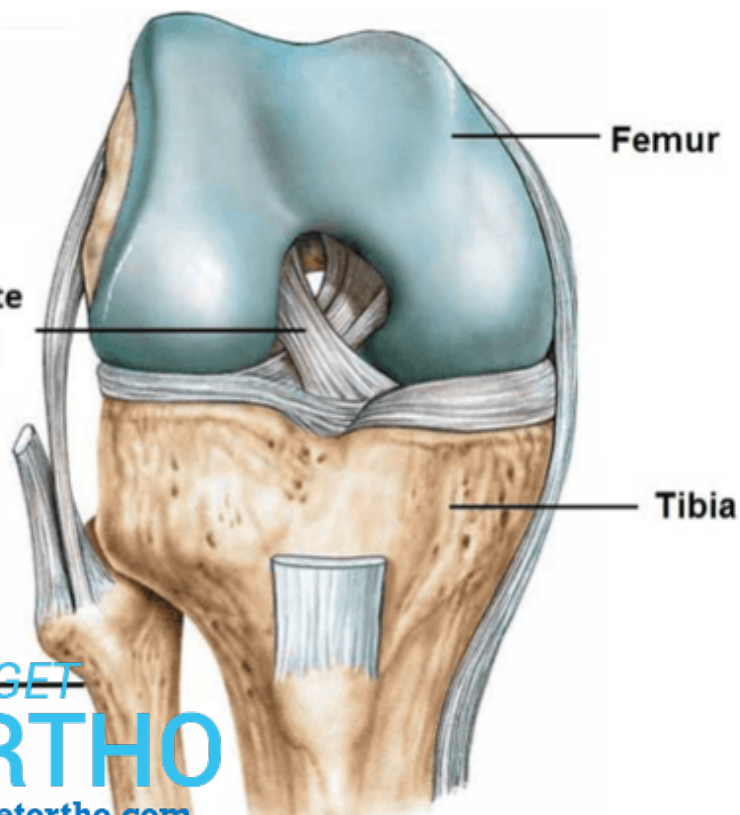
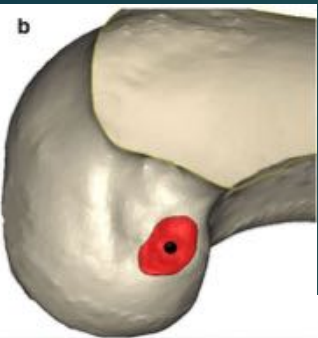


કેન્દ્રીય અસ્થિ - શિલ્પિલ્લા સંસ્થા
CENTRAL INSTITUTE OF ORTHOPAEDICS

Current trends in ACL Reconstruction



ANATOMY



Dense band of collagen type I

- length of 31 mm (range 29 to 35 mm)
- width of 9 mm (range 7 to 11 mm)

- *synovial membrane envelope*

Major blood supply:
from middle genicular artery

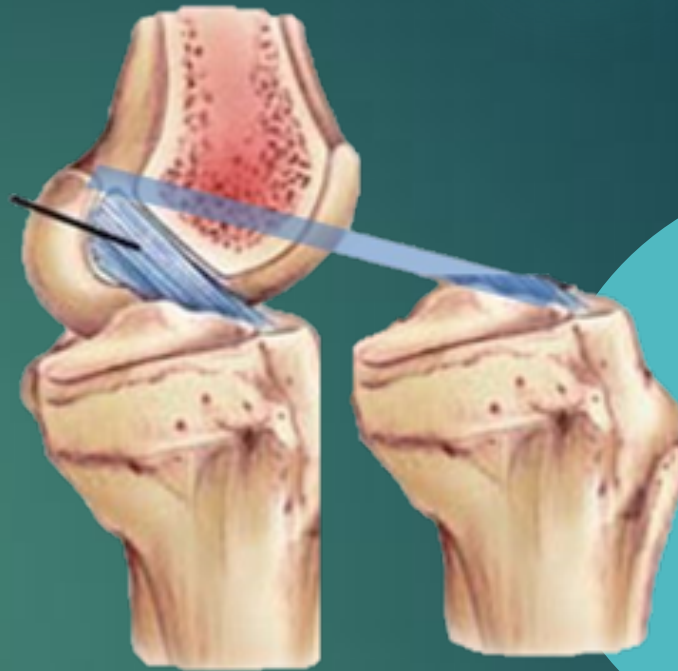
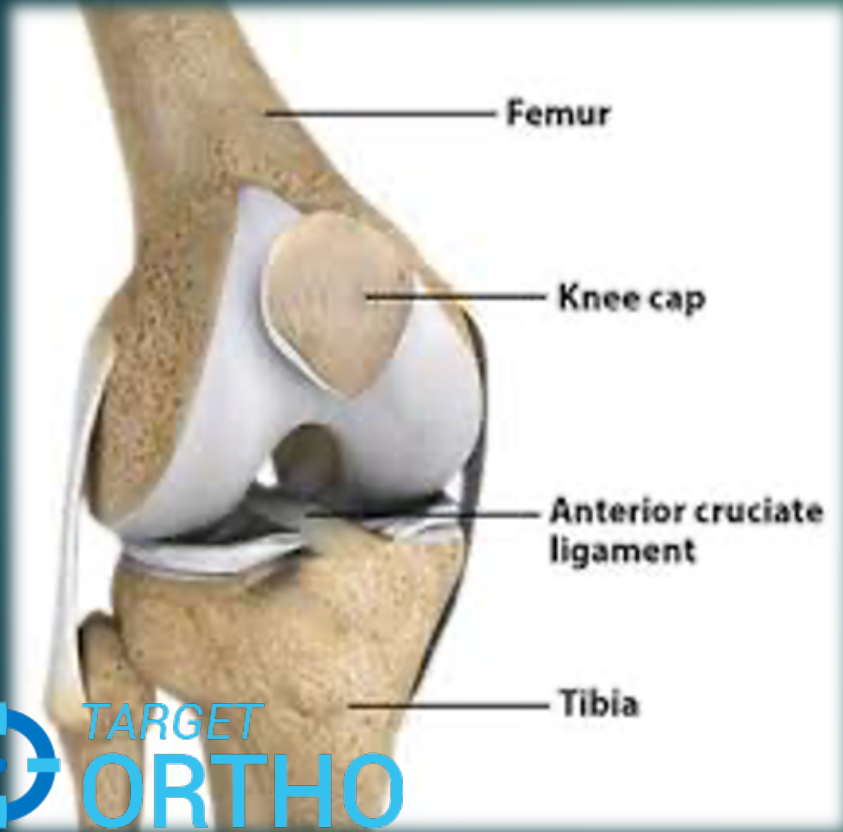
Nerve supply:
receives innervation from Posterior
articular nerve (branch of tibial nerve)

infiltrates the capsule posteriorly

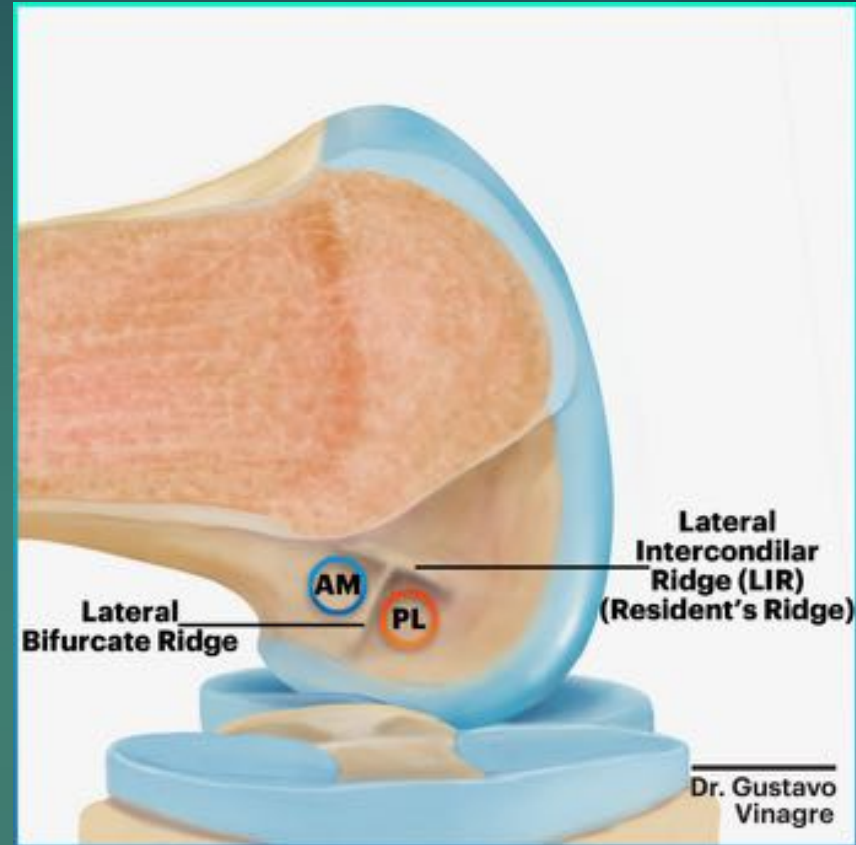
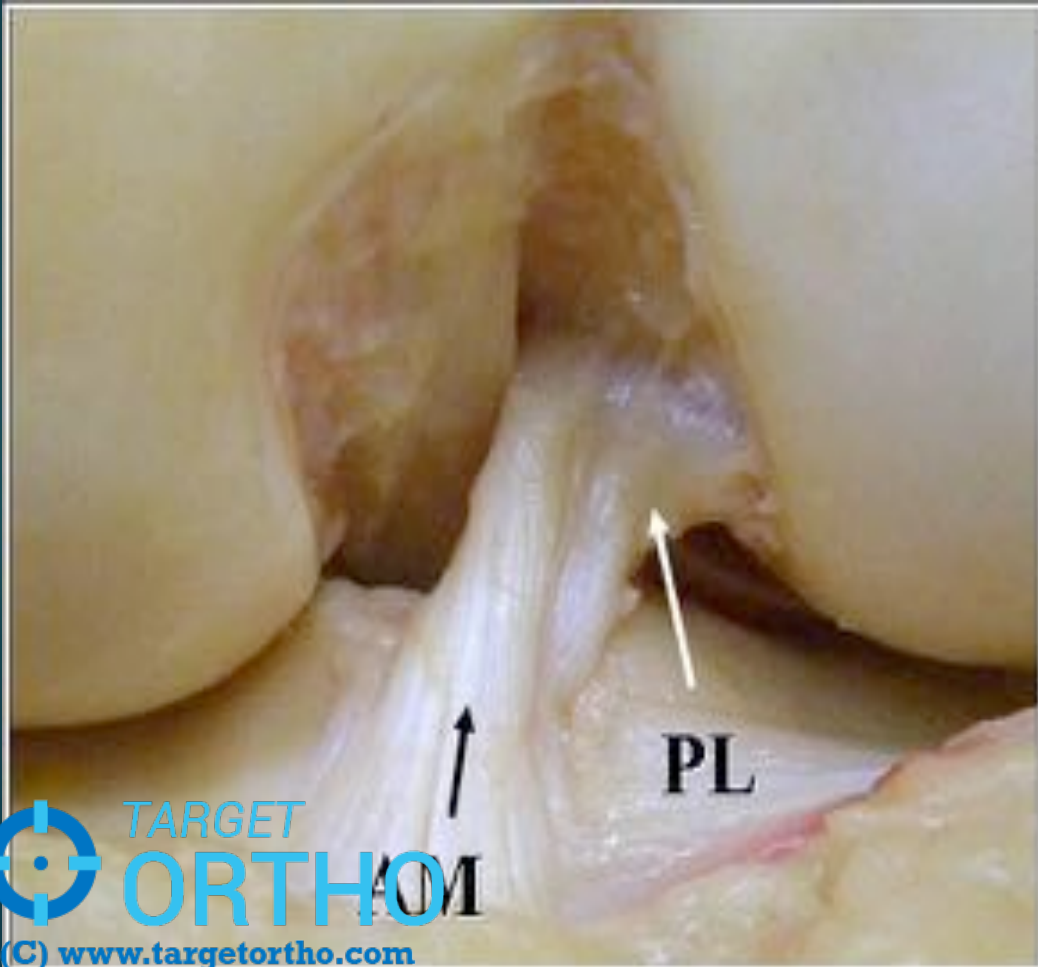
Proprioceptors (golgi tendon type
mechanoreceptors) at insertion sites



FUNCTION

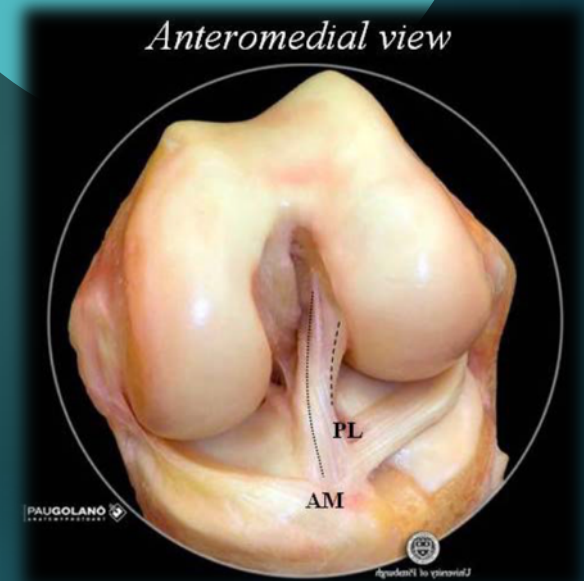
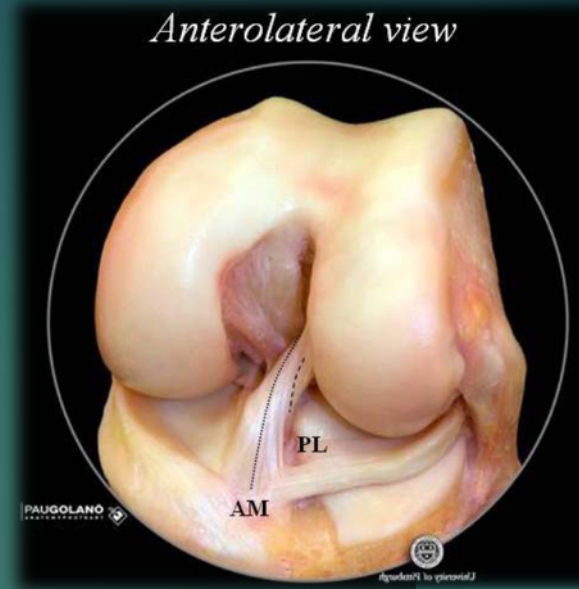
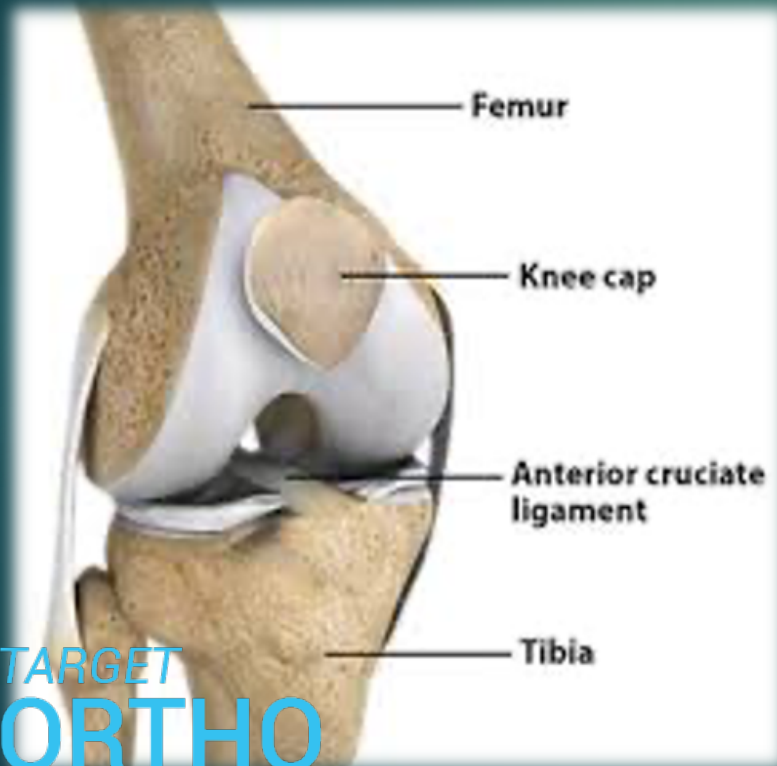


BUNDLES



ANATOMY

The AM bundle of the ACL primarily controls anterior (forward) movement of the tibia underneath the femur, and the PL bundle controls rotational stability of the knee, such as in pivoting, twisting, running, and jumping



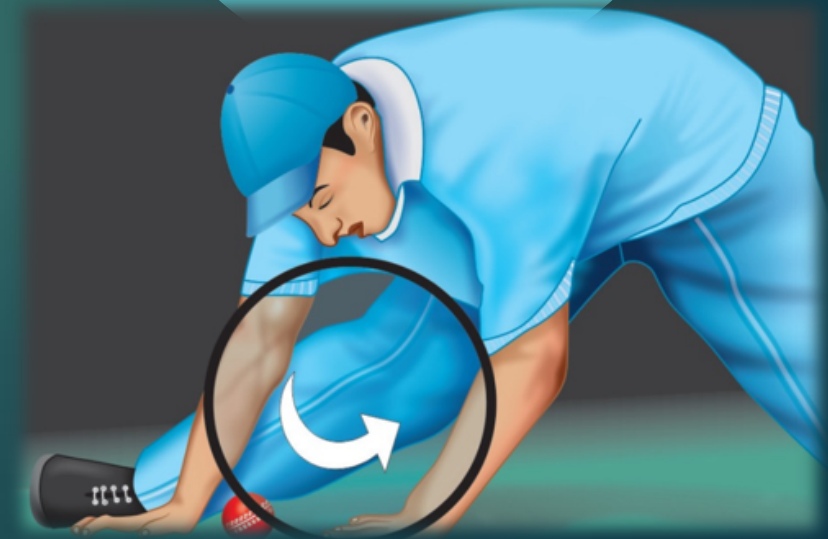
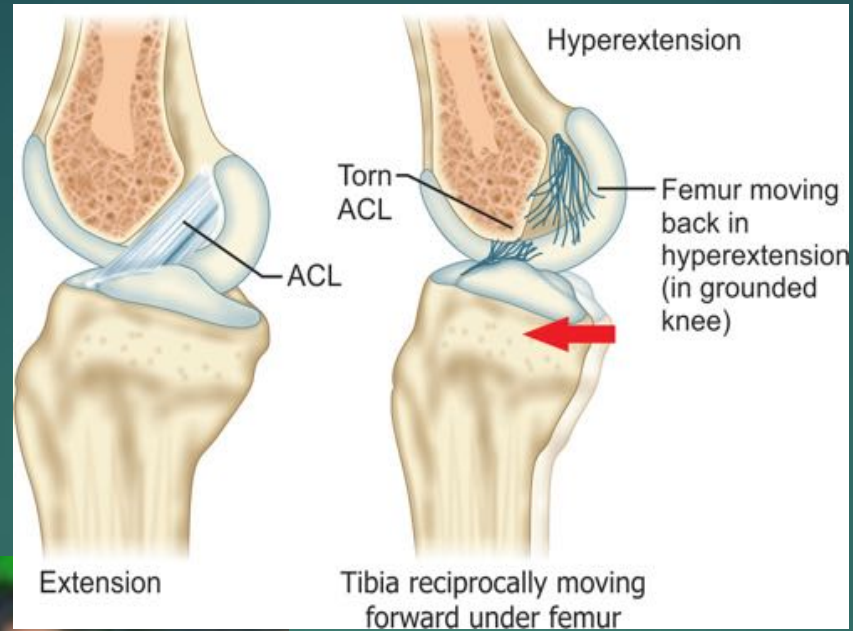
INJURY MECHANISM



Q. The movement involved in a torn ACL

- A. Femur moving back on tibia
- B. Tibia moving forwards on femur
- C. Both movements contribute
- D. ACL tears occur from rotational injuries

INJURY MECHANISM



RISK FACTORS

ENVIRONMENTAL: Hard surface, inappropriate footwear

ANATOMICAL/ GENETIC: High Q angle, knee valgus, foot pronation, high BMI, abnormal bone morphology (narrow notch), Steep tibial slope

N/M FACTORS: Abnormal muscle activation patterns

HORMONAL FACTORS: Relaxin may affect mechanical properties of ACL?

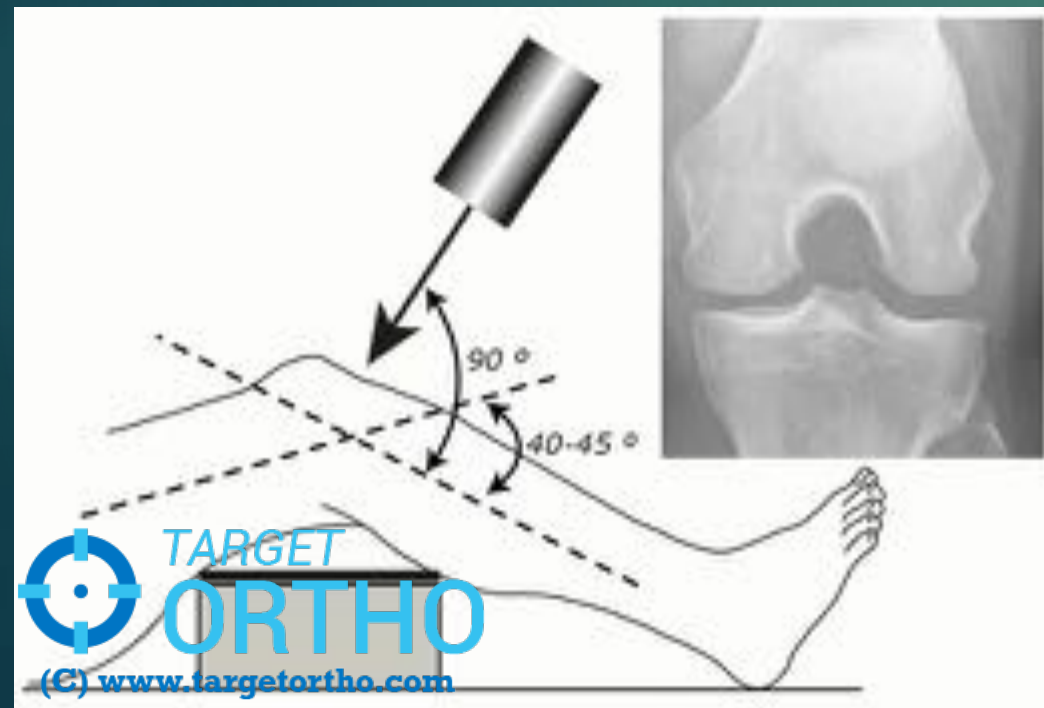


NOTCH WIDTH INDEX

Souryal and Freeman



Normal : 0.231



? Partial tear



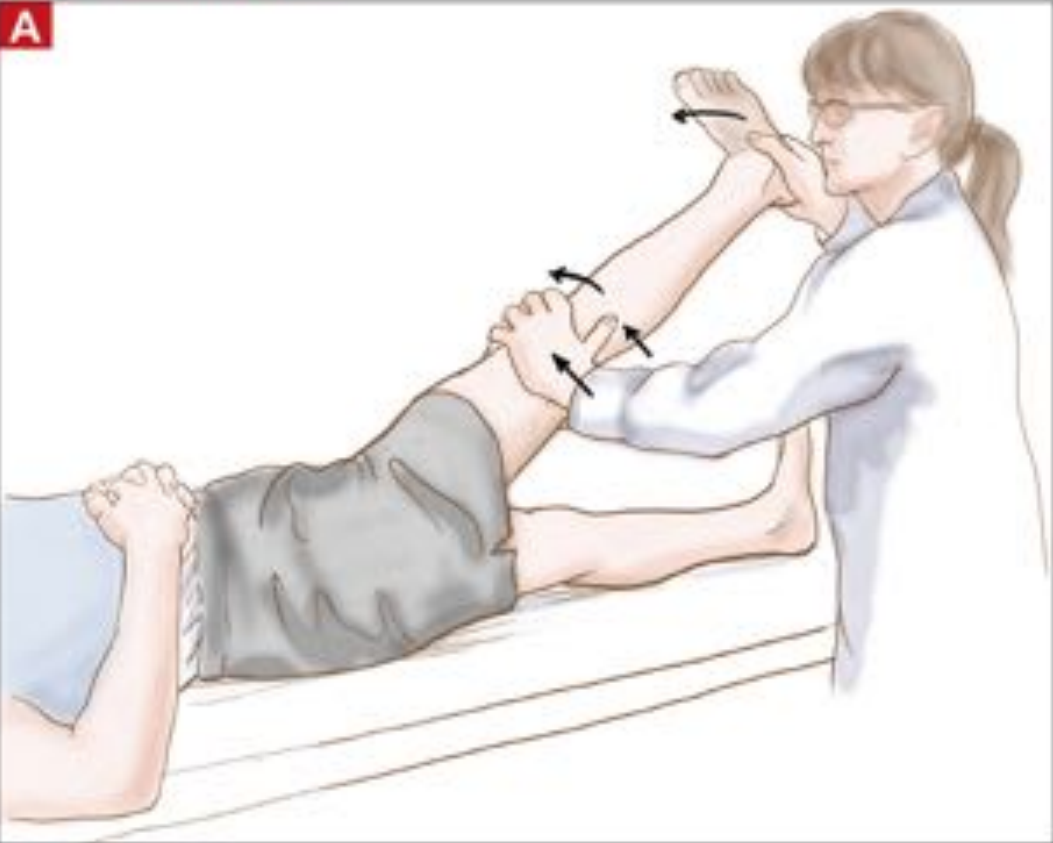
- A. O'Driscoll
- B. JS Torg
- C. John Lachman
- D. William C.Clancy

John Lachman

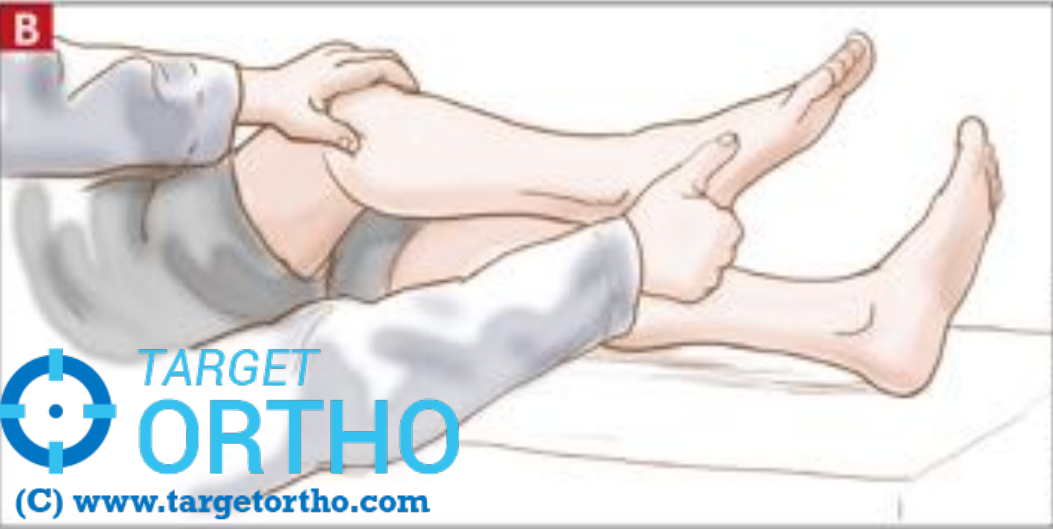
- Graduated from Temple University and Temple School of Medicine
- Discovered ACL integrity was more easily determined with the knee closer to extension than in the position used in the classic anterior drawer test



A

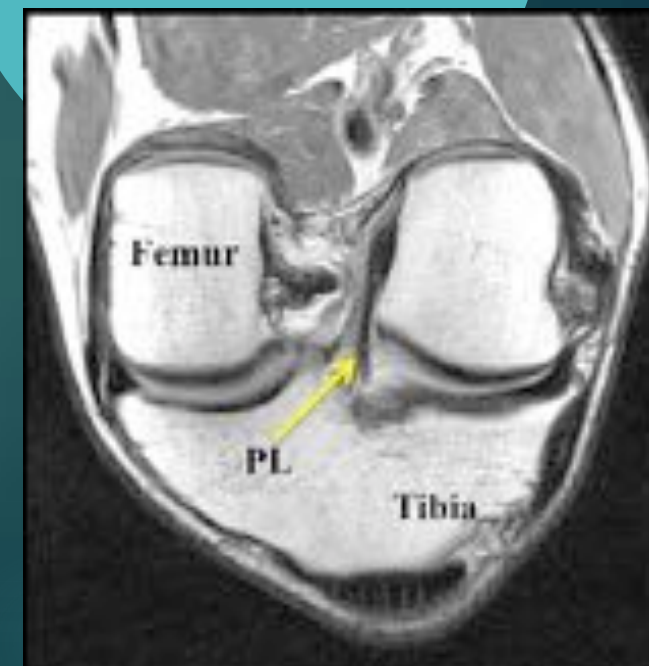


B

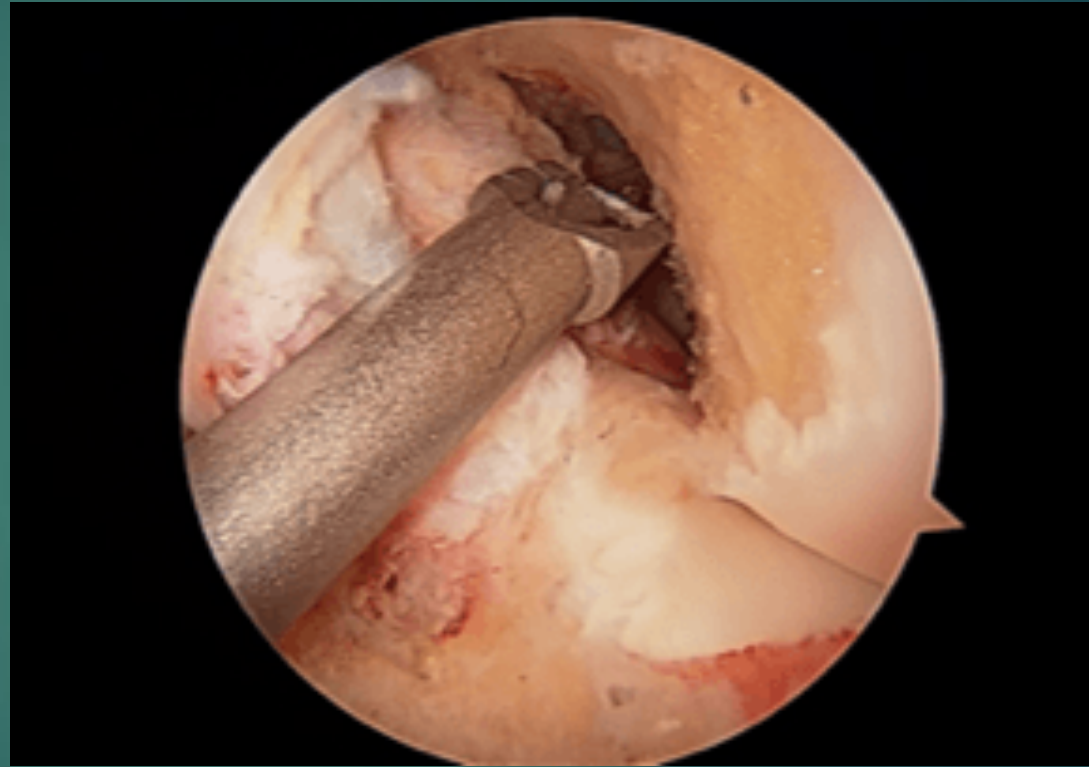


PIVOT SHIFT TEST





EMPTY NOTCH SIGN



MECHANICS

Incidence



Why repair the ACL?

- ❖ More normal knee movements
- ❖ No instability (and less pain)
- ❖ Better proprioceptive sense
- ❖ Decreased risk of osteoarthritis

Key
hole
surgery

Mall NA, Chambers PN et al. Incidence and trends of anterior cruciate ligament reconstruction in the United States. *Am J of Sports Medicine*. 2014 Oct;42(10):2363-70

(C) www.targetortho.com

ACL RECONSTRUCTION AND OA

- The prevalence of osteoarthritis (OA) increased **three-fold** after ACL tear knee compared with a normal contralateral knee.
- The strongest predictor of the development of OA are associated meniscal and osteochondral injury, obesity, return to aggressive sports, and the non-anatomical placement of the ACL graft.



Q. COMPARTMENT OF KNEE INVOLVED IN
OA (after an ACL tear) is:

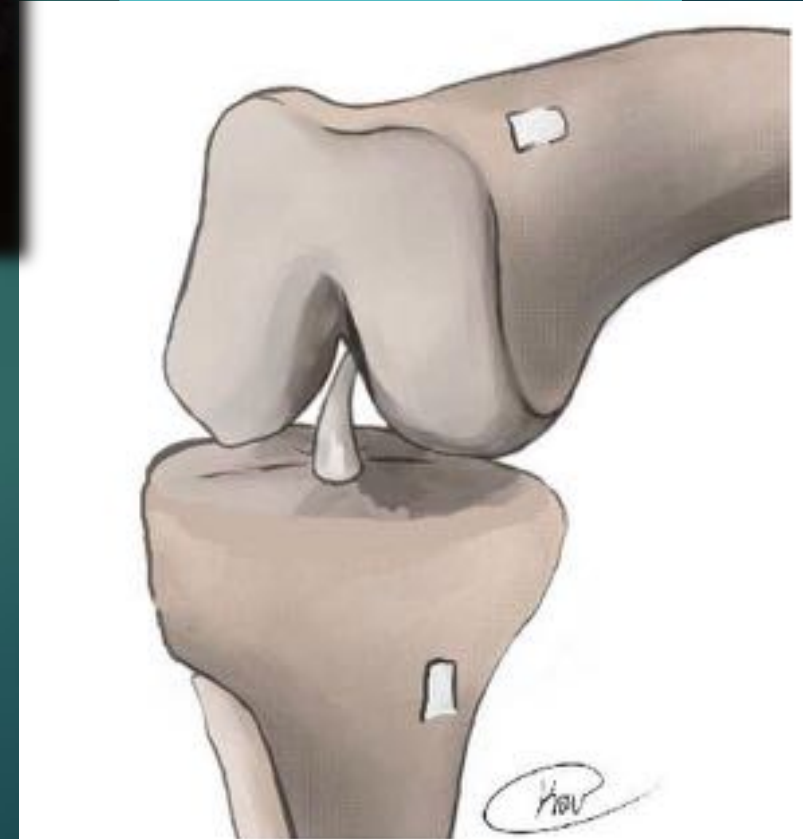
- A. Antero medial compartment
- B. Antero lateral compartment
- C. Postero medial compartment
- D. Postero lateral compartment

HOW TO RECONSTRUCT THE ACL WITH *PERFECTION* !!!



HISTORY

- 1917: Ernest Hey Grooves (ACL repair + IT band reinforcement): Ivory nail for fixation
- 1936: William Campbell (Patellar tendon graft): Graft sutured to periosteum
- 1939: Harry B. Macey (Semitendinosus graft): Distal part left attached, proximally re routed and turned back to be weaved to distal
- 1963: Kenneth Jones (Patellar tendon with bone block) → 1982 William Clancy
- 1970s: Macintosh, Lemaire and others (**Over the top repair** + **Extra articular** reconstruction)
- 1980s: Arthroscopic techniques (PT and ST): Lipscomb, Friedman and others
- 1990s: Fixation devices and techniques (Transtibial to Transportal technique)



Early 2000s (2008-10): Anatomical ACL and Double bundle ACL reconstruction

EVOLUTION OF ACL SURGERY

- Extra articular to Intra articular reconstruction
- Open to Arthroscopic techniques
- Non anatomic to Anatomic reconstructions
- Transtibial to Trans portal tunnel placement
- Single to Double bundle reconstruction



THE EVOLUTION OF MAN



ANATOMICAL ACL

Defined as the functional restoration of the ACL to its native dimensions, collagen orientation and insertion sites.

KARLSON PRINCIPLES

- 1) Restoring native insertions by correct (anatomical) tunnel placements
- 2) Restore two functional bundles
- 3) Provide appropriate tension
- 4) Provide appropriate graft diameter, size and type

CURRENT TRENDS

- Timing of surgery
- Graft choices
- Fixation methods/ devices
- Surgical Technique
- Remnant preservation
- All Inside technique
- Double bundle reconstruction
- Healing augmentation methods
- Synthetic devices
- Rehabilitation



TIMING OF SURGERY

Time of surgery	Early (<3wks)	Late (>1yr)
Complications	Arthrofibrosis Prolonged rehabilitation	Osteoarthritis Meniscal injury Osteochondral damage Ligament tear Decay of proprioceptors

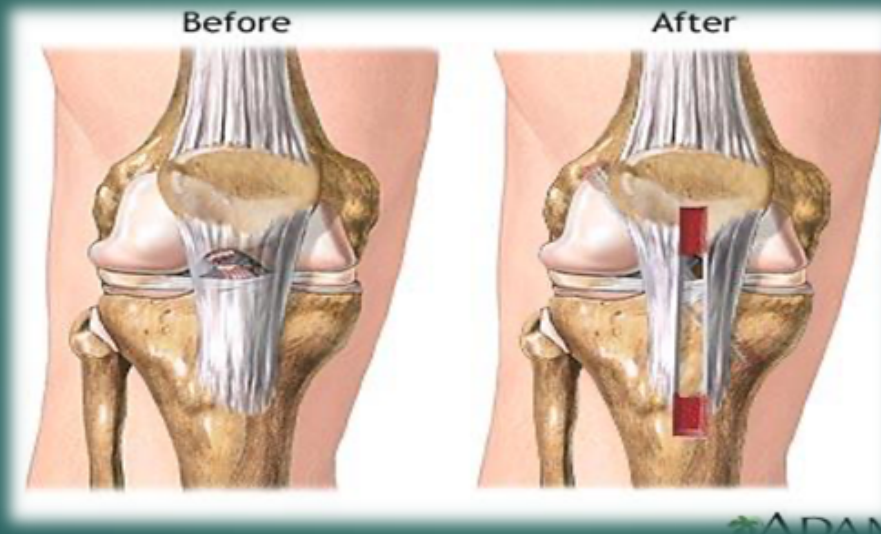


Resolution of inflammation around the knee and return of full motion reduce the incidence of postoperative knee stiffness.

GRAFT CHOICES

AUTOGRAFTS

Bone-patellar tendon-bone
Quadrupled hamstrings (Grac & Semi-T)
Quadriceps tendon-bone



ALLOGRAFTS

Bone-patellar tendon-bone
Achilles' tendon
Hamstrings
Quadriceps tendon
Fascia lata

ALLOGRAFT PROBLEMS

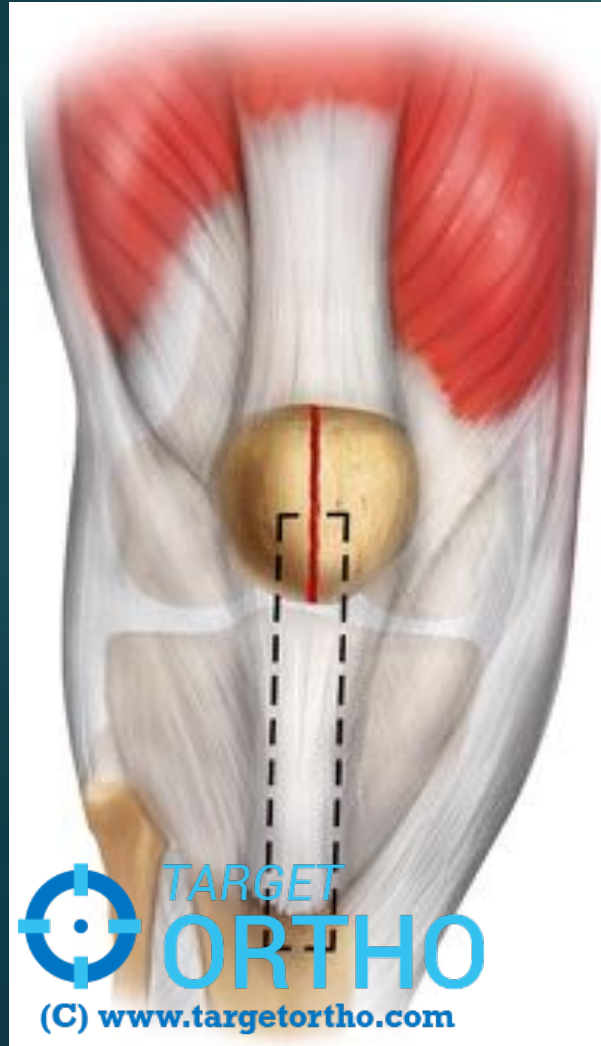
- With allografts
 - There is risk of viral disease transmission (1:1 million)
 - Deep freezing leaves some cells (10%)
 - Freeze-drying & cryo weaken graft; limited self-life
- Graft incorporation & remodeling is faster with autografts (graft is weakest @ 8-12 wks)
- Sterilization: Gamma radiation (1-3.5 M-rad)

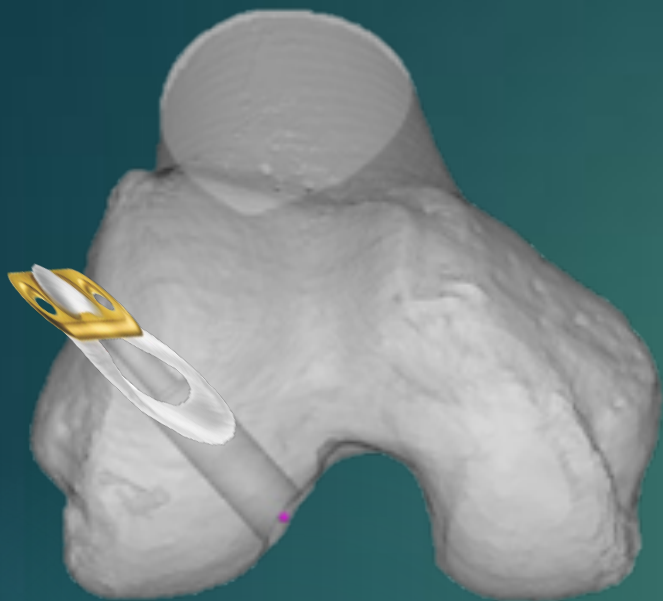
AUTOGRAFTS

Quadruple **hamstrings** possess the greatest ultimate tensile load (4090 N) and stiffness (776 N/mm).

Bone-patellar tendon-bone grafts have an ultimate tensile load of 2977 N and a stiffness of 620 N/mm.

Quadriceps tendon-bone grafts have an ultimate tensile load of 2352 N and a stiffness of 463 N/mm.





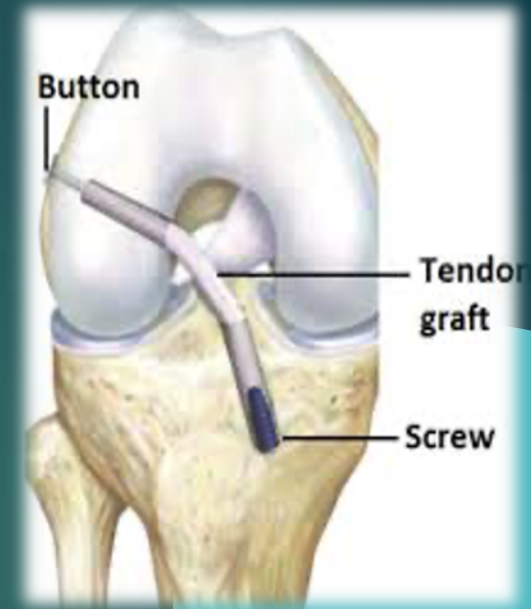
STAGES OF GRAFT INCORPORATION

STAGE	HISTOLOGY	TIMING
INFLAMMATORY PHASE	Partial graft necrosis	3 - 6 weeks
PROLIFERATIVE PHASE	Neo-vascularization	6 - 8 weeks
MATRIX SYNTHESIS	Collagen formation	8 - 12 weeks
REMODELING PHASE	Tendon to bone healing	6 - 9 months

FIXATION DEVICES

There are mainly two types of fixation devices used in ACLR in bone tunnels:

- ❖ **Aperture fixation** means the fixation of a graft at the opening of the bone tunnel (interference screws)



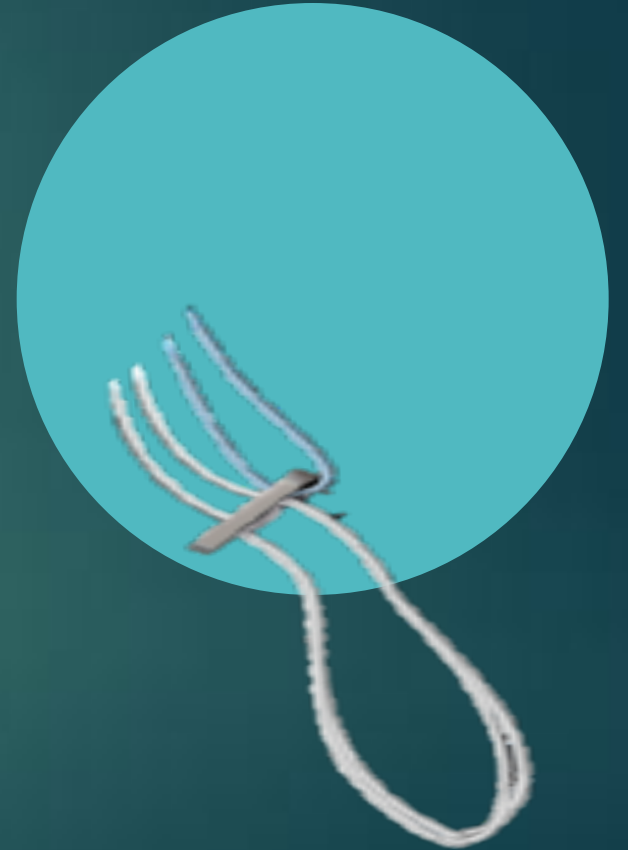
With Hamstrings

Preferred on **Tibial side** to avoid tunnel widening

- ❖ **Suspensory fixation** means fixation of the graft that is remote from the intra-articular space (Buttons, Suture discs)

Preferred on **Femoral side** to avoid graft pull out





SURGICAL STEPS GRAFT FIXATION

TIBIA

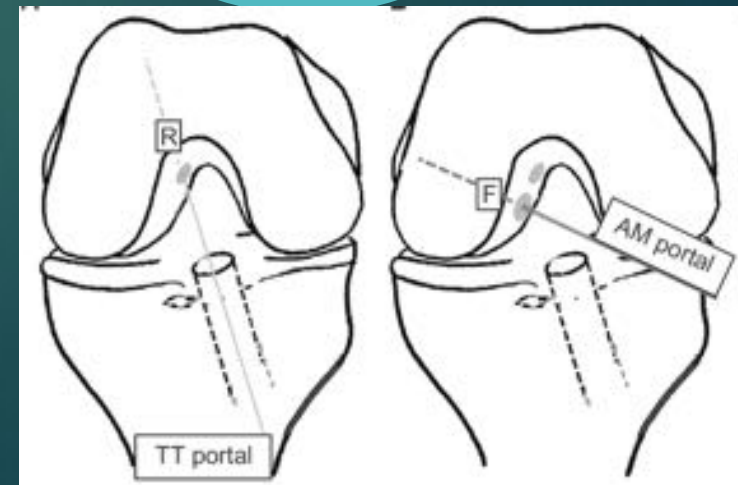
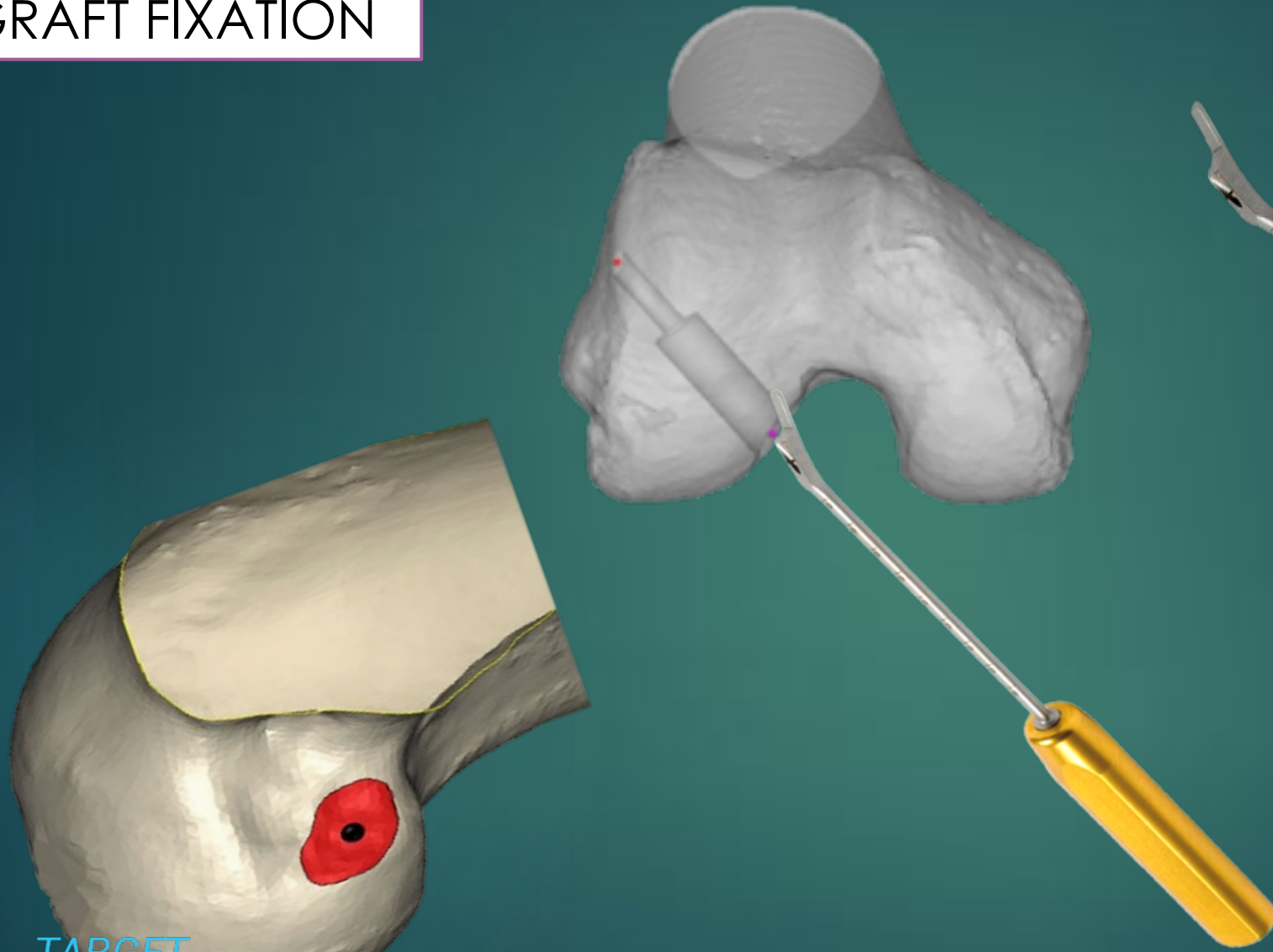
- ❖ 15 mm posterior to anterior tibial edge
- ❖ 7 mm anterior to PCL
- ❖ In line with posterior edge of anterior horn of lateral meniscus

Centre in between the tibial spines

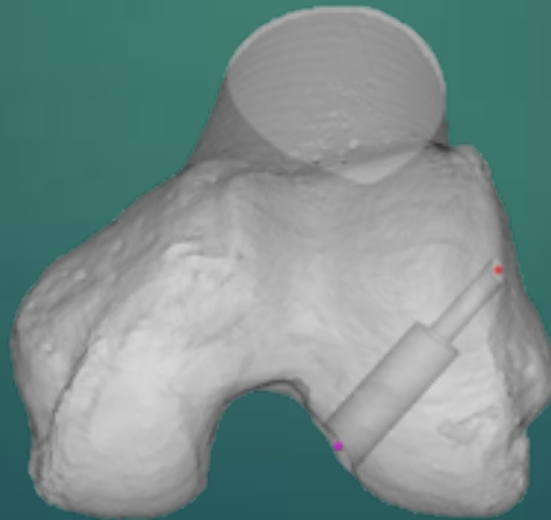
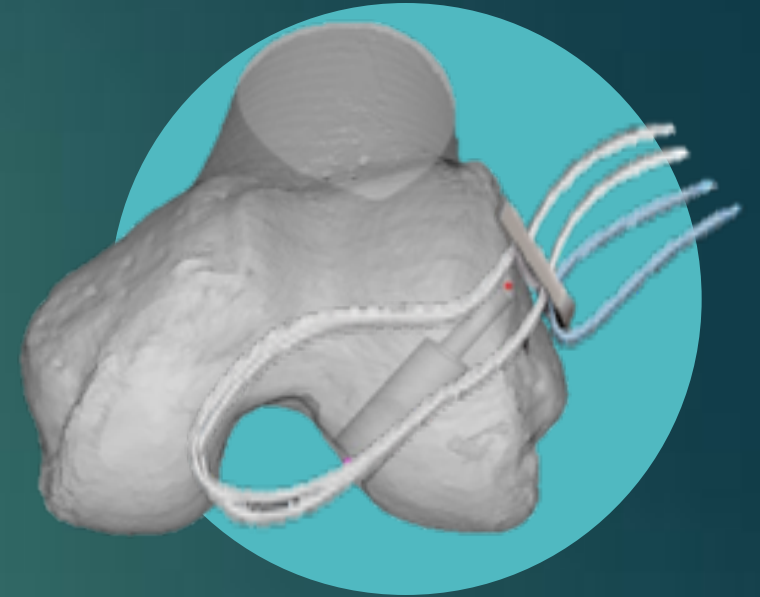
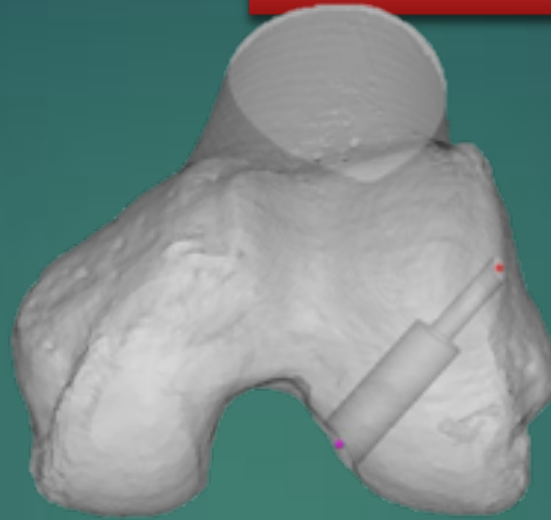
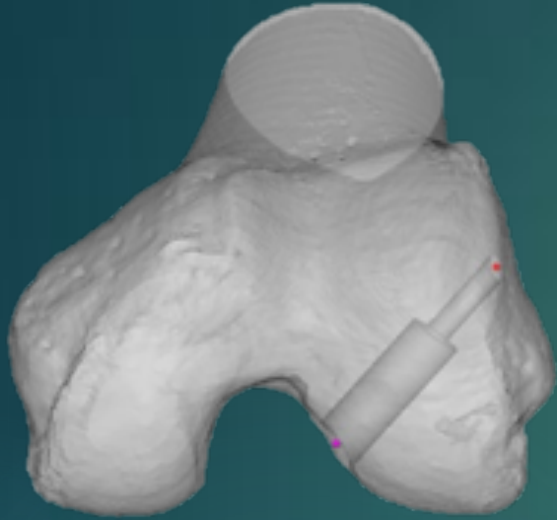


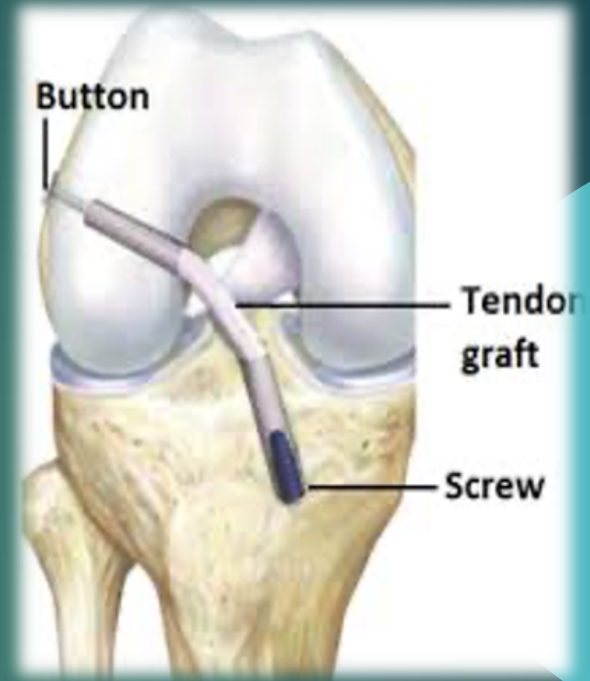
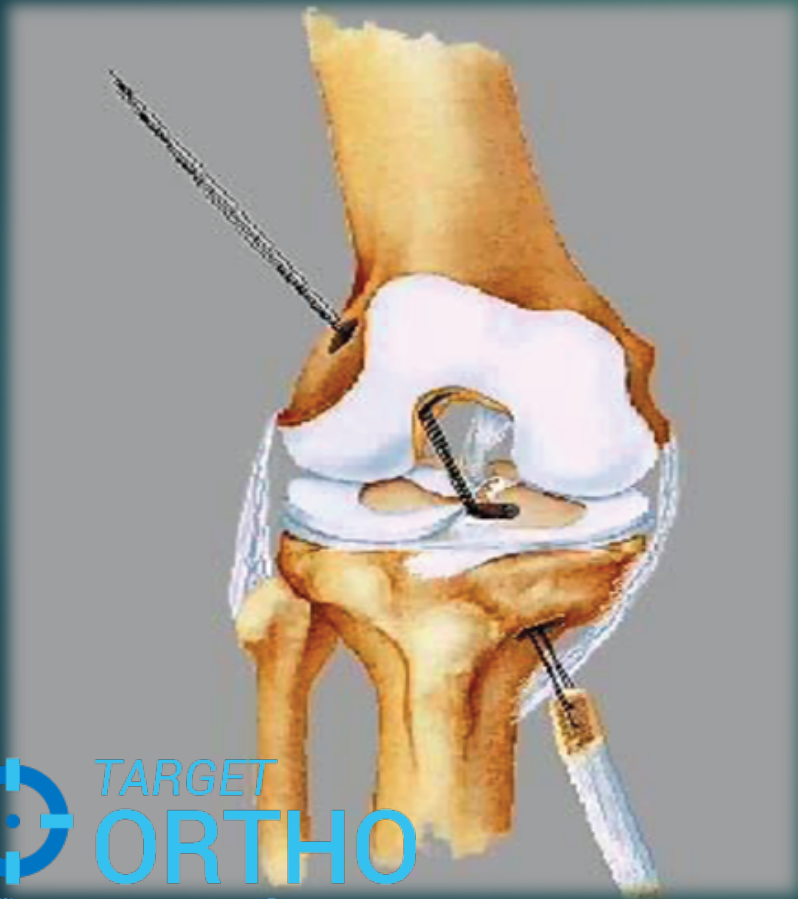
SURGICAL STEPS GRAFT FIXATION

FEMUR



Femoral Tunnel REAMING





INTERNAL BRACE

The surgeon stitches the torn ACL ligament together and then protects it using a 2.5mm polyethylene **FIBER Tape** (the *Internal Brace*), which protects the ligament during the critical phase of healing!



The Internal Brace augmentation can withstand additional forces (up to 64%) at peak loading.

*Creep is addressed at time zero
Reduces dynamic elongation up to 51%*

Scope for adjustable loop to length also goes down!

ARTHREX [NAPLES, FA]

Implant



EVOLUTION

LIGAMENT AUGUMENTATION DEVICES [LADs]

Kennedy Ligament Augmentation device [1980s]: The augmentation with the LAD was based on the concept of load sharing and was meant to protect the native ACL graft during the post-transplantation phase when there is decrease in strength of the autograft. However, the polypropylene polyester structural units of the ligament met with an exceedingly high number of **synovitis** reports that led to out favouring of this device.

1983: Riel KA used the LAD in ACL reconstructions in 856 patients. In 63 cases he had to treat complications like **infection, recurrent effusions, arthrofibrosis**. The overall results are good with respect to stability, regain of strength and sports activity but 73 cases needed re-surgery eventually because of synovitis.

Stiff nature led to '**stress shielding**' resulting in delayed integration of the native grafts eventually ending with higher rates of surgical failure.



REVIVAL

[Arthrosc Tech](#). 2018 Apr; 7(4): e385–e389.

PMCID: PMC5982687

Published online 2018 Mar 26. doi: [10.1016/j.eats.2017.10.010](#)

PMID: [29868409](#)

Anterior Cruciate Ligament Reconstruction With Suture Tape Augmentation

[Matt Deggett](#), D.O., M.B.A.^{a,*} [Andrea Redler](#), M.D.^b and [Kevin Witte](#), D.O., M.B.A.^a

• [Author information](#) • [Article notes](#) • [Copyright and License information](#) [Disclaimer](#)

The use of a suture tape augmentation has been published in the repair/reconstruction of medial knee injuries, ulnar collateral ligament, and ACL repair or reconstruction with allograft.

REMANANT PRESERVATION

SAMBBA

[Arthrosc Tech.](#) 2014 Dec; 3(6): e689–e693.

Published online 2014 Nov 24. doi: [10.1016/j.eats.2014.08.007](#)

PMCID: PMC4314548

PMID: [25685675](#)

Anterior Cruciate Ligament Reconstruction and Preservation: The Single–Anteromedial Bundle Biological Augmentation (SAMBBA) Technique

[Bertrand Sonnerly-Cottet, M.D.](#),* [Benjamin Freychet, M.D.](#), [Colin G. Murphy, M.D.](#), [Barbara H.B. Pupim, M.D.](#), and [Mathieu Thaumat, M.D.](#)

ACL remnant preserving

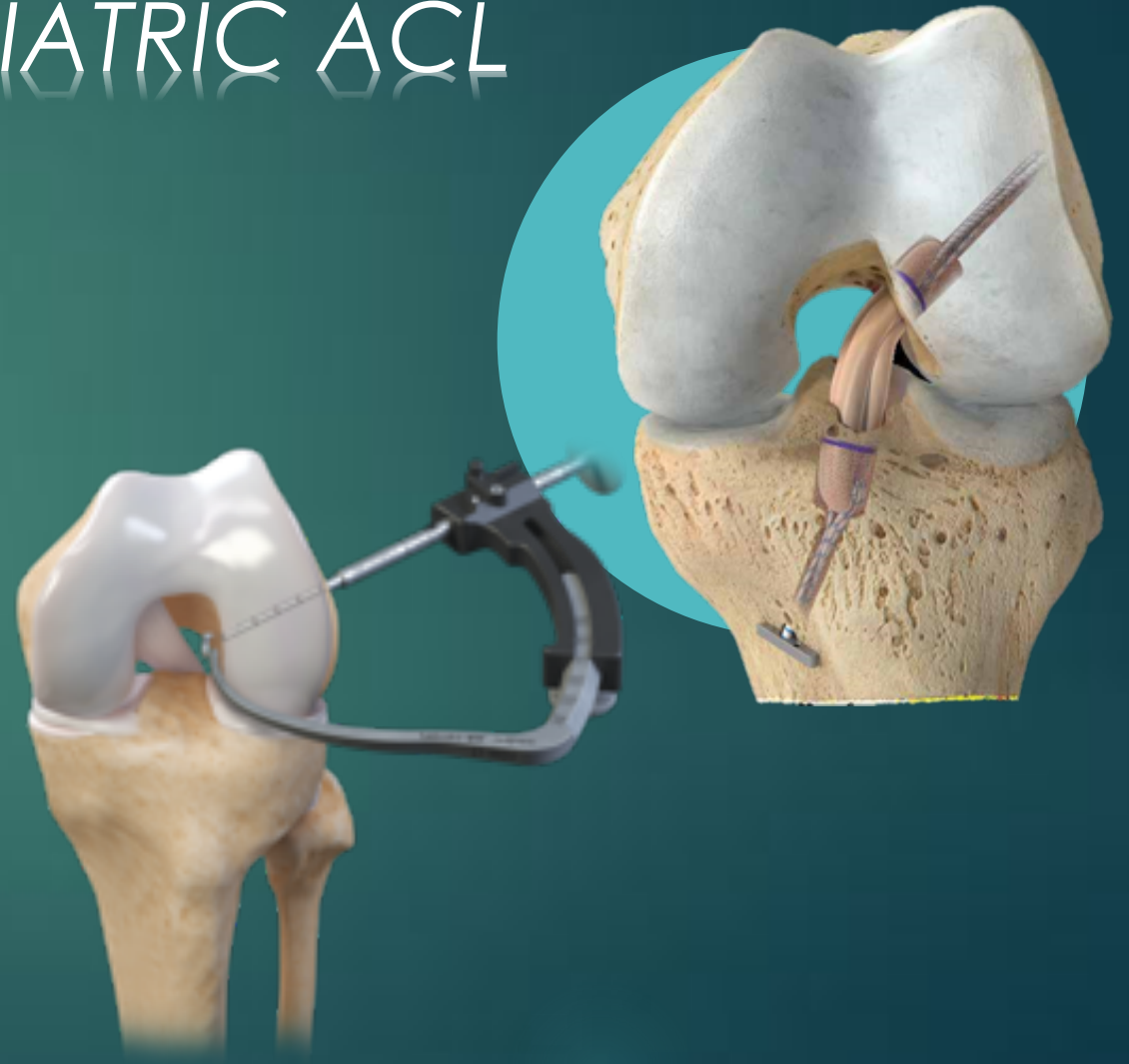
- ❖ Intact remnants played an important role in mechanical strength in the early postoperative period
- ❖ Reservation of the blood supply aid in the healing process of the graft
- ❖ Maintenance of proprioceptive innervation with evident benefits for the subjective outcome and return to sports
- ❖ Optimization of the accuracy of the procedure by improving the arthroscopic orientation and bone tunnel placement at the insertion site



ALL INSIDE ACL RECONSTRUCTION

PEDIATRIC ACL

- Closed-socket tunnels
- Decreased bone removal
- Dual suspensory graft fixation
- Smaller skin incisions
- Less post operative pain
- Faster rehabilitation and return to sport



DOUBLE BUNDLE ACL RECONSTRUCTION

- ❖ DB ACLR is to reconstruct both the AM and PL bundles, **more closely reproducing the native knee anatomy and kinematics**

MAIN ADVANTAGE GAINED

Lower Pivot shift Grades
And hence, better
Rotational stability!

- ❖ Biomechanical promise of DB **fails to translate into clinical significance** and may predispose the graft to impingement and excessive tension through the PL bundle during knee extension, resulting early graft rupture or attenuation

SB vs. DB ACLR

SB ACL reconstruction	DB ACL reconstruction
Small knee (no room for the DB technique)	Large enough knee
Thin hamstring tendons	Good quality of the hamstring tendons
Non-athlete or Recreational athlete	High-level athlete
Isolated ACL injury	Pivoting sports ACL injury combined with meniscal injury

SB Vs DB ACL

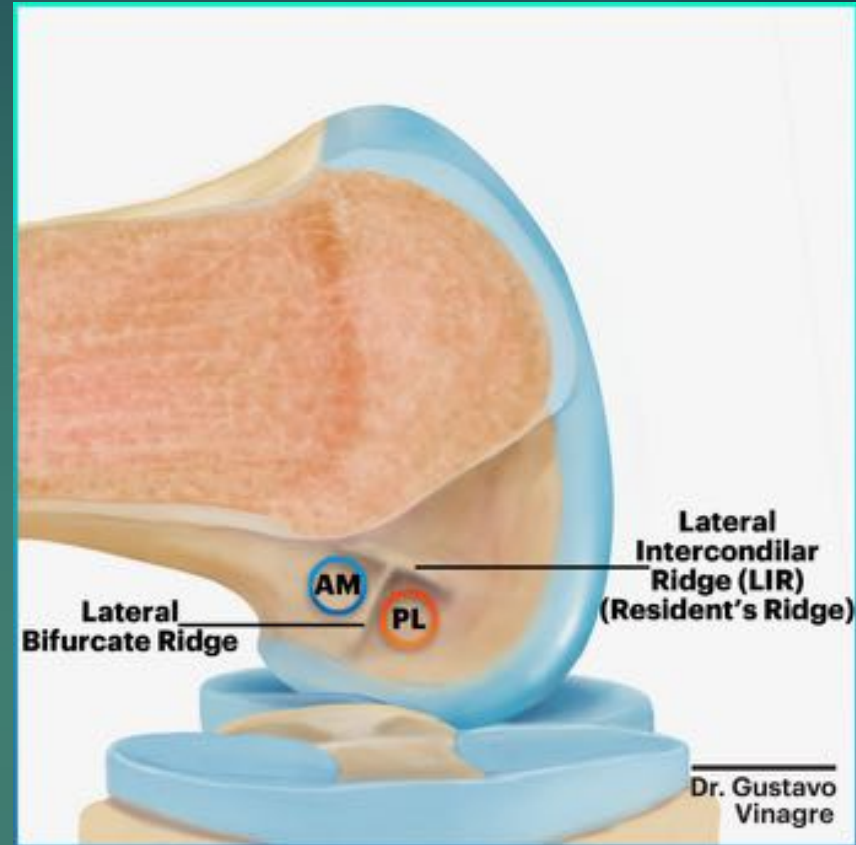
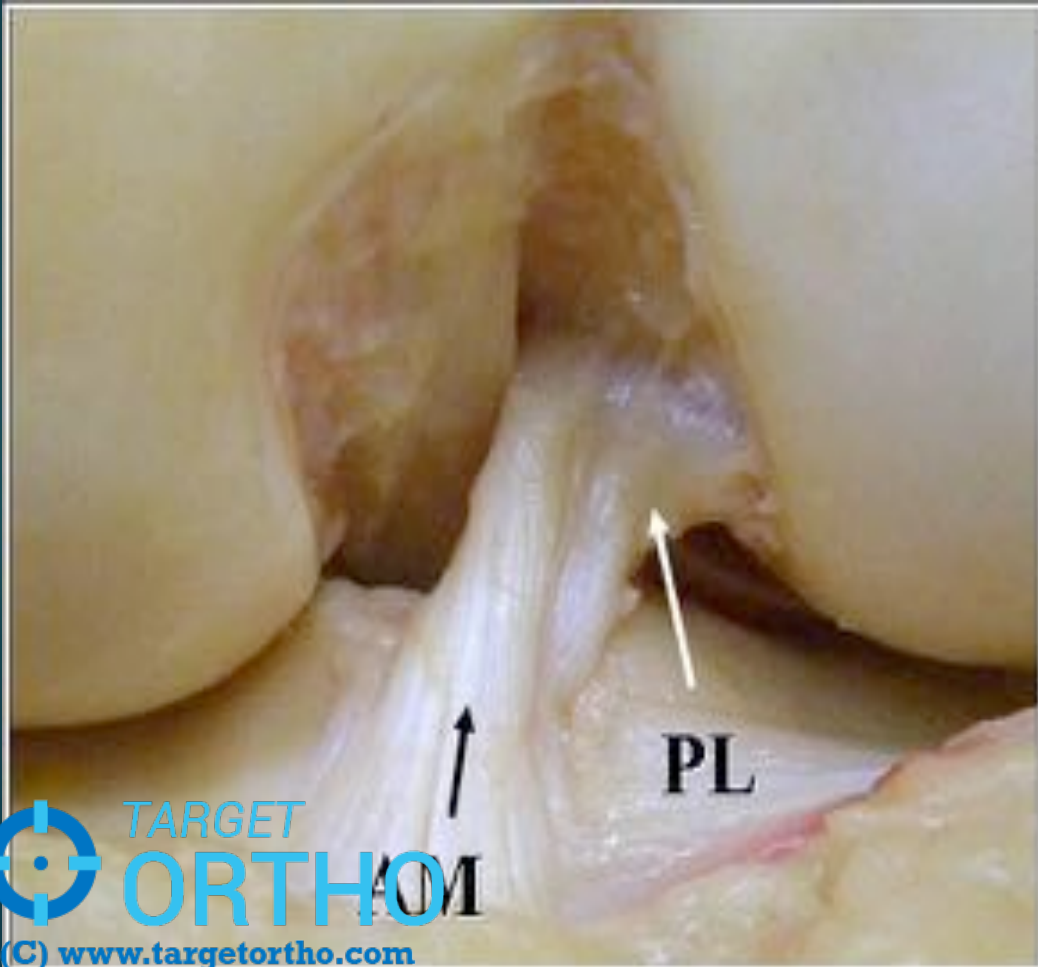
❖ Single bundle (SB) reconstruction is indicated for

- tibial insertion sites less than 14 mm in length,
- narrow notches (less than 12 mm in width)
- concomitant ligamentous injuries
- severe bone bruising
- severe arthritic changes (KL3-4)
- in the setting of open physis

❖ Double bundle (DB) reconstruction - considered in patients with

- a large tibial insertion site (anteroposterior length >14 mm)
- large intercondylar notch (length and width >14 mm)
- absence of concomitant ligament injuries
- absence of advanced arthritic changes (KL <3)
- absence of severe bone bruising
- closed physis

DB ACL



Q. Man behind DOUBLE BUNDLE ACL ??

A.Lemaire

B.Laprade

C.Lafosse and Hughston

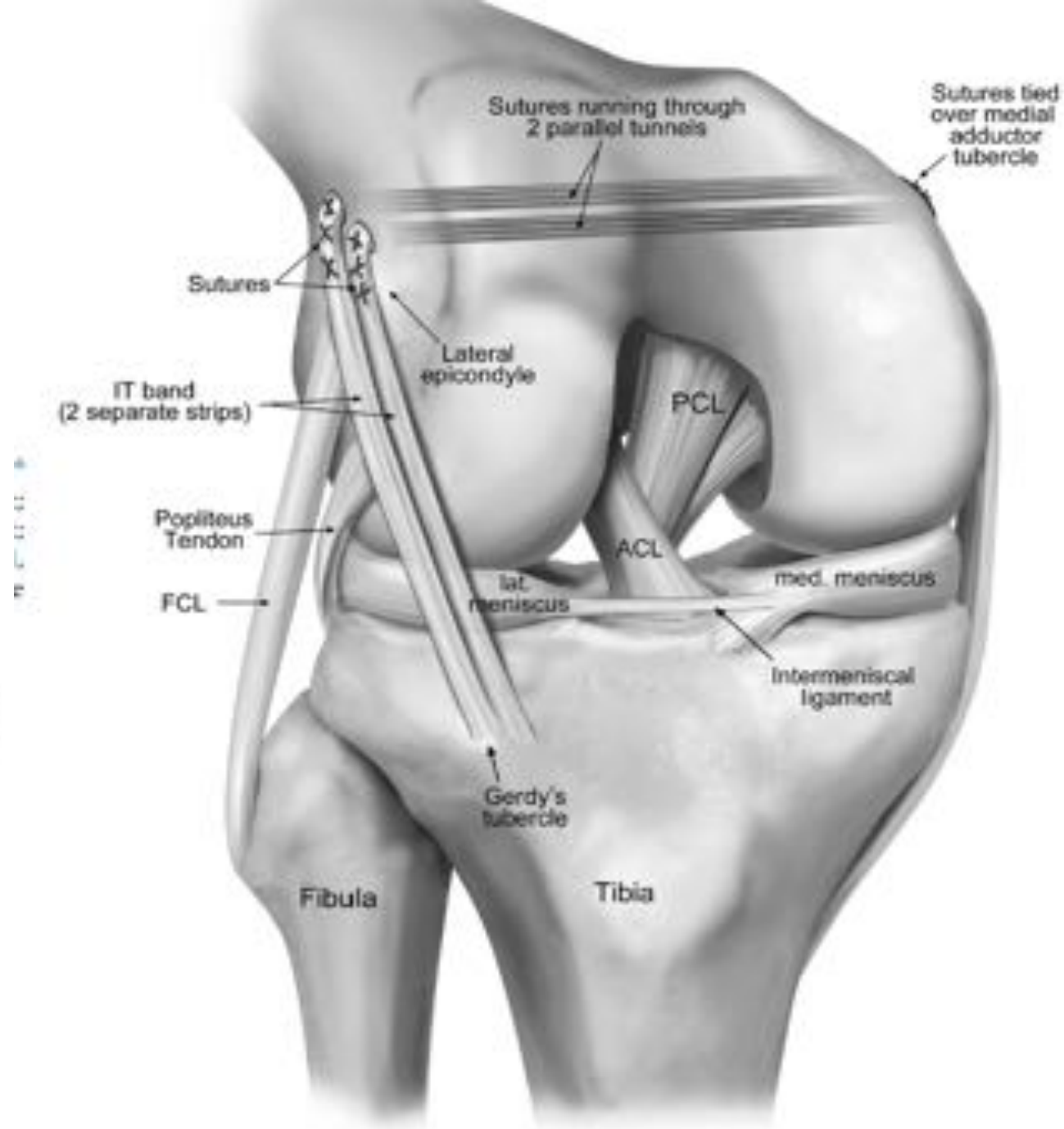
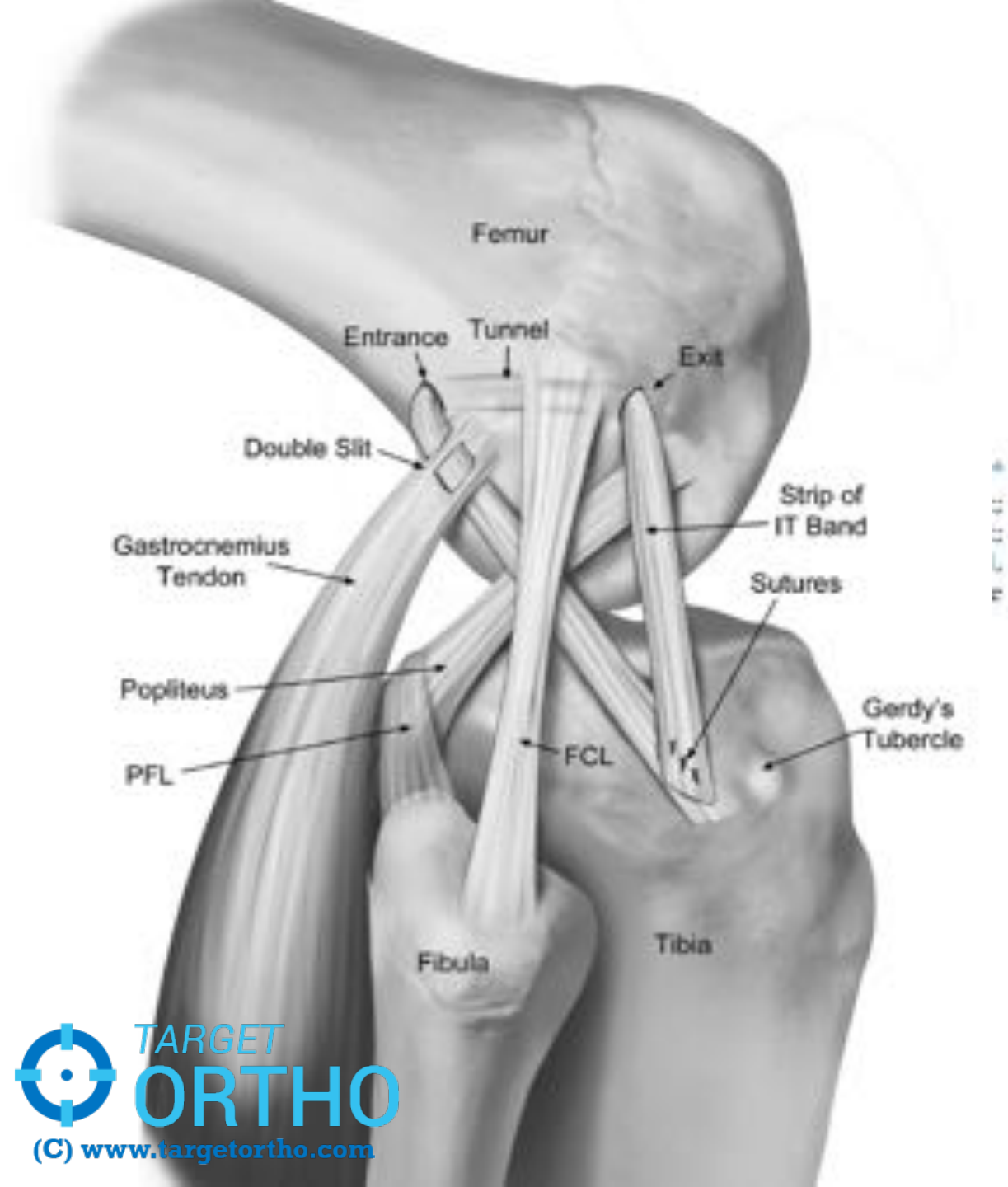
D.Friedi Fu

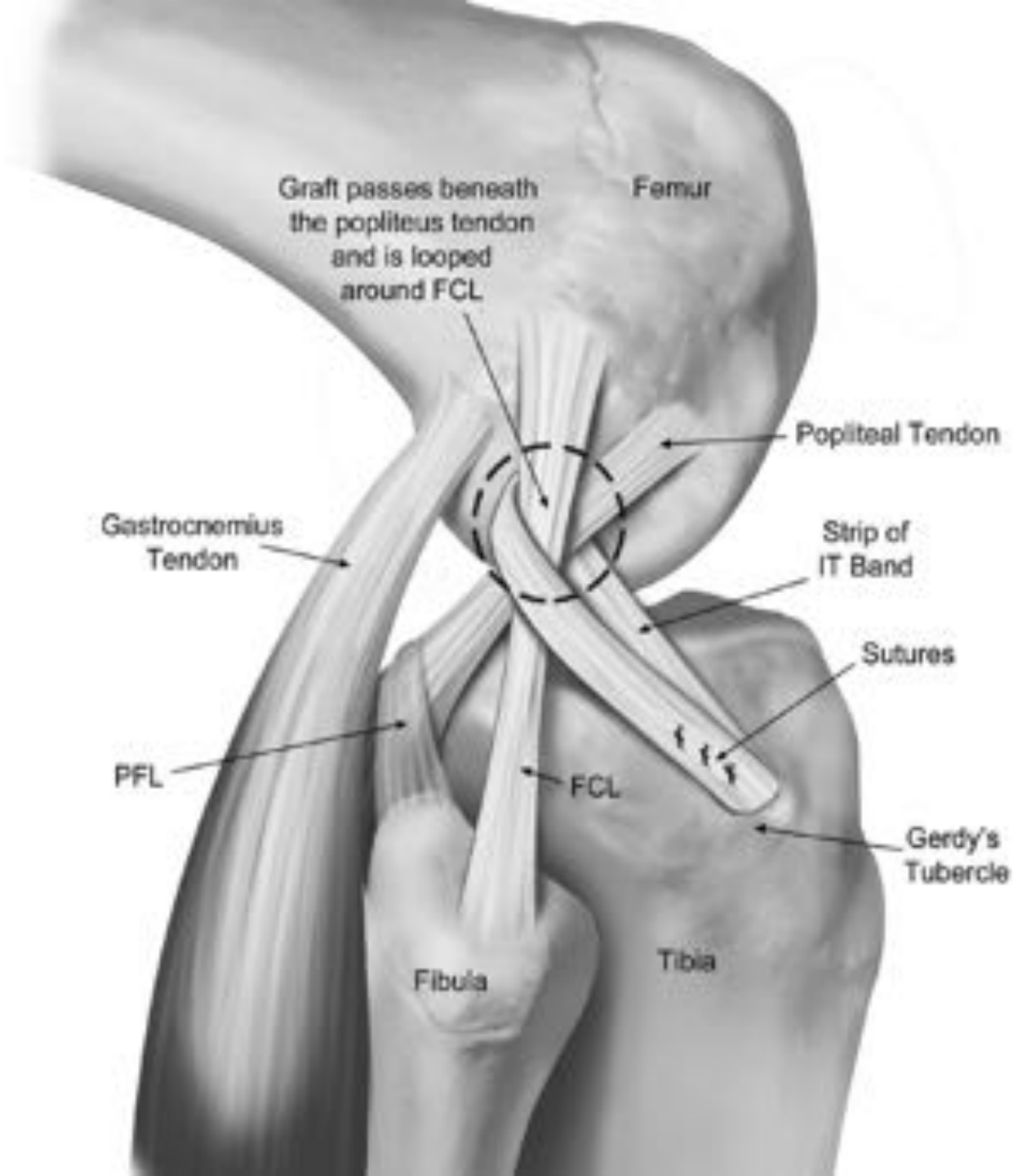
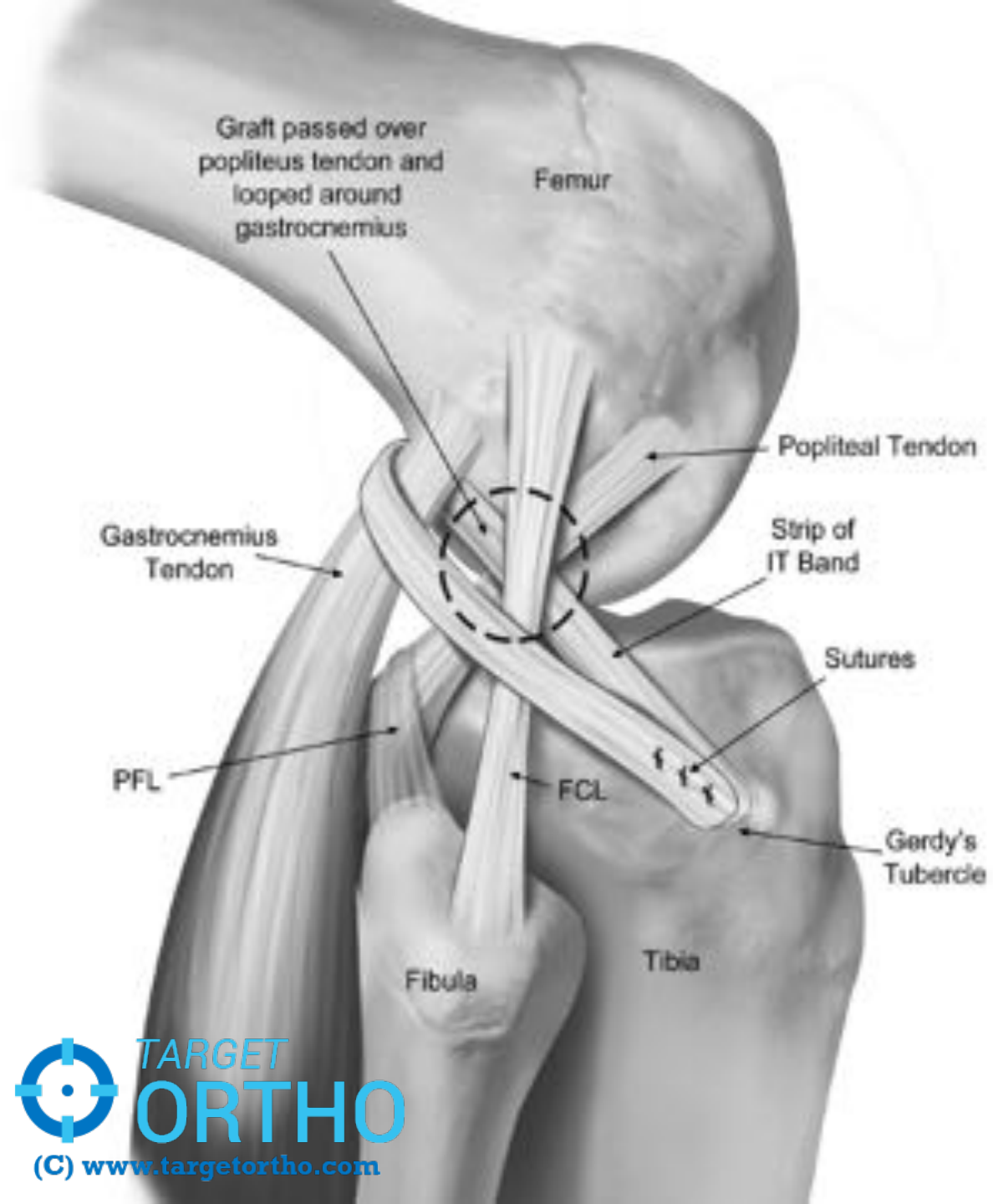


CONCEPT OF ALL (*ANTERO LATERAL LIGAMENT*)









HEALING AUGUMENTATION

ROLE OF PRP

- There was slightly less tunnel widening in PRP group, however, there was no noticeable difference in the clinical outcome of PRP versus non-PRP groups. Radice, et al.
- With the use of PRPG (PRP gel), a complete homogeneity of the ACL graft can be seen earlier on MRI (in 179 days) compared to the non-PRPG group (in 369 days). Thus, there was a reduction of the timing of 48% with the use of PRPG in the incorporation of the graft.
- So far, most published studies have not been able to show any significant role of PRP in the acceleration of healing of soft tissue graft in bone tunnel in ACLR, while only a few studies have shown its beneficial role in the acceleration of healing.

SYNTHETIC DEVICES

- Gore-tex: PTFE
- LADs: Polypropylene/ PE
- Leids-Keio Artificial Ligament: Polyester mesh
(Fujikawa and Seedhom)
- LARS (Ligament Advanced Reinforcement System:
Polyethylene Tetrappthalate (PET)



COMPLICATIONS

four BROAD CATEGORIES

- ❑ Infection (Intra operative graft contamination)
- ❑ Recurrent instability
- ❑ Decreased ROM
- ❑ Extensor mechanism dysfunction

Molina et al

4% chlorhexidine
Double antibiotic solution
(neomycin and Polymyxin B)

Sobel et al

4% chlorhexidine gluconate
x 30 min

FAILURE ??

RECURRENT INSTABILITY

Vertically placed tunnels

Failure to address associated ligament injuries [15 %]

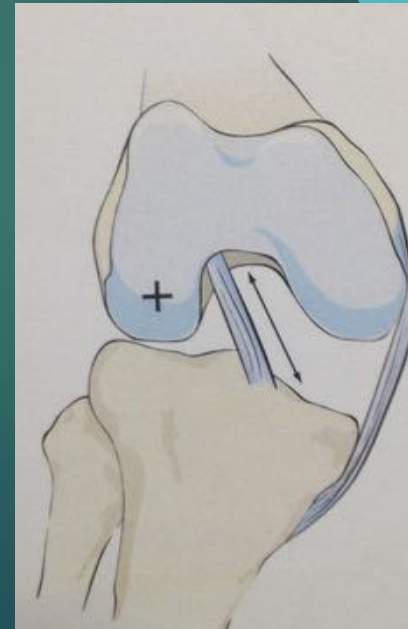
Tensioning/ fixation related issues

Re-ruptures

Fresh traumatic injury

Limb mal-alignment

Graft impingement



FAILURE ??

DECREASED ROM

Cyclops

CAPTURED KNEE - An anteriorly placed femoral tunnel shortens effective graft length and limits ROM

NUTCRACKER KNEE - An anteriorly placed tibial tunnel limits extension with graft impinging on notch

Arthrofibrosis [2-35%]

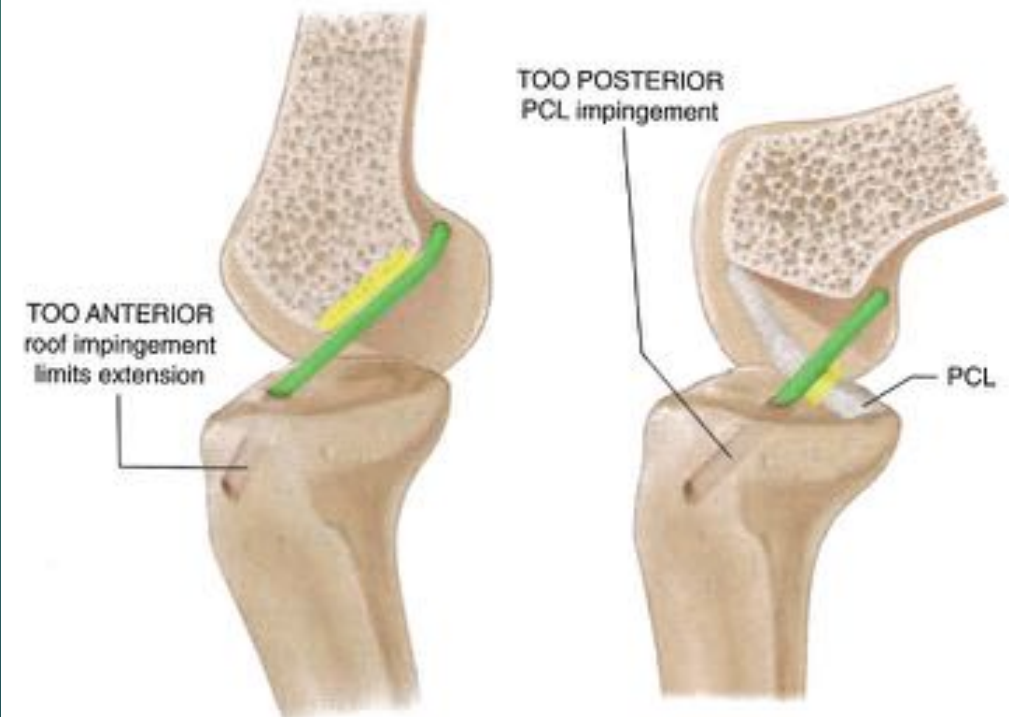
Loss of $> 10^\circ$ extension, $> 25^\circ$ flexion, Patellar mobility

CRPS

Poor patient compliance

Prolonged immobilization

Tibial Tunnel Malposition



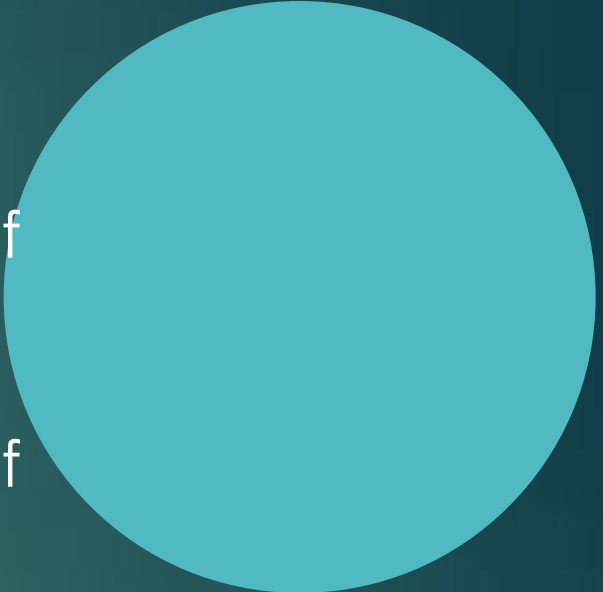
REHABILITATION

- ❖ Pre-op rehabilitation – preserve Q strength and knee ROM
- ❖ Post-op rehabilitation
 - Acute phase - restore ROM ,maintain Q strength, reduce inflammation (0-3 wks.)
 - Recovery phase - improve lower limb muscle strength and functional stability (3-6 wks.)
 - Functional phase - return to previous level of activity and reduce risk of re-injury (6+ wks.)

Early open chain isotonic QUADRICEPS NOT to be allowed !



Q. Which of the following is not a criteria for return to play for a professional athlete

- A. Time since surgery > 8 months
 - B. Iso-kinetic quadriceps strength > 85% of contralateral
 - C. Vertical jump test → no dynamic valgus
 - D. One leg hop test strength > 75% of contralateral
- 

RETURN TO PLAY !!!

- Isokinetic muscle strength > 85% of contralateral
- One leg hop test > 85% of contralateral
- Drop vertical jump → no dynamic valgus
- Negative Lachman and Pivot < grade I
- ROM comparable to contralateral
- No knee pain and effusion
- Time since surgery > 8-12 months



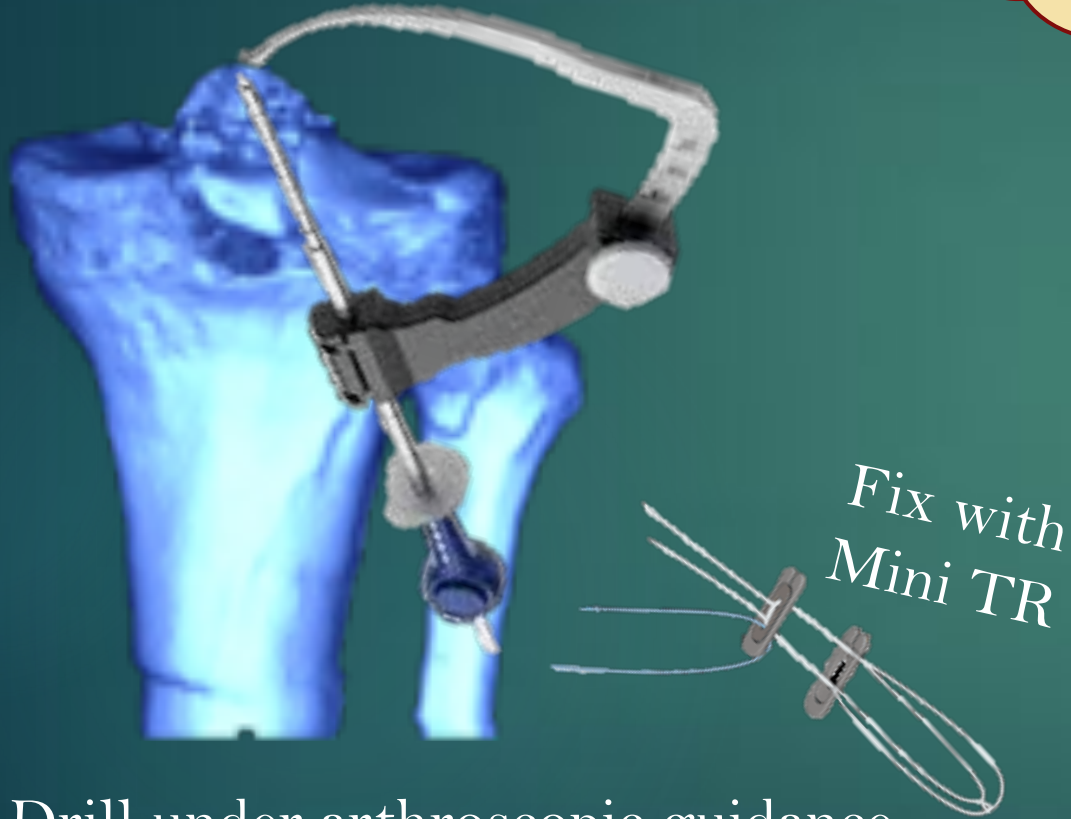


SURGICAL TECHNIQUE

Avg. Surgical time
22.35 min



Final outside picture



Drill under arthroscopic guidance
While using Jig for indirect reduction



marks and
nt on the
lateral
's ridge,
articular car-
D-CT bone
tion of native
'area) and
CL footprint
ding to these

