

# ACL recovery based on therapeutic exercises principles



# Topics



Anatomy of the  
knee joint



General ACL  
biomechanics &  
mechanism of  
injury

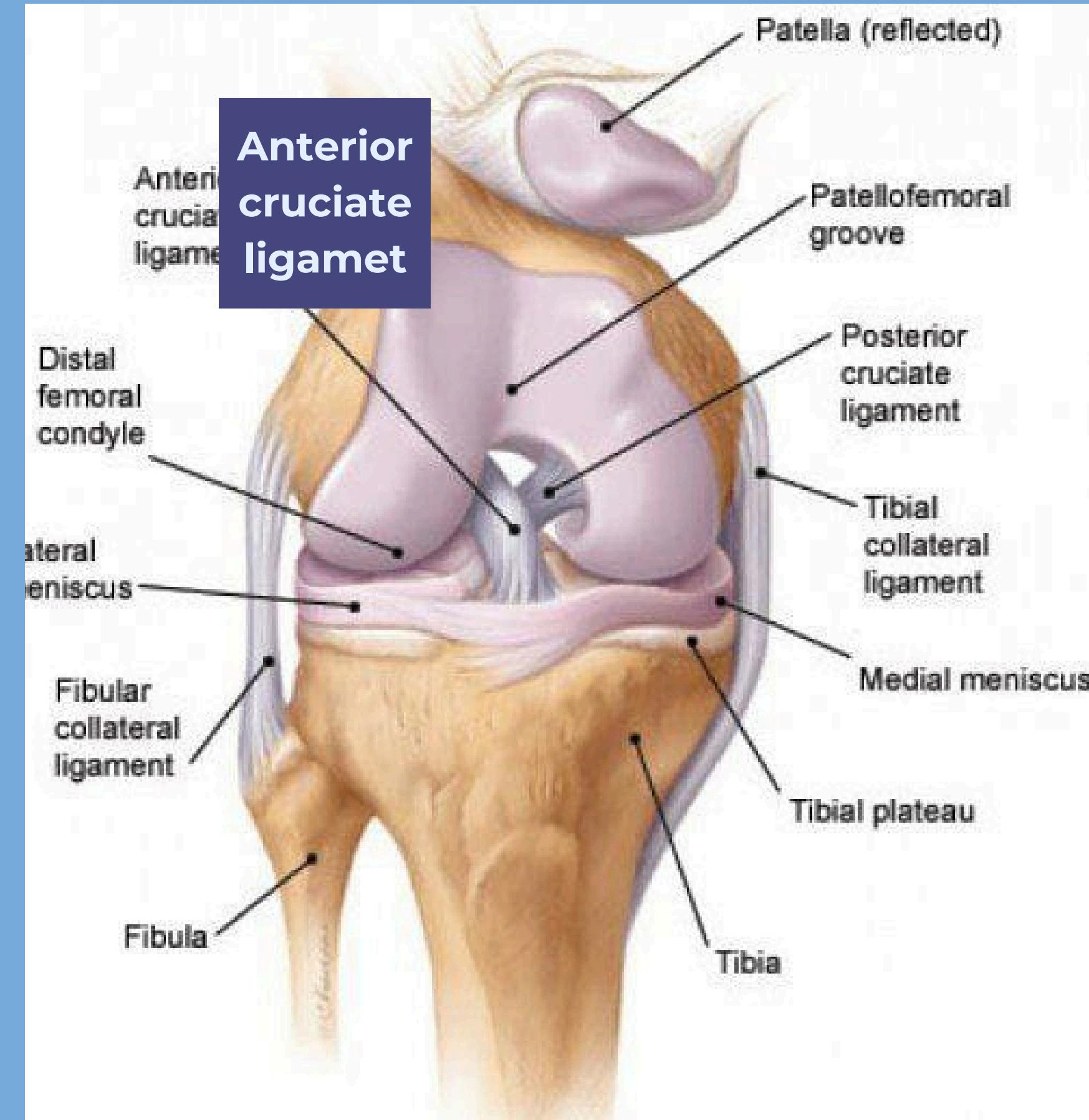


Grades of ACL  
tears



Electrotherapy

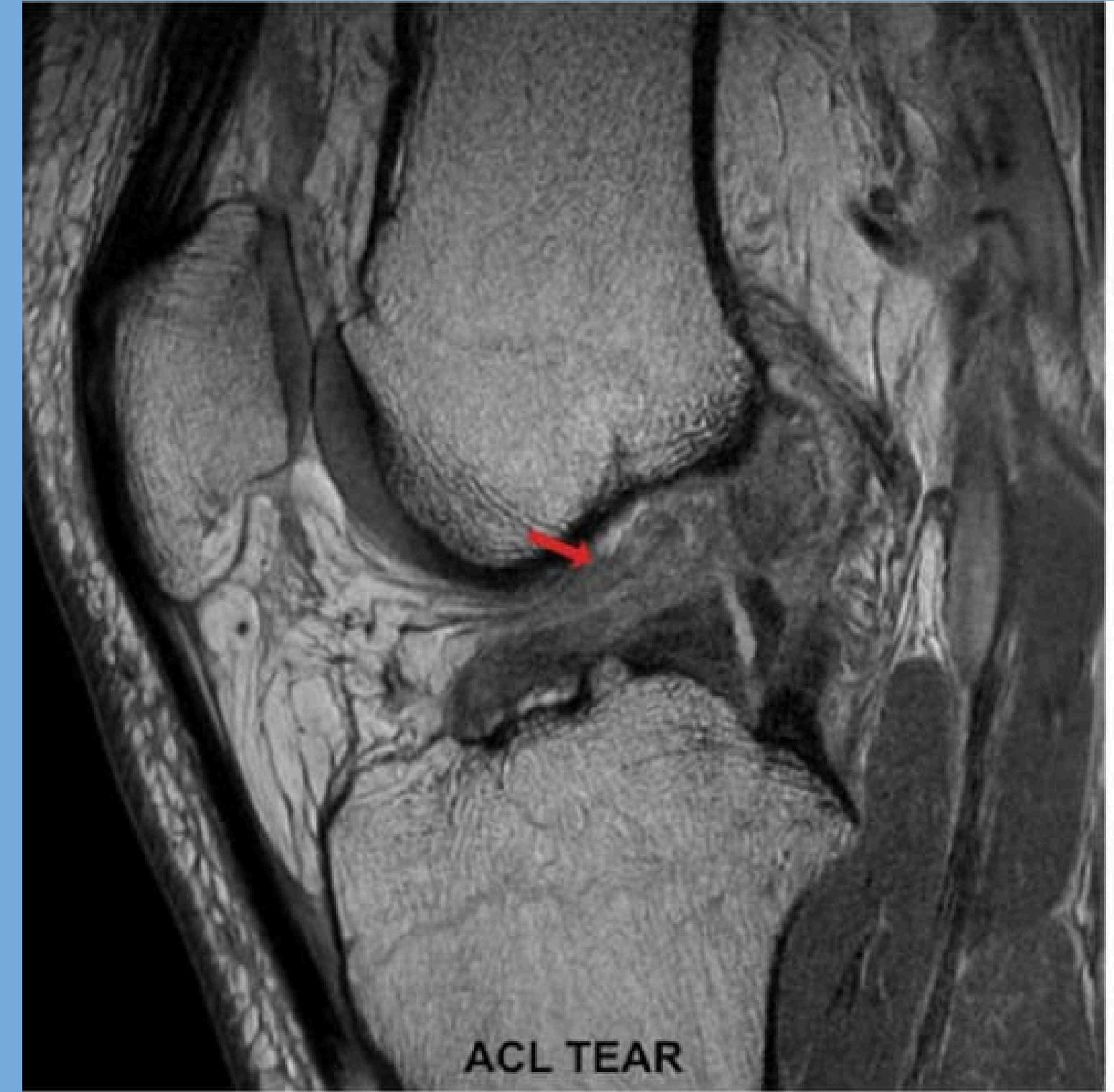
# KNEE JOINT ANATOMY



# NORMAL KNEE JOINT



# KNEE JOINT WITH ACL TEAR



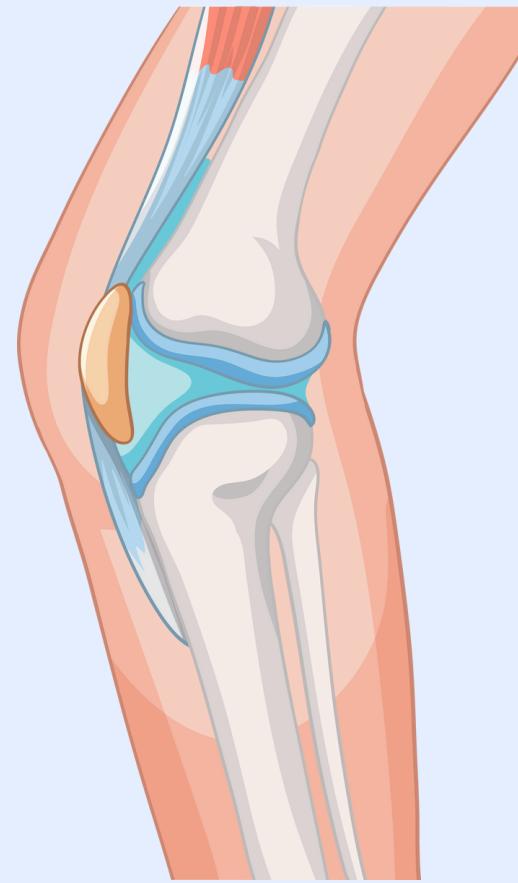
# KNEE JOINT

## Forces acting on the knee joint

- **Compression forces:** caused by body weight and movement.
- **Shear forces:** caused by a rapid change in direction.
- **Tensile forces:** stretch ligaments during movement or injury.

## Factors affecting knee mechanics

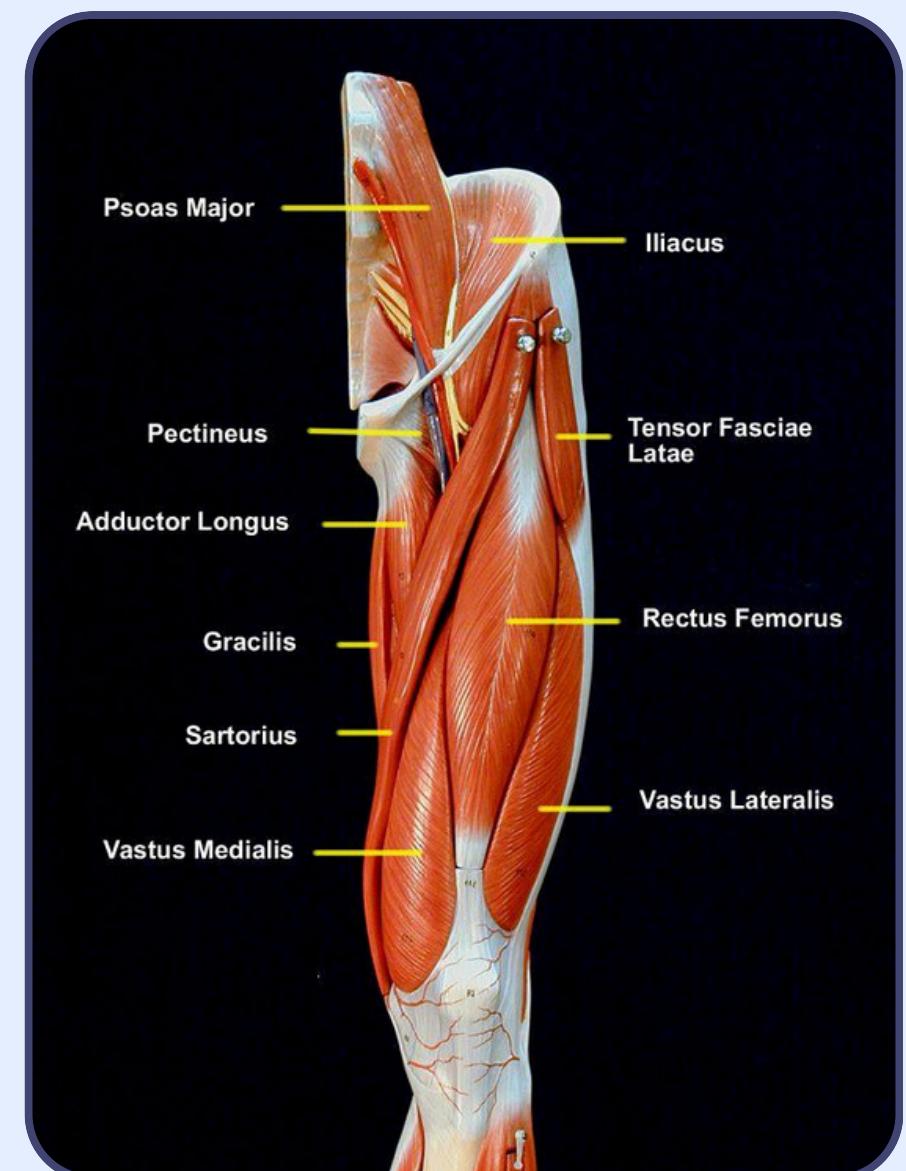
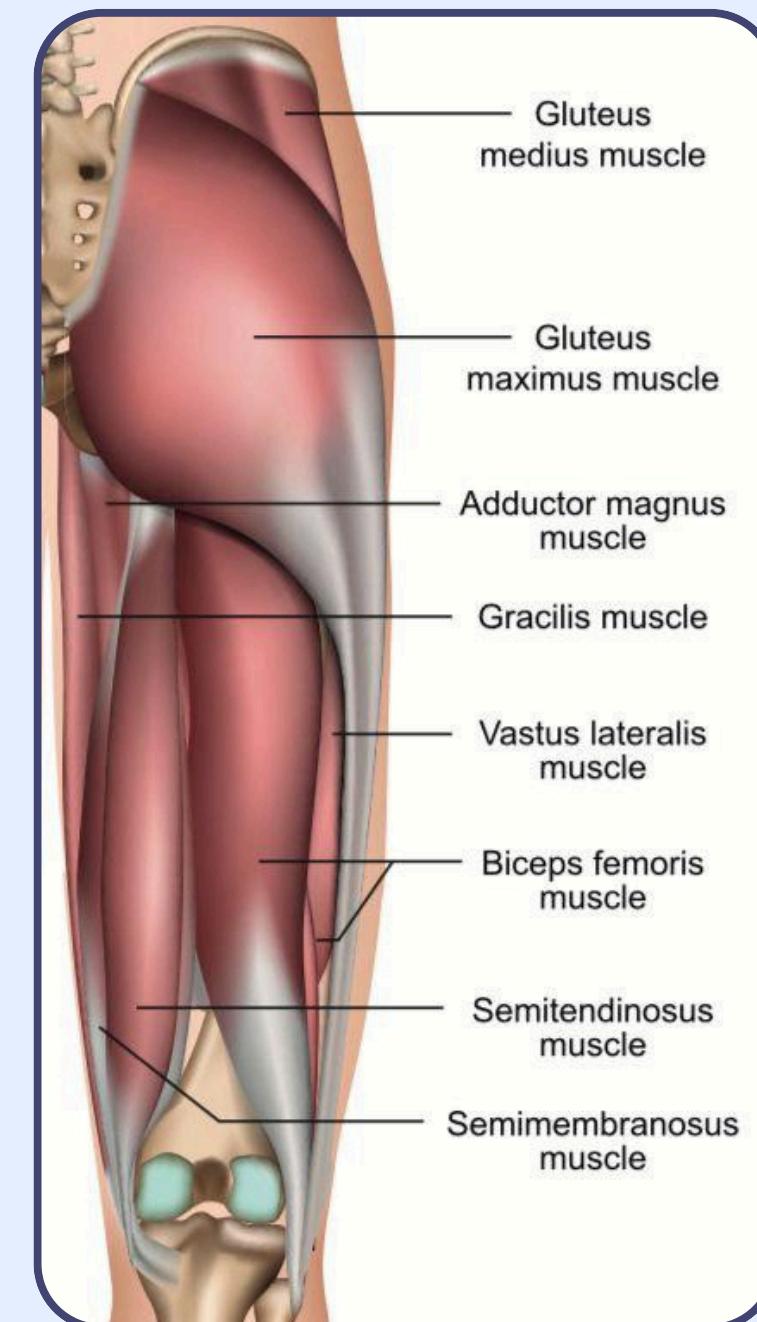
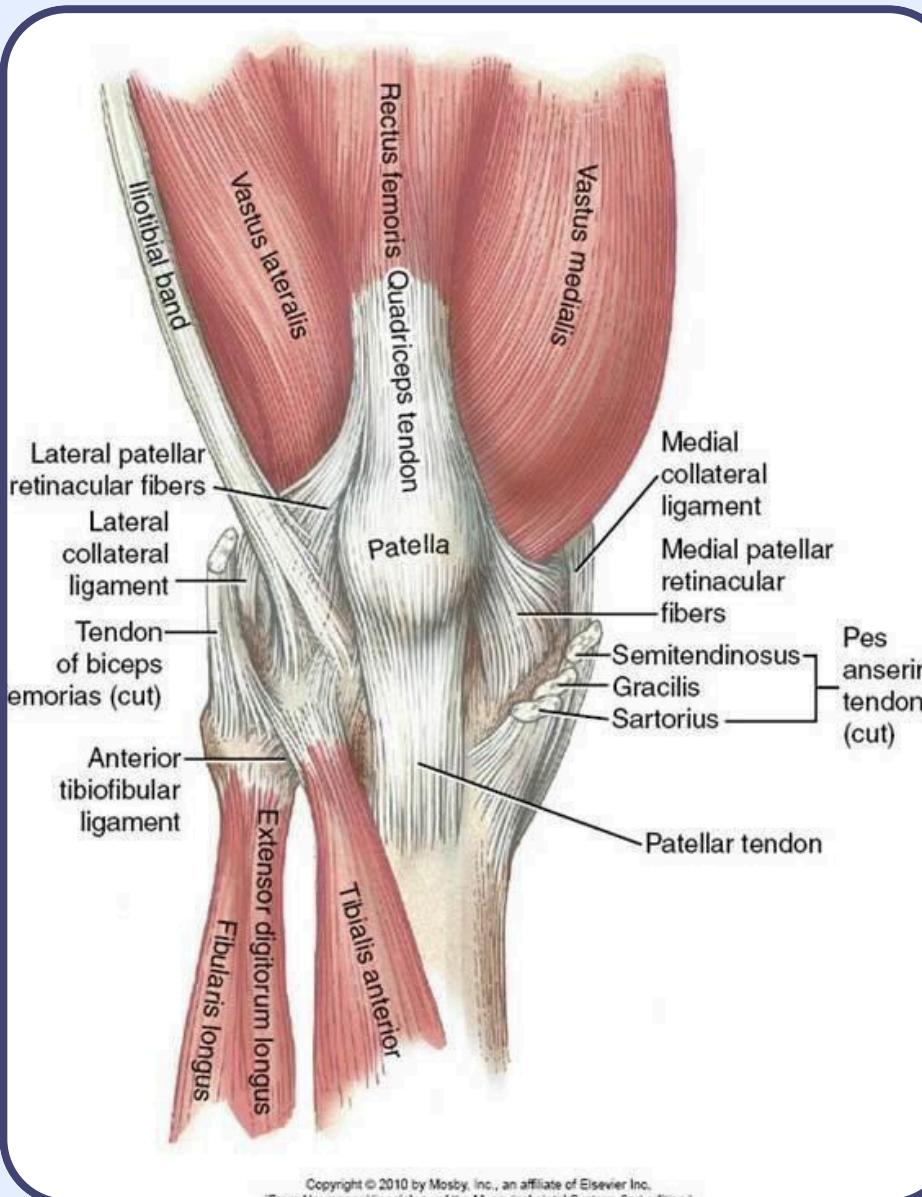
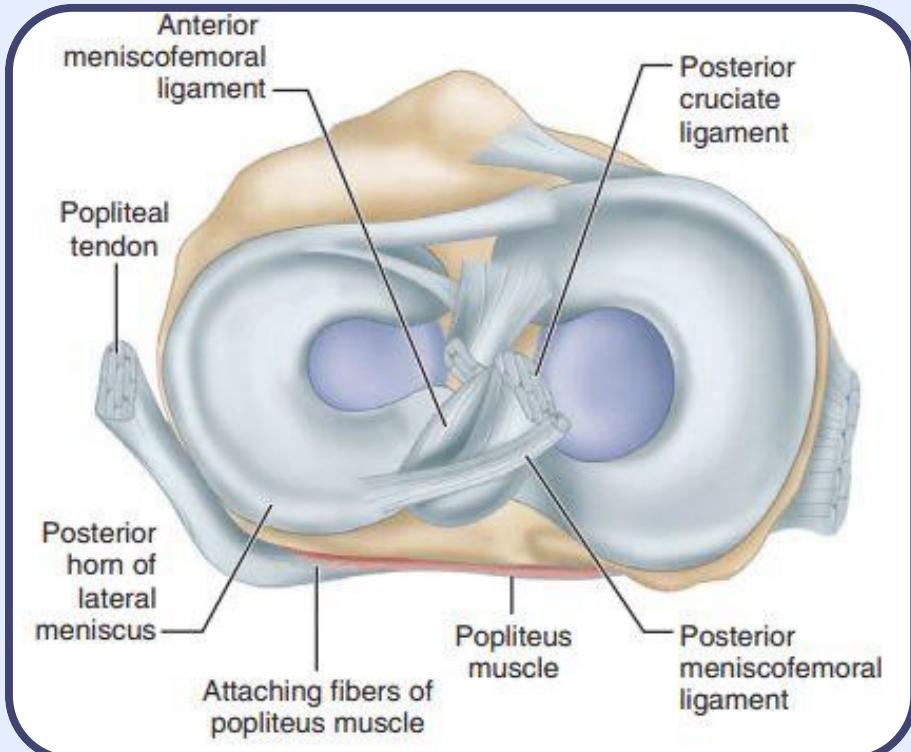
- **Q-angle:** Excessive Q angle can lead to problems such as patella pain.
- **Foot position:** Such as varus or flat feet, affects knee alignment.
- **Excess weight:** Increases stress on the joint and increases the risk of cartilage wear.



# Movement mechanics

- While walking or running, the knee joint acts as a lever joint to improve movement efficiency.
- The patella acts as a cushion, improving the angle of tension of the quadriceps muscle, increasing its ability to generate force

## Muscles



# **ACL functions in biomechanics:**

- **Preventing the tibia from sliding forward under the femur:** this is its primary function during movements involving deceleration or sudden stops.
- **Reducing excessive internal tibia rotation:** Prevents excessive twisting of the knee, especially during rapid rotational movements such as changing direction.
- **Anterior-posterior stability:** Contributes to maintaining normal bone alignment during movement.
- Reducing anterior shear forces caused by quadriceps contraction During landing from a jump, the quadriceps contract forcefully to stabilize the joint. This generates anterior shear forces on the tibia. The ACL absorbs these forces and prevents excessive movement.
- **The ACL interacts with:** Posterior cruciate ligament (PCL) Contralateral ligaments (MCL C LCL) Muscles such as the quadriceps and hamstrings The hamstrings, in particular, help support the function of the ACL by resisting anterior sliding.

# Biomechanics during natural movement

- **In an extended knee:** The ACL is subjected to the greatest stress.
- **In a partially flexed knee (approximately 30-60 degrees of flexion):**  
The stress is less, and this is the optimal position for safety.
- **During running, walking, and jumping:**  
The ACL works to balance the strength of the quadriceps and hamstring muscles to maintain joint stability.
- **Loading on the ACL:**  
The ACL is most commonly affected by : Anterior shear forces , Rotational forces , Excessive loading during a jump or improper landing

# ACL injury:

- Injuries to the ACL are relatively common knee injuries among athletes , which is commonly seen in football, basketball and soccer. The amount of pain experienced at the time of the injury is somewhat variable but can be quite severe.



What are the symptoms of an ACL injury or tear?



Mechanisms of injury



Risk factors



Biomechanics of Injury

<b>muscles involved</b>	<b>Position of safety</b>	<b>body position</b>	<b>body position</b>	<b>Point of 'no return'</b>	<b>muscles involved</b>
back		normal lordosis	forward flexed, rotated opposite side		
hips	extensors abductors gluteals	flexed neutral abduction adduction, neutral rotation	adduction internal rotation		flexors adductors iliopsoas
knee	flexors hamstrings	flexed	less flexed, valgus		extensors quadriceps
tibial rotation	plantar flexors	neutral	internal or external		dorsiflexors
landing pattern	gastrocnemius posterior tibialis	both feet in control balanced	one foot out of control unbalanced		peroneals tibialis anterior

The diagram illustrates the lower limb in two main states: 'Position of safety' and 'Point of "no return"'. In the 'Position of safety', the limb is shown in a balanced, upright stance with both feet on the ground. The hip is in normal lordosis, the knee is flexed, and the tibia is in neutral rotation. The body is in a balanced position. In the 'Point of "no return"', the limb is shown in an unbalanced, unstable position. The hip is forward flexed and rotated to the opposite side. The knee is less flexed and in valgus. The tibia is in internal or external rotation, indicated by red arrows. The body is in an unbalanced, forward flexed position.

# What are the symptoms of an ACL injury or tear?

A “pop” in the knee at the time of injury

Swelling of the knee

Inability to bear weight on leg (though some have little or no pain)

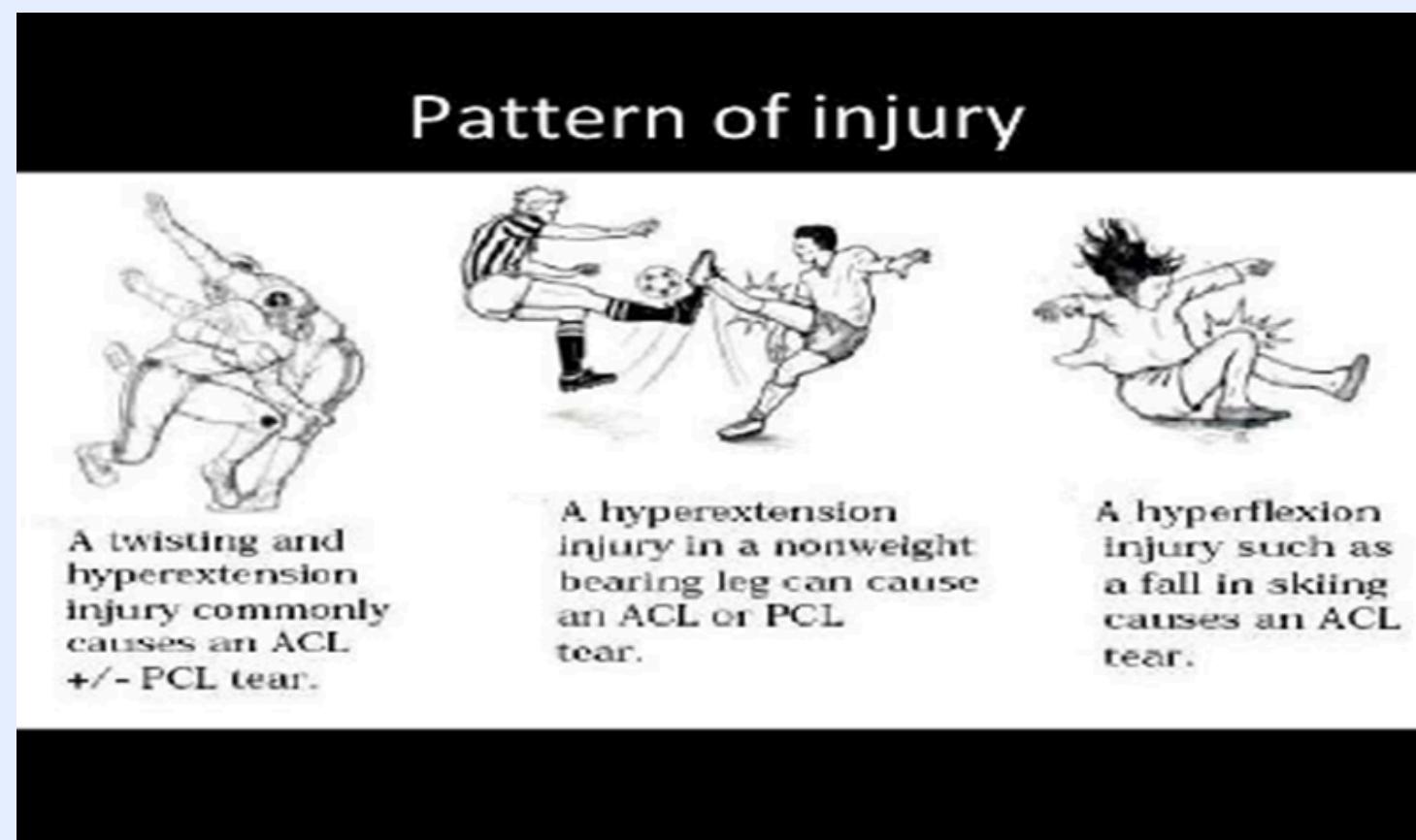
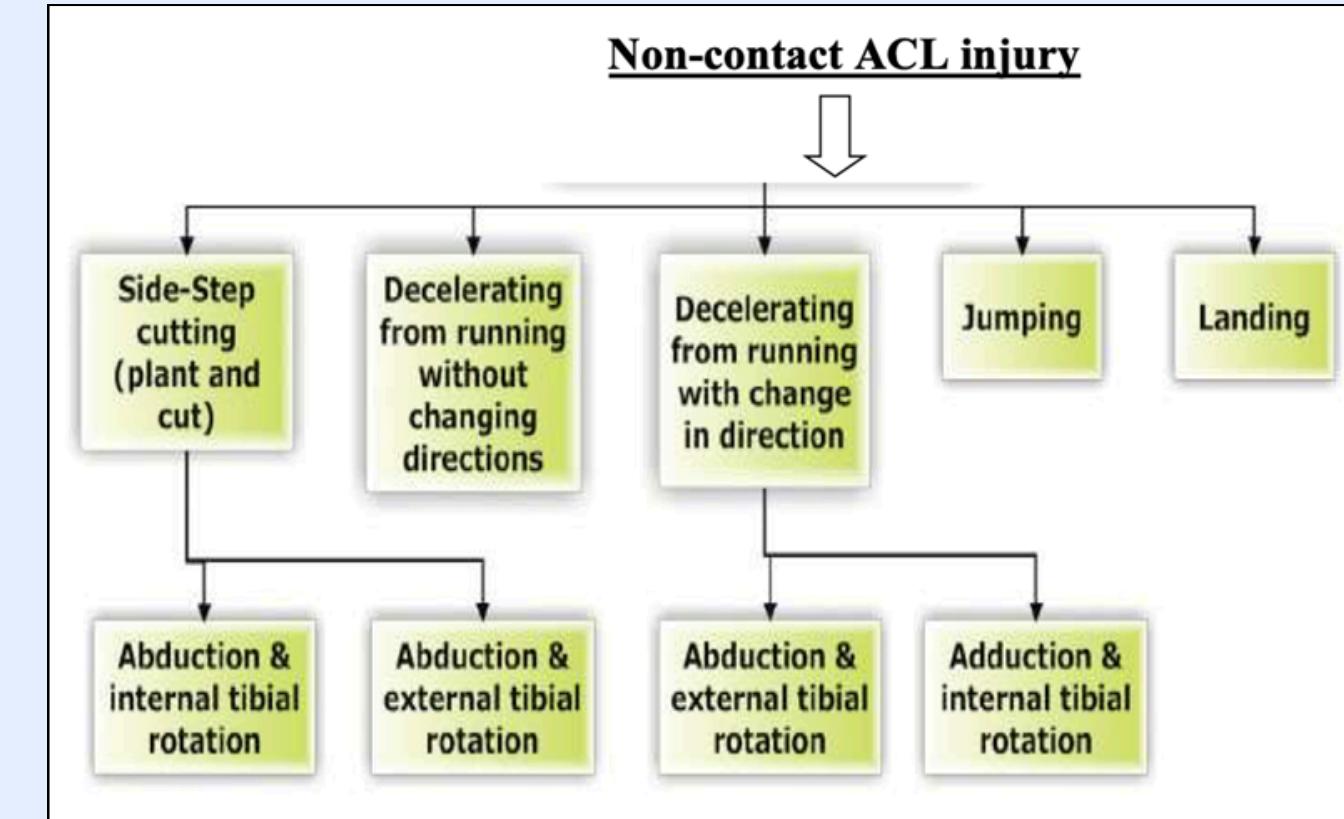
Instability of the knee

# Mechanisms of injury

Three major types of ACL injuries are described:

- Direct Contact: 30% of the cases
- Indirect Contact.
- Non-Contact: 70% of the cases: by doing a wrong movement

A cut-and-plant movement is the typical mechanism that causes the ACL to tear



# Risk factors

## External Risk Factors

### (Footwear and playing surface)

Increasing the friction between the sports shoe and playing surface may improve traction and sports performance, it also has the potential to increase the risk of injury to the ACL.

## Internal Risk Factors

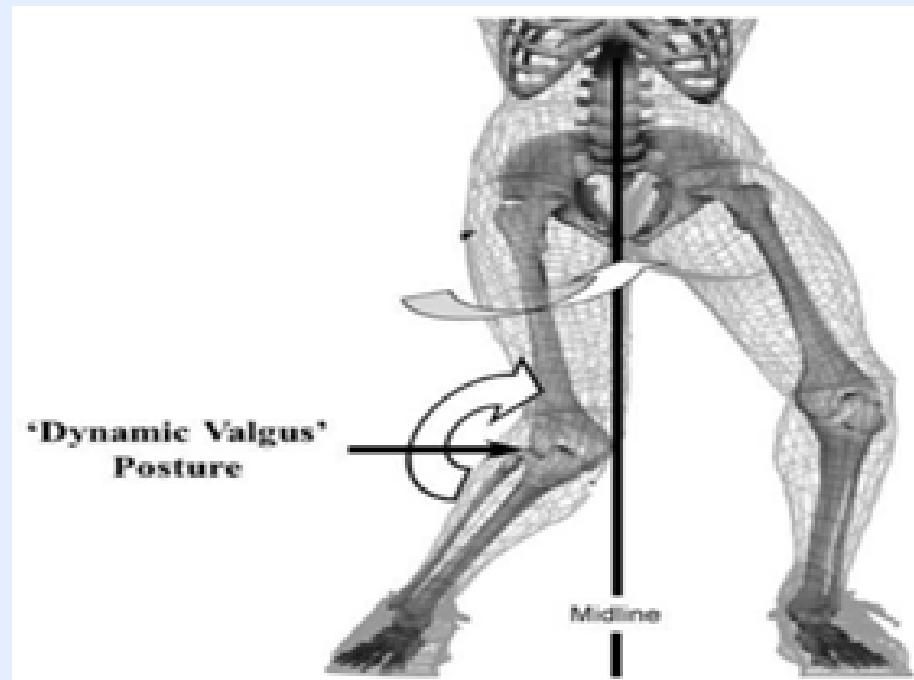
### (Anatomical factors)

Abnormal posture and lower extremity alignment may predispose an individual to ACL injury

Risk factors for ACL injuries include environmental factors ,and anatomical factors

# Biomechanics of Injury

The risk of ACL injury increase if there are more than one of these movements happened; knee joint twisted, bent backward, or side to side stress.



- The typical ACL injury occurs with the knee externally rotated and in 10-30° of flexion (shallow knee flexion)

After the ACL is torn, the primary restraint to anterior translation of the tibia is gone.

# **WHEN THE LEGAMENT IS DAMAGED THERE IS A PARTIAL OR COMPLETE TEAR OF TISSUE WHICH DETERMINES THE GRADE OF INJURY**

**Grade 1**  
ACL tear

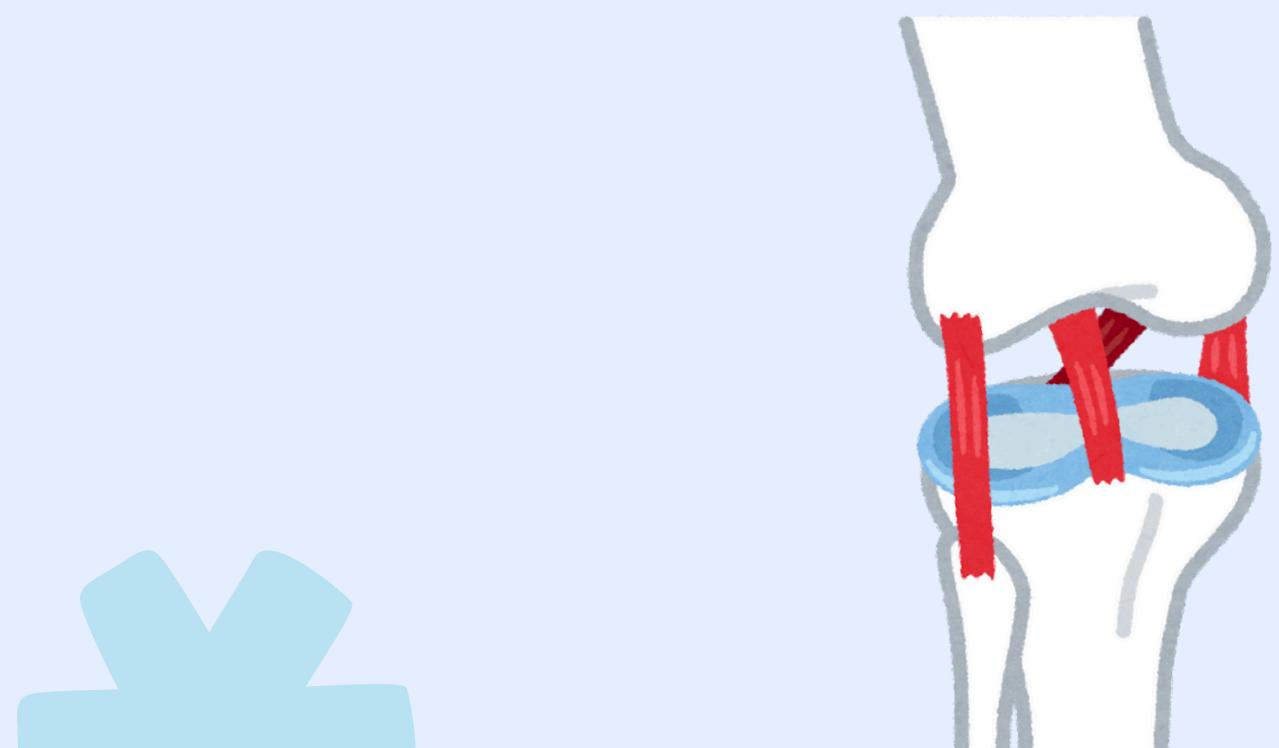
**Grade 2**  
ACL tear

**Grade 3**  
ACL tear

- P**  **PROTECTION**  
Avoid activities and movements that increase pain during the first few days after injury.
- E**  **ELEVATION**  
Elevate the injured limb higher than the heart as often as possible.
- A**  **AVOID ANTI-INFLAMMATORIES**  
Avoid taking anti-inflammatory medications as they reduce tissue healing. Avoid icing.
- C**  **COMPRESSION**  
Use elastic bandage or taping to reduce swelling.
- E**  **EDUCATION**  
Your body knows best. Avoid unnecessary passive treatments and medical investigations and let nature play its role.
- &**
- L**  **LOAD**  
Let pain guide your gradual return to normal activities. Your body will tell you when it's safe to increase load.
- O**  **OPTIMISM**  
Condition your brain for optimal recovery by being confident and positive.
- V**  **VASCULARISATION**  
Choose pain-free cardiovascular activities to increase blood flow to repairing tissues.
- E**  **EXERCISE**  
Restore mobility, strength and proprioception by adopting an active approach to recovery.



# Grade 1 & 2 ACL tear

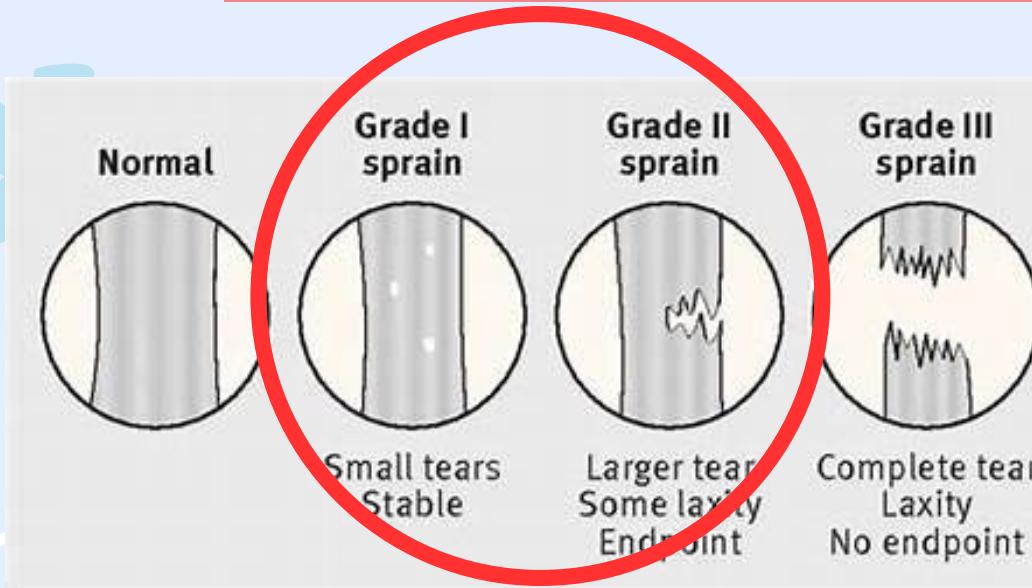


# Grade 1 & 2 PROGRAM

## Grade 1 (Mild)

1. Isometric “static” exercises (quadriceps and hamstring sets) (gluteal sets)
2. passive and active assisted range of motion exercises
3. Soft tissue massage
4. Joint mobilization
5. Balance and Proprioception
6. Gait training with assistive devices
7. Use of PEACE and LOVE and Electrotherapy modalities (eg., Ultrasound, TENS)

## Grade 2 (Moderate)



1. Eccentric strengthening exercises (muscle lengthening under tension)
2. Closed kinetic chain exercises (eg; Mini squats) “Co contraction isometric exercise” for enhancing knee stability
3. Open kinetic chain knee flexion exercises (hamstring focused) “prone knee flexion”
4. Plyometric exercises (jumping and explosive movements) to prepare for return to dynamic activities
5. Balance and Proprioception training (eg; single leg stand on stable surface then on unstable surface)
6. Cardiovascular (stationary cycling with low resistance)
7. Electrotherapy modalities (eg; NMES, TENS and Vibration therapy)

# Continuous Passive Motion (CPM) Machines after ACL Surgery

## Purpose

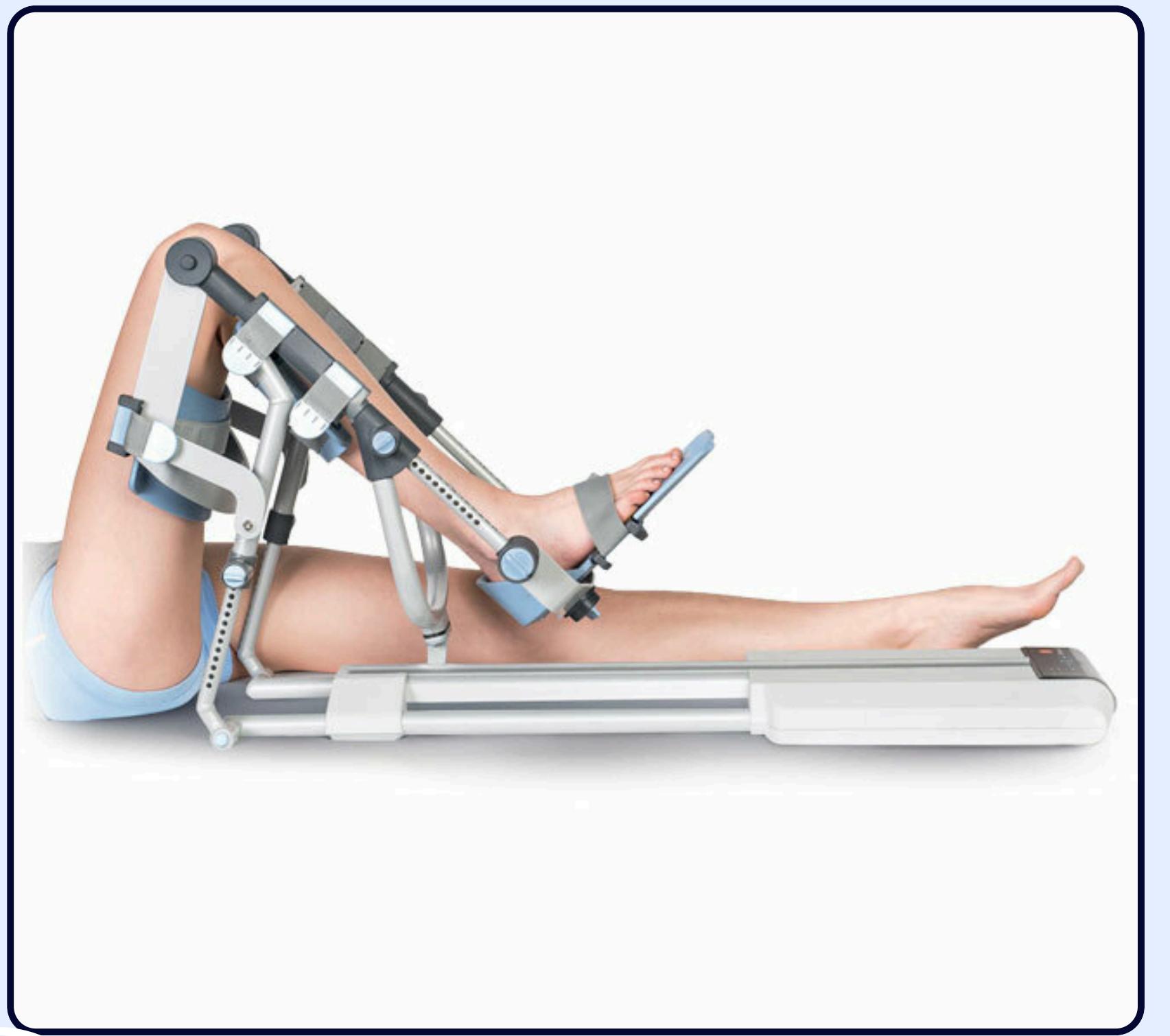
Used early after ACL surgery to gently and continuously move the knee joint.

## Current Perspective

- New research questions the long-term benefits.
- Some studies show little difference compared to rehab without CPM.
- Modern rehab focuses more on early active exercises.
  - CPM is now used selectively, typically short-term, and under medical advice.

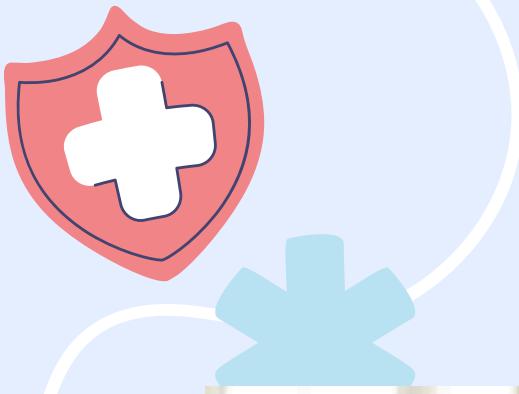
## Potential Benefits

- Reduces pain and swelling
- Improves range of motion
- Decreases stiffness and scar tissue risk
- Enhances tissue healing
  - Helps prevent blood clot
- Provides psychological comfort





# Grade 3 ACL tear



# Pre-operative phase for ACL surgery:

## Goals

- Decrease Pain and swelling .
- Maximize Knee ROM (Flexion and Extension).
- Improve Muscular Strength and proprioception
- Normalize Gait.



## Program

### ROM Exercises:

- Passive knee flexion and extension
- knee flexion and extension (Active and Active Assisted Rom)
- Quadriceps set
- Hamstring Set

### Balance and Proprioception exercises:

- Single leg stance
- Double leg stance (with progression and modifications )

### Muscular strength Exercises:

- stationary bicycle
- Swimming
- Low impact exercise such as treadmill, and leg press machine.

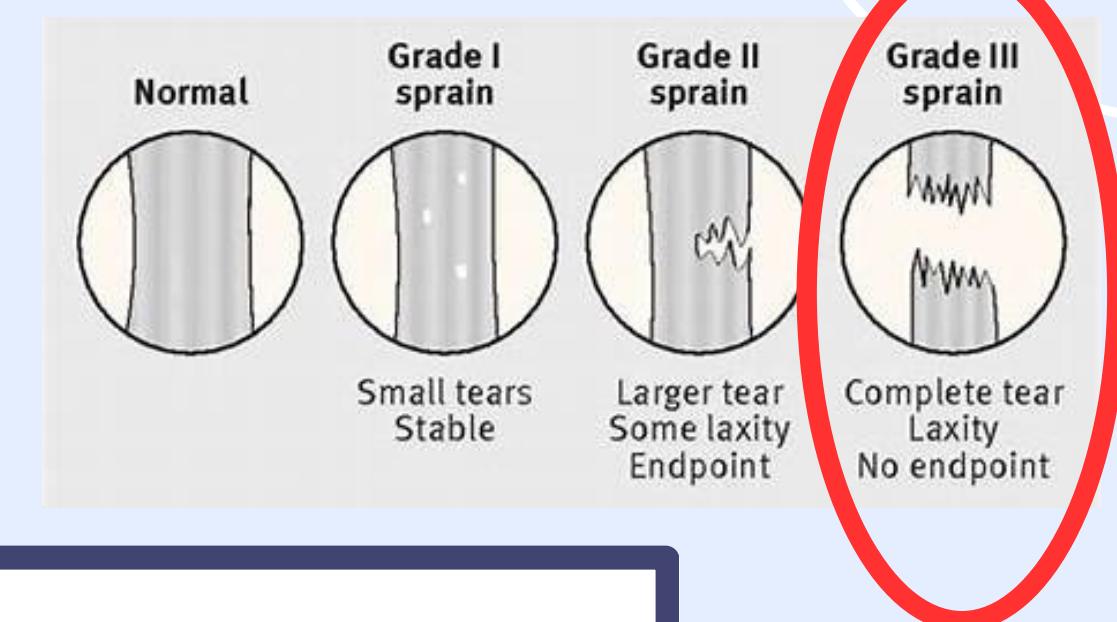
# Grade 3 Post Acl surgery (3 phases)

## Recovery duration : 9-12 months

Phase 1

Goals

- ROM Flexion/extension
- Edema/swelling reduction
- Pain reduction
- Gait training - removal of crutches  
two crutches ---->>> one crutch ---->>> no crutches
- Anatomical adaptation for muscles (noticeable muscle borders )



# Phase 1

## Program

Volume : everyday multiple times a day Intensity : Low

- Peace and Love:
- Gentle passive and active-assisted knee extension and flexion exercises.
- Use crutches
- Scar tissue massage
- Retrograde Massage
- Patellar Mobilizations
- Physiologic Joint Mobilizations

# Phase

## 1 PROM

The goal is full extension and 70 degrees of flexion by the end of the first week then progress gradually till 90-100 knee flexion .

(Heel props)

(Manual extension by the therapist)

(Knee flexion from supine heel is on a sliding smooth surface )  
passive or self assisted with straps

## 2 Edema/swelling reduction

There is no evidence that icing and elevation is useful after Week 1.

(ankle pumps with elevated leg )

## 3 Isometric exercises / OKC With assistance

( Quadriceps sets)

Once terminal knee extension is obtained start preforming

( SINGLE LEG raises )

(Supine ankle planter flexion)

(side lying hip abduction )

## 4 Gait training

Partial Weight Bearing

(Weight shifts side to side / front to back)

# Grade 3 Post Acl surgery (3 phases)

## Recovery duration : 9-12 months

### Phase 2

#### Goals

In this phase we decrease the training volume to 3-4 times a week as we slowly shift our focus to strengthening.

- Strengthening quads/hams/glutes/calf
- Endurance
- Enhance neuromuscular control and joint stability
- Closed kinetic exercises
- Initial running
- Prepare for more advanced functional and sport-specific activities
- Continue using PEACE and LOVE if needed
- Manual therapy techniques
- Maintain knee extension and improve flexion

# Phase 2

## Program

### **Strengthening quads/hams/glutes/calf**

- (leg press with no weight to minimal weight 0 degree to 45 degree knee flexion)
- Starting eccentric quadriceps training (in CKC)
- (step downs)
- (wall sits)
- (Dl bridges )
- ( heel raises)
- (ankle dorsiflexion with light resistance TheraBand)
- ( hip abduction from side lying with TheraBand resistance according to patient tolerance ) progress to (lateral steps with TheraBand resistance)
- ( back extension) for glutes , hamstrings and back muscles
- (side plank)

# Phase 2

## Program

### Endurance

- (Strength exercises with high reps and low resistance)

### Balance

- Start proprioception and balance exercises gradually
- ( BOSU squats) minimal ROM HOLD at the end of the range
- (Single leg balance)
- (Single leg press with BAPS board) increased movement is decreased proprioception
- ( Lateral step ups and step downs with balance focus )
- ( Preforming squats while catching a ball or responding to verbal cues)
- (Reverse lunges )
- Perturbation Training

# Phase 2

## Progression and Criteria for Advancing

- No significant swelling or pain 
- Flexion and extension range of motion close to the uninjured side 
- Symmetrical strength and control during functional tasks 

# Phase 3

## Goals

### 1 Proprioception and neuromuscular training

program ↗

- progression : eyes closed or soft surface
- (Single leg press with BAPS board) increased movement is decreased proprioception
- For landing ( Step down drills )
- (Planks with leg lifts )
- ( Cable resisted rotations)
- (RDLs)
- (Palloff press in single leg stance)

### 2 Jumping

- improve landing control ( mini jumps and soft landings then progress )
- (box jumps)

### Criteria for running / jumping / cutting

- Full knee extension → done
- No swelling
- Adequate knee control → done
- No pain
- No joint line tenderness

### 3 Running

- Walk - jog progression
- 30 sec walk then 1 min jog and repeat
- ( Back pedaling exercises)
- ( Agility ladder forward , lateral , cutting)
- ( High knees , bounding , skips and triple extension exercises)
- Gradually build from 10-20 mins continuous jogging
- Sprints only after a good endurance jog
- Strides or tempo runs

# Phase 3

## Goals

4

### Footwork

- (Agility ladder forward , lateral , cutting) with progression “movement in all planes ”

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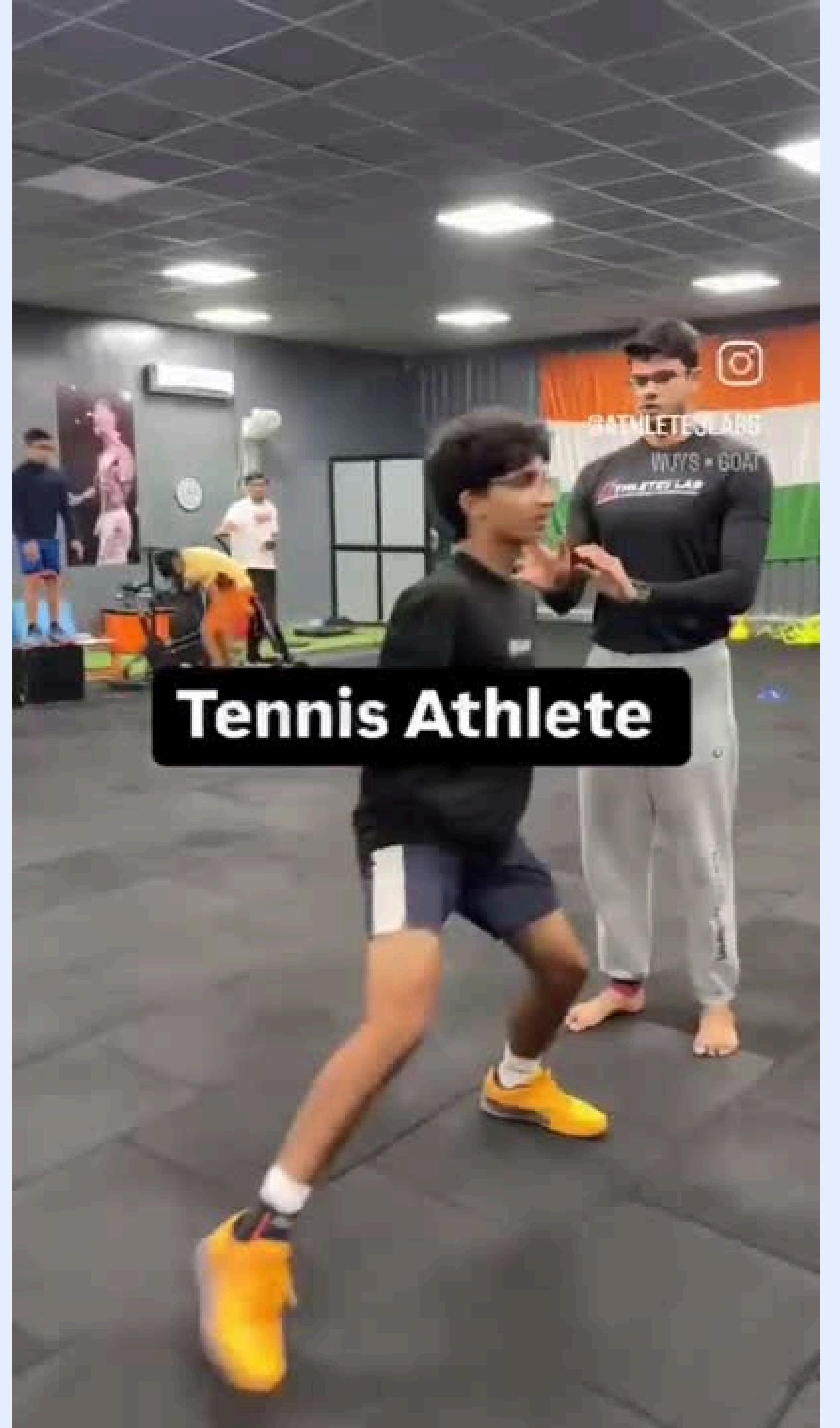
### Training the muscles to perform in the suitable action according to the patient's Sport he's returning to

- Work on sports specific strength , plyometrics , agility and foot work.
- progress from bilateral to unilateral drop jumps/ landing / deceleration
- (5-10-5 Agility drill) improving lateral movements
- (box jumps)
- (lunge push back)
- (Single leg depth jumps) improving landing and vertical movements

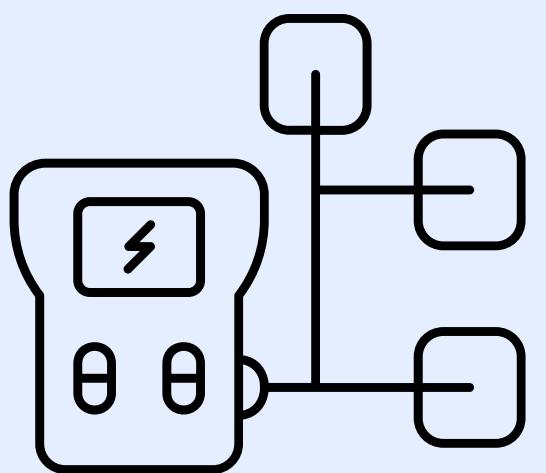




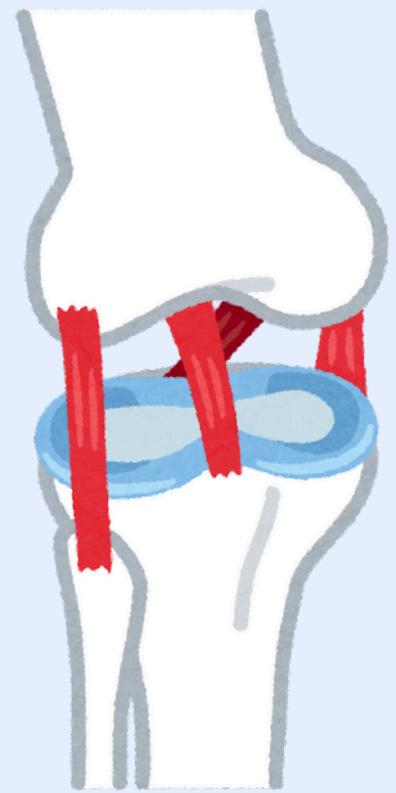
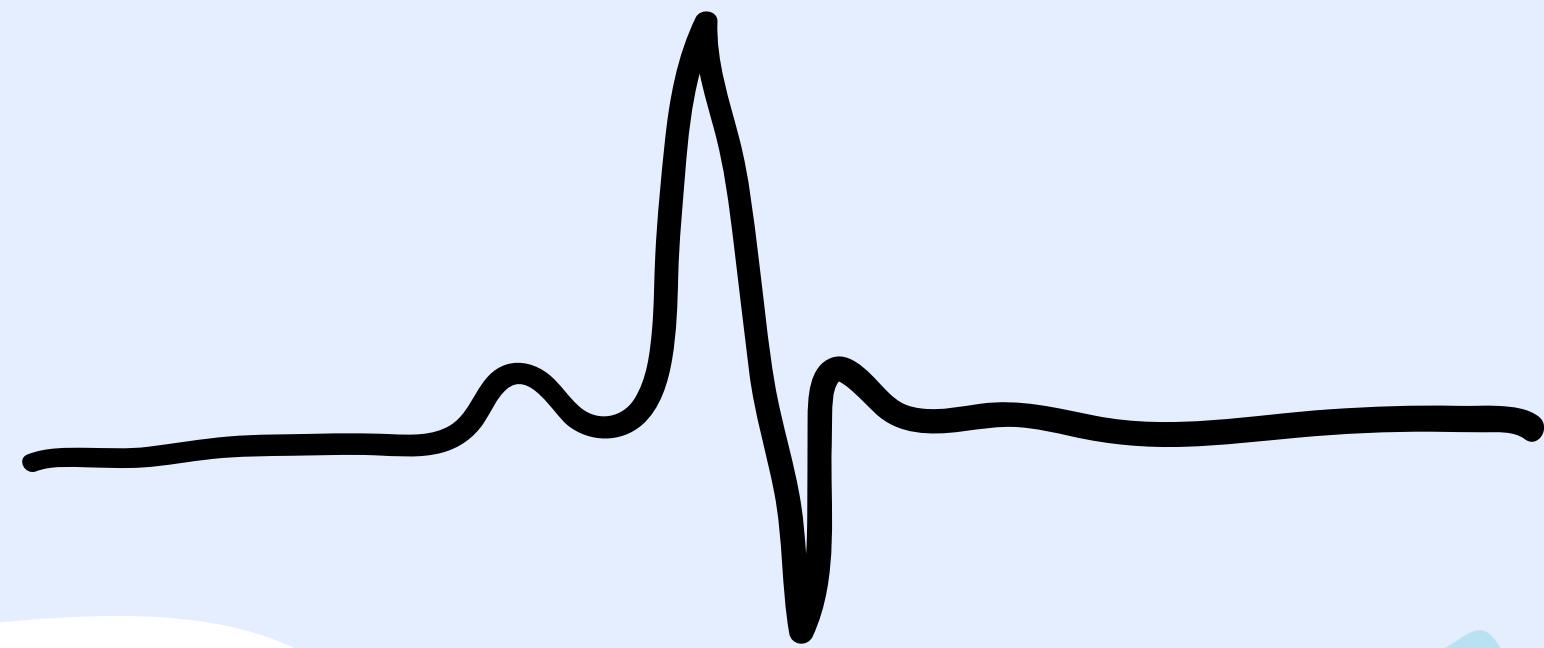
**2. DB 1ST STEP  
ACCELERATION**



Tennis Athlete



# Electrotherapy





# Swelling treatment

First, if the patient experiences swelling in the knee, we must treat the swelling before performing the surgery if needed , using high-voltage pulsed stimulation (HVPS) for edema control.



## Parameters

mode of stimulation

Continuous(The device delivers electrical pulses in a regular and continuous pattern, without interruption, channel switching, or rest periods.)

Polarity

negative (cathode) over the swollen area (helps repel negatively charged proteins in edema)

Frequency

120 pulses

duration of treatment

our 30-min treatment sessions (30-min treatment, 30-min rest cycle for 4 h) or a single, continuous180-min session to achieve the edema-suppressing effects

intensity

intensity of 90% visual motor contraction may be effective at curbing edema formation

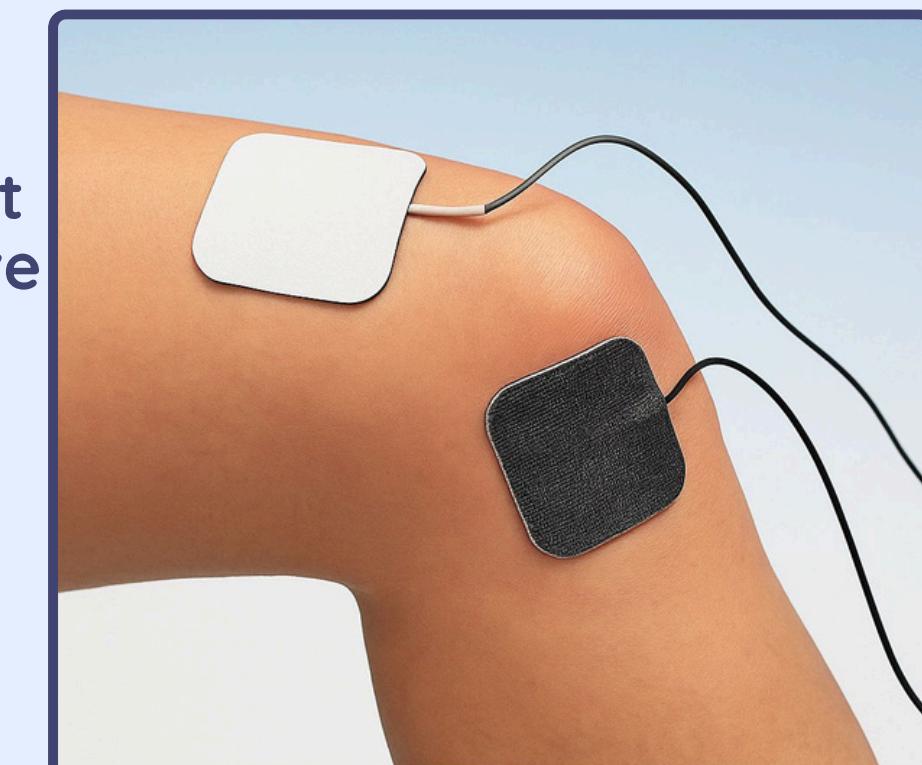
No. of treatments

1 session everyday

overall time treatment

from 5 to 14 days Depending on the patient's response to treatment.

Or 3 weeks if the swelling occurred after surgery.



Application of high-voltage pulsed galvanic (HVPG) current over the knee to reduce swelling (active electrode over swelling, dispersive electrode proximal)

# Grading

## GRADE(2)

If the patient has a grade 2 injury ,he either undergoes surgery or relies on physical therapy, depending on the case. In this case, we will assume that the patient will be treated with physical therapy only, using FES current.

It improves functional movements like squatting or walking by stimulating muscles that assist in motion. This is particularly useful for retraining neuromuscular pathways.

### FES PARAMETERS

**Target muscle :** Quadriceps (esp. Vastus medial oblique)

Hamstrings (occasionally)

**Frequency :** 35-50 Hz (sometimes up to 75 Hz for more torque)

**Pulse Duration:** 200-400 us

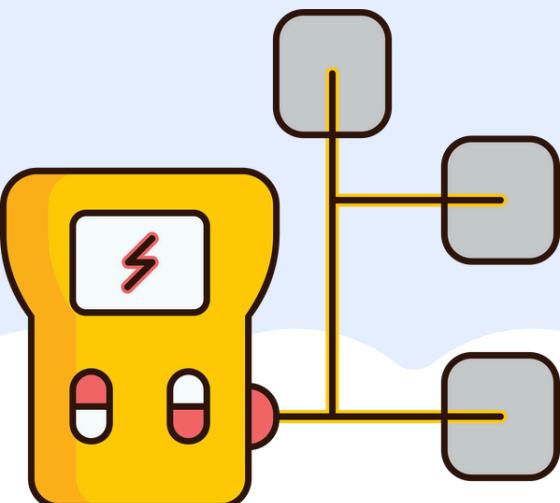
**Amplitude:** sufficient for visible, strong, but tolerable contraction

**Ramp Up/Down:** 2-4 sec (to reduce sudden jerks or discomfort)

**On:Off Ratio :** 1:3 to 1:5 (e.g., 10 sec on :30-50 sec off)

**Session Time:** 5-30 min, 1-2x/day initially, progressing over time

**Electrode Placement:** Bipolar over mid-thigh (quad belly + motor point)



# GRADE(3)

If the patient has a grade3 injury , the neuromuscular stimulation application group started on the second day after ACL reconstruction. More extensive use of NMES in a more proactive manner following the index injury and surgical repair may derive greater benefits.



## The neuromuscular stimulation PARAMETERS

frequency: 70 Hz

Stimulation-pulse duration:(pulse wide) was 300  $\mu$ s to 400  $\mu$ s, and contraction for 10 s and relaxation for 50 s

Duration of treatment: 20-min

Number of treatment: twice a week

Overall time treatment: 12 week during rehabilitation exercises



# PAIN RELIEF

During and after the rehabilitation exercises, the patient experiences severe pain that can be relieved using TENS current.

Parameters of Tens cuurent for acute pain:

Frequency: 80-120Hz

Pulse duration: 175-200us

Time duration: 20-60 min

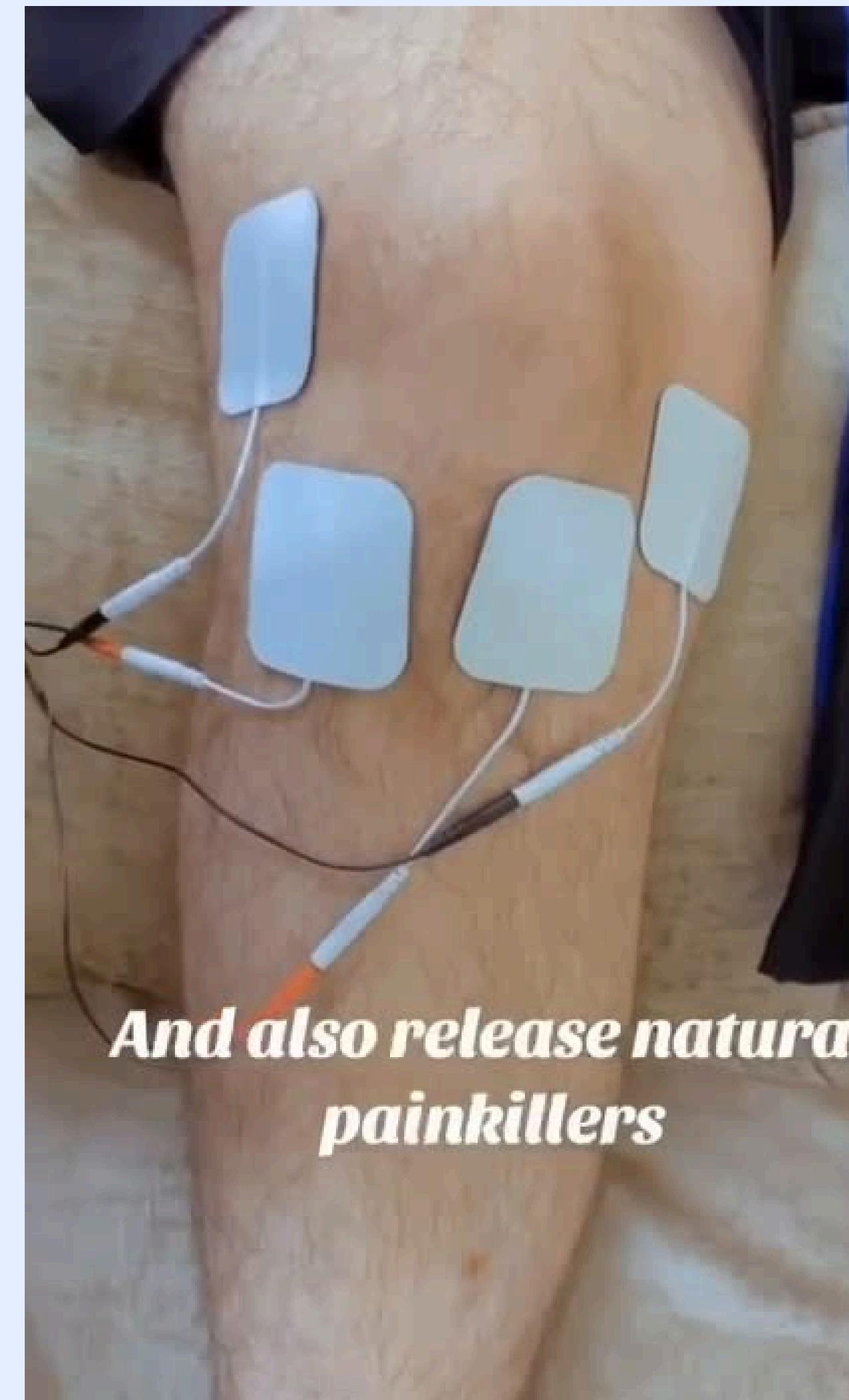
Number of sessions: 4 times daily

Application of electrodes:Position electrodes around the knee joint above and below on each side

# ultrasound

After two weeks post-surgery, we begin using ultrasound therapy, where it transmits high frequency waves to the soft tissues underneath the skin, including the ligaments and tendons. These sound waves help to rejuvenate the soft tissues and produce heat within them, which promotes better flexibility and speeds up the healing process.

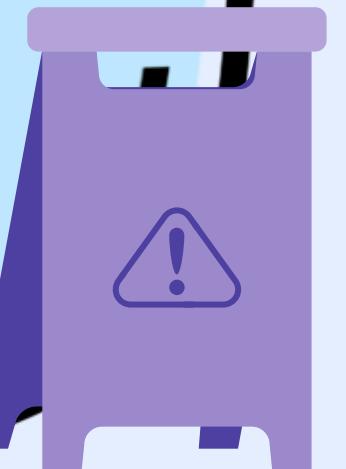




*And also release natural  
painkillers*

# Contraindications

- 1-pregnancy
- 2-Epilepsy
- 3-Malignant tumors
- 4-cardiac patients
- 5-Skin lesions in the area to be treated
- 6-Loss of skin sensation
- 7-Metal implants



# Thank You

