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Acl injury Rehabilitation

Based on
Therapeutic exercises principles

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Topics:

- Anatomy of the knee joint
- General Acl biomechanics & mechanism of injury
- Grades of ACL tears
- Medical Case

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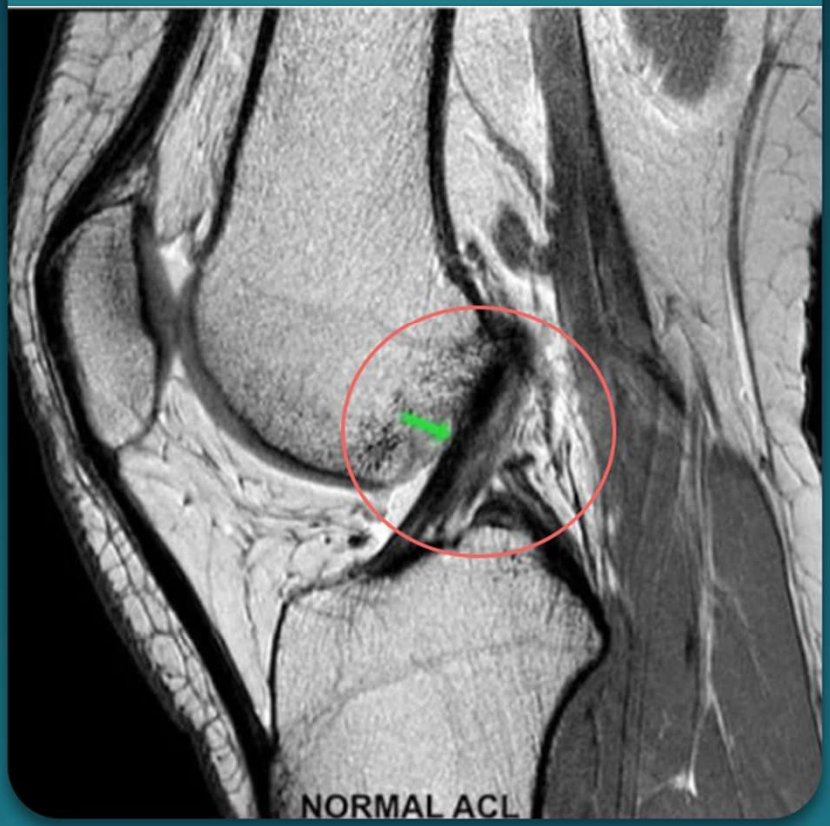
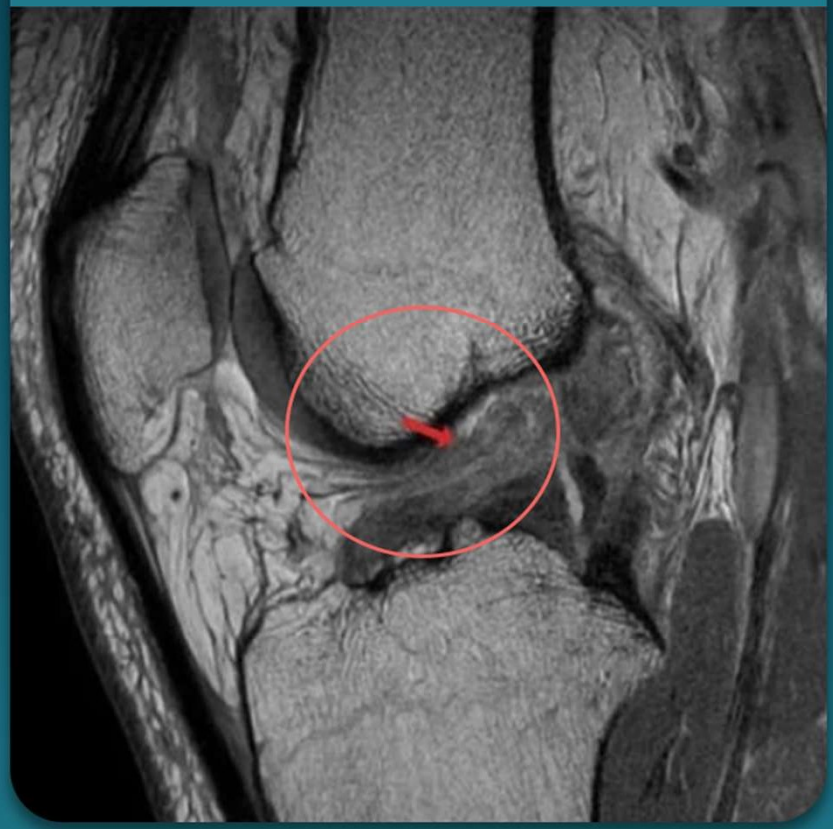
Normal ACL



ACL Tear



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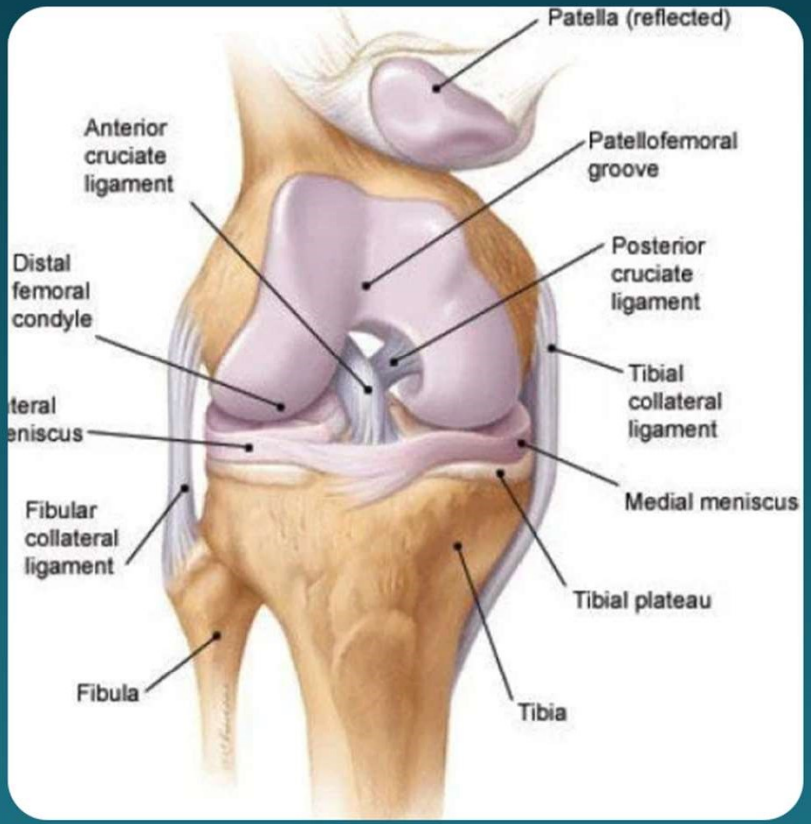
Knee joint:

The knee joint is one of the largest and most complex joints in the body. It is considered a vital joint that bears the body's weight and allows movement during walking, running, sitting, and more.

Bones: Femur -Tibia- Patella – helps improve the efficiency of the quadriceps muscle.



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Knee joint: (continued)

Cartilage:

- Articular cartilage: covers the ends of bones to reduce friction.
- Menisci: meniscal-shaped cartilages (medial and Lateral) distribute loads and increase stability.

Ligaments:

- Anterior and posterior cruciate ligaments (ACL, PCL): prevent anterior and posterior sliding. Medial and lateral collateral ligaments (MCL, LCL): provide lateral stability

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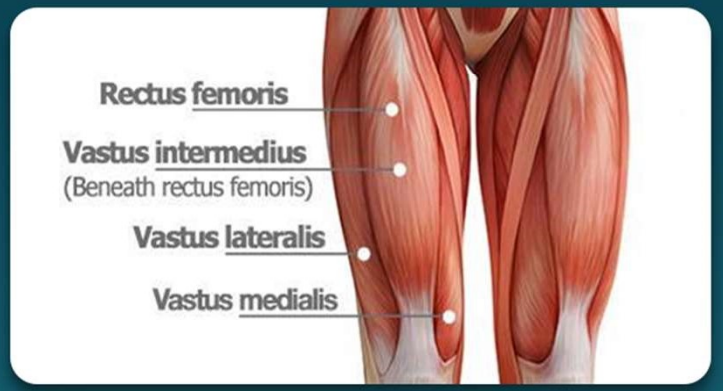
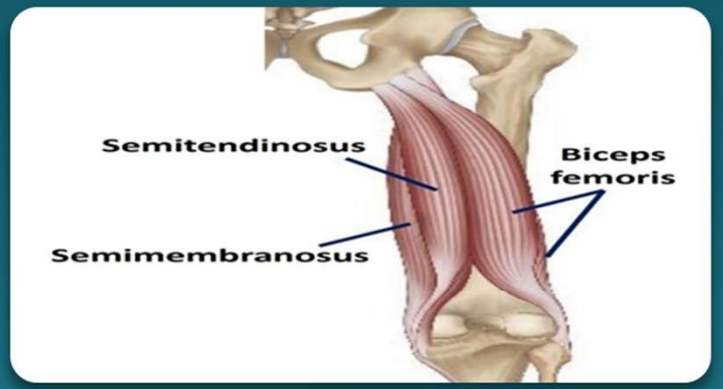
Knee joint: (continued)

Muscles:

- The most important are the quadriceps and ham-strings, which play a major role in controlling movement and stability.
- Movements allowed by the knee joint:
- Flexion-Extension and Slight movements of internal and external rotation (when the knee is bent).
- 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.





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Knee joint: (continued)

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.

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Knee joint: (continued)

What factors affect knee mechanics?

Q-angle

Excessive Q-angle can lead to patella pain.

Foot position

Varus or flat feet can affect knee alignment.

Excess weight

Increases stress on the joint and risk of cartilage wear.

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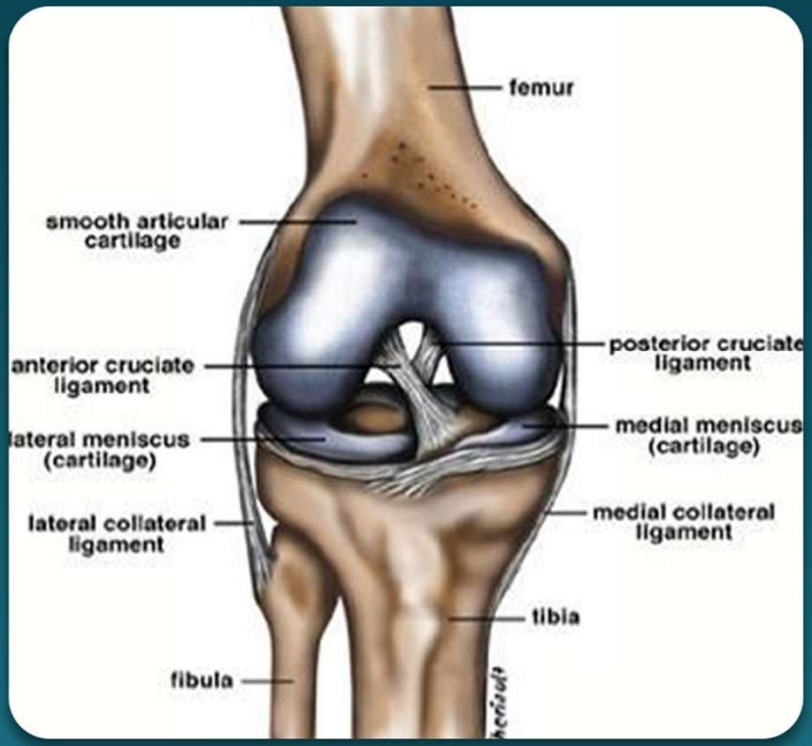
Biomechanics of ACL

- **First: What is the ACL?**
- The anterior cruciate ligament (ACL) is one of the major ligaments within the knee joint.
- **The ACL** extends from the posterior portion of the medial surface of the lateral femoral condyle to the anterior intercondylar area of the tibia. This oblique orientation places it in an ideal position to control forward and rotational motion of the tibia.



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Preventing Tibia Sliding

Stops tibia from sliding forward under the femur.

Reducing Tibia Rotation

Prevents excessive knee twisting during movements.

Anterior-Posterior Stability

Maintains bone alignment during knee movement.

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Functions of ACL

- **Role in joint proprioception:**
The ACL contains nerve receptors that help the body sense the knee's position in space.
- **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) Counterlateral ligaments (MCL & LCL) Muscles such as the quadriceps and hamstrings The hamstrings, in particular, help support the function of the ACL by resisting anterior sliding

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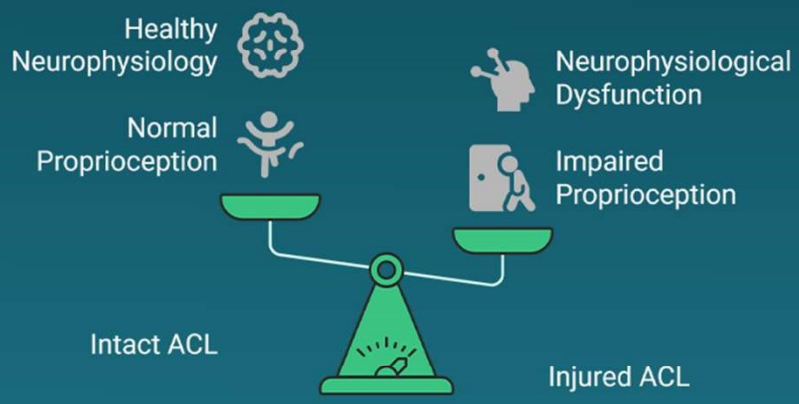
Proprioceptive Function:

The ACL contains mechanoreceptors, which play a key role in proprioception (the body's ability to sense joint position and movement). When the ACL is injured, this function is lost, leading to neurophysiological dysfunction a condition that goes beyond a simple peripheral musculoskeletal injury.

Because of this, restoring proprioceptive function is essentialfor a comprehensive rehabilitation program.



ACL Injury Impacts Proprioception and Neurophysiology


Symptoms of
ACL Injury
Clinical Signs
Observable physical symptoms like swelling and stiffness.
Subjective Instability
Personal sensation of knee instability or weakness.

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Biomechanics during 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.

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Biomechanics during movement (continued):

- Loading on the ACL.The ACL is most commonly affected by:
  - Anterior shear forces
  - Rotational forces
  - Excessive loading during a jump or improper landing
  - Examples of high-risk situations for the ACL.
  - Landing from a jump with the knee extended and the foot flat.
  - Deceleration without sufficient knee flexion.
  - Rapidly changing direction with the knee rotating

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ACL Injury Causes

Sudden Direction Change

Cutting the anterior cruciate ligament (ACL) due to a sudden change of direction.

Unstable Landing

ACL injury can occur from an unstable landing after a jump.

Sudden Stop

Stopping suddenly can cause the ACL to tear or rupture.

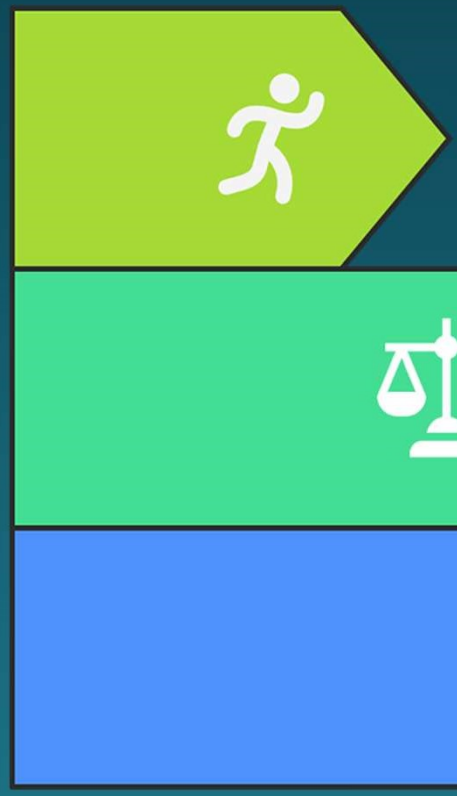
Direct Blow

Receiving a direct blow to the knee can result in ACL damage.

Complications of Injury

Injury ⟶ Higher Risk of Osteoarthritis

Prevention



Technique Training

Improve jumping, landing, sprinting techniques

Hamstring Balance

Exercises for hamstring muscle balance

Core Strength

Exercises to strengthen core muscles

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ACL injury :

Injuries to the ACL are relatively common knee injuries among athletes. They can range from mild (such as small tears/sprain) to severe (when the ligament is completely torn). The most common mechanism is that of a sudden pivoting or cutting maneuver during sporting activity, which is commonly seen in football, basketball and soccer. The ligament can also tear due to work injuries or automobile accidents. The amount of pain experienced at the time of the injury is somewhat variable but can be quite severe. Typically, the person is unable to continue play or activity, and has the impression that a significant injury has occurred.

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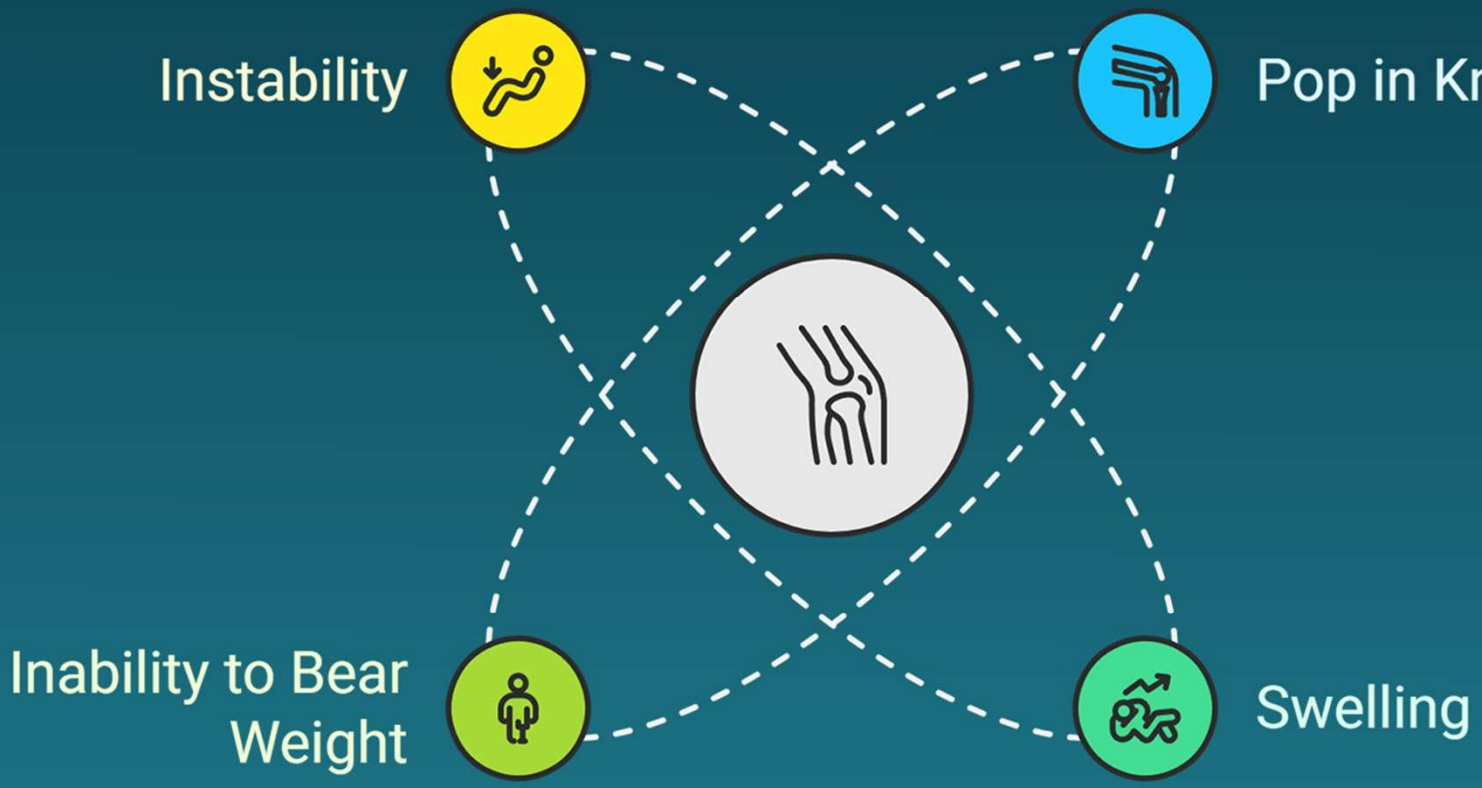
ACL Symptoms

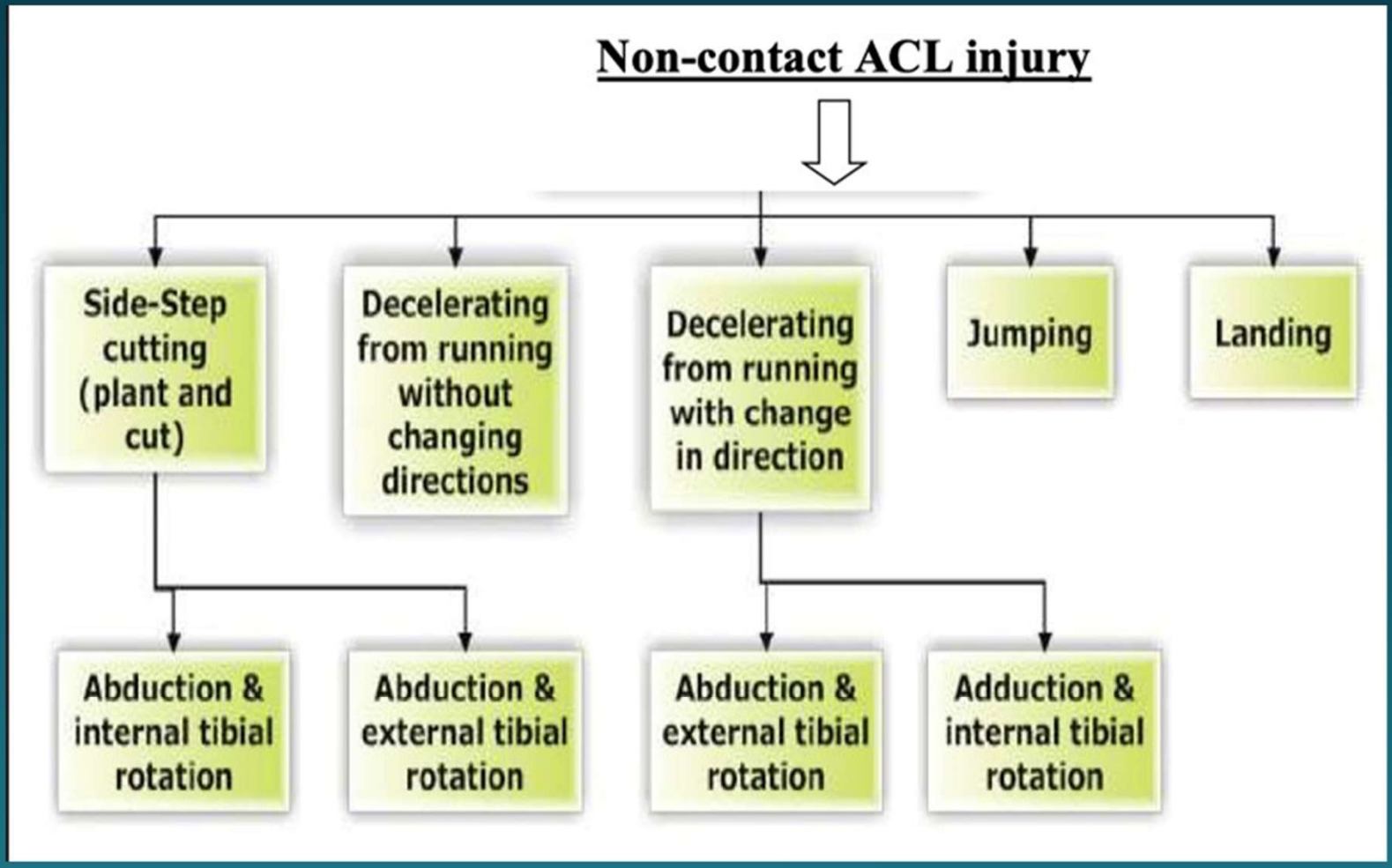


Mechanisms of injury :

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, being a sudden change in direction or speed with the foot firmly planted. Rapid deceleration moments, including those that also involve planting the affected leg to cut and change direction, have also been linked to ACL injuries, as well as landing from a jump, pivoting, twisting, and direct impact to the front of the tibia. The timing during the game and during the season is related to the injury mechanism of ACL but the relation still unclear.


Non-contact ACL injury
Side-Step cutting (plant and cut)
Decelerating from running without changing directions
Decelerating from running with change in direction
Jumping
Landing
Abduction & internal tibial rotation
Abduction & external tibial rotation
Abduction & external tibial rotation
Adduction & internal tibial rotation

Pattern of injury

A twisting and hyperextension injury commonly causes an ACL +/- PCL tear.

A hyperextension injury in a nonweight bearing leg can cause an ACL or PCL tear.

A hyperflexion injury such as a fall in skiing causes an ACL tear.

Risk factors:

- Risk factors for ACL injuries include environmental factors (e.g. high level of friction between shoes and the playing surface) and anatomical factors (e.g. narrow femoral intercondylar notch). The injury is characterized by joint instability, which is associated with both acute dysfunction and long-term degenerative changes such as osteoarthritis and meniscal damage. The risk factors for ACL injury have been considered as either internal or external to an individual.

External Risk Factors

Competition in games versus practice

. The finding introduces the hypothesis that the level of competition as in a game rather than practice , the way in which an athlete competes, or some combination of the two, increases an athlete's risk of suffering an ACL injury.

Risk factors (continued):

Footwear and playing surface

Although increasing the coefficient of 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. Lambson found that the risk of suffering an ACL injury is greater in football athletes who have boots with a higher number of cleats and an associated higher torsional resistance at the foot-turf interface.

Internal Risk Factors

Anatomical risk factors

Abnormal posture and lower extremity alignment (eg, hip, knee and ankle) may predispose an individual to ACL injury by contributing to increased ACL strain values. Alignment of the entire lower extremity should therefore be considered when assessing risk factors for ACL injury. Unfortunately, very few studies have studied alignment of the entire lower extremity and determined how it is related to the risk of ACL injury.

Biomechanics of Injury :

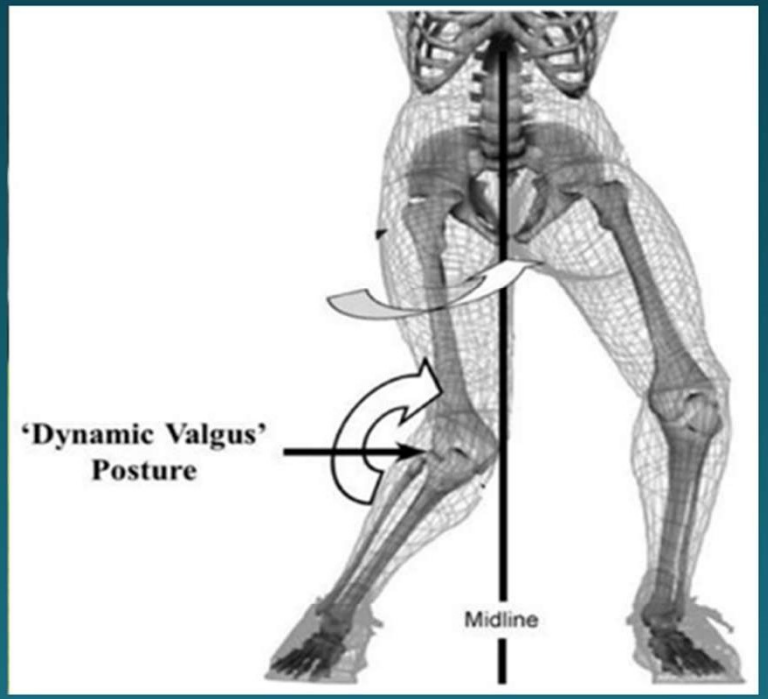
60-80% of ACL injuries occur in non-contact situations . The risk of ACL injury increase if there are more than one of these movements happened; knee joint twisted, bent backward, or side to side stress.

When there is an anterior tibiofemoral shear force ACL is loaded and the force is first controlled by ACL, the knee valgus moment with the anterior drawer force proximal to tibia increases ACL loading significantly according to Varus- Valgus laxity.

The typical ACL injury occurs with the knee externally rotated and in 10-30° of flexion (shallow knee flexion) when the knee is placed in a valgus position as the athlete takes off from the planted foot and internally rotates with the aim of suddenly changing direction. The ground reaction force falls medial to the knee joint during a cutting maneuver and this added force may tax an already tensioned ACL and lead to failure. Similarly, in landing injuries, the knee is close to full extension. High-speed activities such as cutting or landing maneuvers require eccentric muscle action of the quadriceps to resist further flexion.

Biomechanics of Injury (continued) :

After the ACL is torn, the primary restraint to anterior translation of the tibia is gone. This causes the medial femoral condyle to also be displaced posteriorly, resulting in external rotation of the tibia. Valgus loading is a key factor in the ACL injury mechanism and at the same time, the knee rotates internally. A quadriceps drawer mechanism may also contribute to ACL injury as well as external rotation.




Grade
01
Grade
02
Grade
03

GRADE (1) "ACL INJURY":

-Ligaments fibers are overstretched and mildly damaged but no tears
-patient will be able to move their knee but it will be associated with pain , swelling and slightly limited mobility may occur
-ligaments is still able to support knee and it doesn't give away
-no increase in laxity and there is a firm end feel
-treatment is non invasive and recovery time is quick within (2-4) weeks

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Goals

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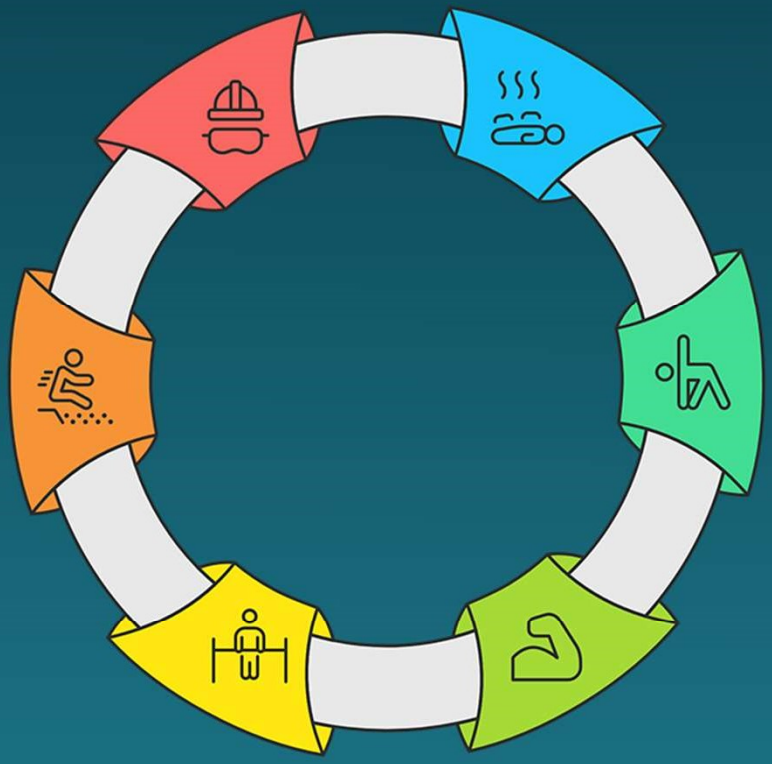
Re-injury Risk Reduction

Minimizes the likelihood of future injuries

Pain and Swelling Reduction

Aims to minimize discomfort and inflammation



Functional Level

Strives to achieve optimal physical performance

Full Range of Motion

Focuses on restoring complete joint flexibility

Functional Stability

Improves the joint's ability to support movement

Muscle Strength

Enhances the power of muscles surrounding the knee

01 Reduce pain and swelling:

-electrotherapy modalities as (ultrasound , laser ,TENS) to reduce pain and inflammation
-high voltage pulsed galvanic can be used to reduce edema
-Manual therapy techniques such as soft tissue massage or joint mobilization may also be used to reduce pain and improve joint function.

02 gain the full rom at knee joint:

applying gentle stretches , passive , active rom exercises , joint mobilization
-physiotherapist may also use taping or bracing to help support the knee joint and prevent further injury.

03 increase strength of muscles around knee joint:

1-isometric exercises (quads and hamstrings set)
2-co contraction isometric exercises for hamstrings and quads for stability
3- strength concentric exercises (quads ,hamstrings ,also calf muscles ,gluteus...)
4-balance and proprioception exercises
5-agility and plyometrics exercises
4)volume and duration of exercises

Reps	Sets	Rest intervals	frequency
8-12 reps according to tolerabilit	3 sets	2-3 mins (moderate intensity) / less (low intensity)	3 days / week

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GRADE 2 Acl rehabilitation

1. Introduction

The rehabilitation process for a Grade 2 ACL injury is structured into four progressive phases to restore knee function, strength, and stability. A key feature of this approach is the integration of electrotherapy—including TENS, IFC, NMES, FES, and biphasic pulsed current—to reduce pain, control swelling, prevent muscle atrophy, and enhance neuromuscular control throughout recovery.

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GRADE 2 Acl rehabilitation

Rehabilitation Program Sequence

Passive and Active-Assisted ROM

Gentle exercises to improve joint mobility (e.g Heel slides , Gentle knee Flection/Extention)

Patellar Mobilization

Techniques to enhance patellar movement

Isometric Sets

Muscle strengthening exercises without movement for Quads,hamstring& Glutes

Ankle Pumps

Exercises to improve circulation in the lower legs

Gait Training

Practice walking with assistive devices

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GRADE 2 Acl rehabilitation

Electrotherapy Role:

- TENS/IFC: Continued use for pain management
- NMES/Russian Stimulation: Applied to enhance muscle activation during exercise and prevent disuse

Electrotherapy Roles Comparison

	TENS/IFC	NMES/Russian Stimulation
Primary Role	Pain management	Muscle activation
Usage	Continued use	During exercise
Additional Benefit	None	Prevents disuse

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GRADE 2 Acl rehabilitation

Atrophy Progression Criteria




Minimal or no swelling

The absence of swelling indicates initial recovery

Knee flexion within 10°

Achieving knee flexion of uninjured leg

Full extension achieved

Complete extension of the knee

No pain or instability

Absence of pain and instability during exercises

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Phase 3 Rehabilitation Goals (6-12 Weeks)

Maintain Knee ROM

Maintain full knee ROM with minimal/no swelling or pain

Improve Balance

Improve single-leg balance and neuromuscular control

Introduce Sport Drills

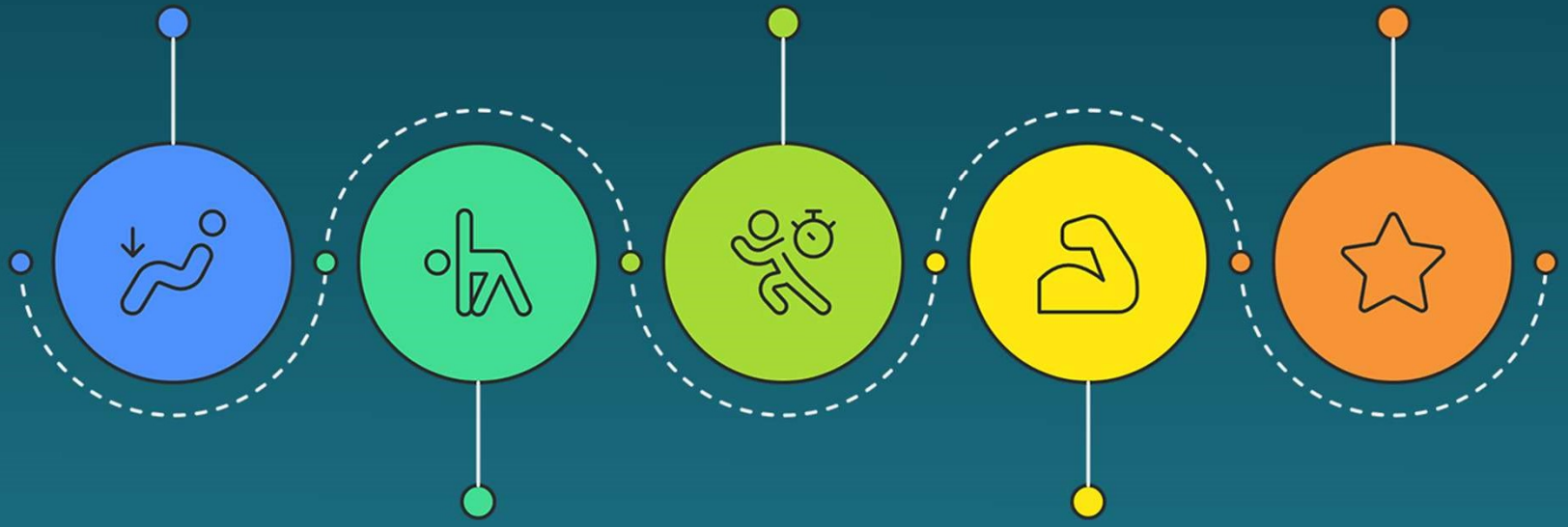
Introduce light sport-specific drills as tolerated

Regain Power & Endurance

Regain power, endurance, and flexibility

Restore Coordination

Restore dynamic movement coordination



Rehabilitation Program

	Strengthening	Balance	Endurance
Activities	hamstring curls, single-leg squats	single-leg activities on unstable surfaces, dynamic drills (e.g., ball passing)	stationary cycling, pool running if post-surgical

GRADE 2 Acl rehabilitation

Electrotherapy Role:

- NMES: Used for maintaining muscle performance under load
- FES: Applied during functional and dynamic tasks to enhance control and coordination under sport-like

GRADE 2 Acl rehabilitation

Key Notes:

- Exercises should be performed 3–4 times per week
- Electrotherapy should be used under clinical guidance to ensure safety and effectiveness
- Progression should be based on functional milestones, not just time

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GRADE 3 Acl rehabilitation

Pre-operative program for ACL surgery:

Goals:

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

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 (eyes open , eyes closed)
- Double leg standing on unstable surface
- Single leg Standing on unstable surface.

Muscular strength Exercises:

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

GRADE 3 Acl rehabilitation

Grade 3 Post Acl surgery (3 phases) :
Recovery duration : 9-12 months

Phase 1 goals (3 months) :
1-ROM Flexion/extension
2-Edema/swelling reduction
3-Pain reduction
4- Gait training - removal of crutches
two crutches ---->>> one crutch ---->>> no crutches
5- Anatomical adaptation for muscles (noticeable muscle borders)

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GRADE 3 Acl rehabilitation

Phase 1 Program
Volume : everyday multiple times a day Intensity : Low
Peace and Love:
Avoid Ice and Anti-inflammatory medications as they may disrupt tissue healing
Elevate and compress to reduce the swelling
Gentle passive and active-assisted knee extension and flexion exercises.
Use crutches to assist with walking, progressing to weight bearing as tolerated.
Education on safe movement and home exercise program
Scar tissue massage as scarring decreases the moment arm of the extensor mechanism, reducing the extension force produced by the quad
Retrograde Massage: Gentle massage to help move fluid away from the knee and reduce swelling2
Patellar Mobilizations: Gentle movements of the kneecap (superior/inferior and medial/lateral) to prevent adhesions

GRADE 3 Acl rehabilitation

Physiologic Joint Mobilizations: Gentle tibiofemoral and patellofemoral joint mobilizations (e.g., posterior tibial glide) help restore normal joint mechanics and reduce pain

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
Edema/swelling reduction
There is no evidence that icing and elevation is useful after Week 1.
(ankle pumps with elevated leg)

Grade 3 ACL rehabilitation

Isometric exercises / OKC With assistance
(Quadriceps sets)
Once terminal knee extension is obtained start preforming (SINGLE LEG raises)
(Supine ankle planter flexion)
(knee flexion from supine heel is on a sliding smooth surface) passive or self assisted with straps
(side lying hip abduction)
Gait training
Partial Weight Bearing
(Weight shifts side to side / front to back)

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Grade 3 ACL rehabilitation

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.

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

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Grade 3 ACL rehabilitation

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)
For leg posterior chain (Dl bridges)
For calf muscle (heel raises)
For dorsiflexors (ankle dorsiflexion with light resistance TheraBand)
For abductors (hip abduction from side lying with TheraBand resistance according to patient tolerance) progress to (lateral steps with TheraBand resistance)
For core
(back extension) for glutes , hamstrings and back muscles
(side plank)

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Grade 3 ACL rehabilitation

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: Gentle manual or mechanical disturbances while balancing to improve reflexive stability
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

Grade 3 ACL rehabilitation

Phase 3 goals :
1- Proprioception and neuromuscular training
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)
(Pallof press in single leg stance)
Criteria for running / jumping / cutting
Full knee extension ☒ done
No swelling
Adequate knee control ☒ done
No pain
No joint line tenderness
Walk - jog progression
30 sec walk then 1 min jog and repeat
(Back pedaling exercises)
(Agility ladder forward , lateral , cutting)

Grade 3 ACL rehabilitation

2-Jumping
improve landing control (mini jumps and soft landings then progress)
(box jumps)
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
4-Footwork
(Agility ladder forward , lateral , cutting) with progression “movement in all planes ”

Grade 3 ACL rehabilitation

5-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

CPM Device :

Use of Continuous Passive Motion (CPM) Devices After ACL Surgery:

Continuous Passive Motion (CPM) machines are commonly used during the early stages of rehabilitation following Anterior Cruciate Ligament (ACL) surgery. These devices gently and continuously move the knee joint without requiring effort from the patient.

Physiotherapy research suggests several potential benefits of using CPM, including:

Reduced pain and swelling
Improved range of motion
Lower risk of joint stiffness and scar tissue formation
Enhanced tissue healing
Prevention of blood clots
Psychological comfort in the early recovery phase

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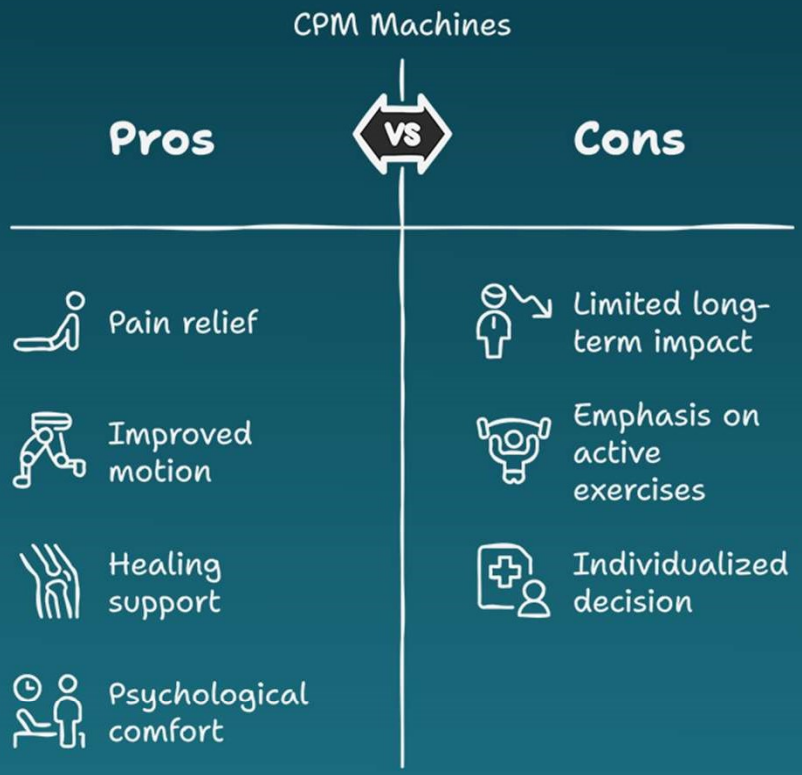
CPM Device (continued):

However, recent studies have raised questions about the long-term effectiveness of CPM. Some findings show no significant difference in outcomes compared to rehabilitation programs that do not include its use.

As a result, modern rehabilitation protocols tend to emphasize early active exercises. The decision to use a CPM machine should be individualized, applied only for a short period during the initial postoperative phase, and always under medical supervision.



Electrotherapy :

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.
electrical stimulation treatment
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: four 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
number of treatments: 1 session every day
Overall time of treatments: from 5 to 14 days Depending on the patient's response to treatment.
Or 3 weeks if the swelling occurred after surgery.

Electrotherapy (Grading) :

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 neuro-muscular pathways.
FES current parameters:
Target Muscle: Quadriceps (esp. Vastus medial oblique)
Hamstrings (occasionally)
Frequency:35-50 Hz (sometimes up to75 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:15-30 min, 1-2x/day initially, progressing over time
Electrode Placement: Bipolar over mid-thigh (quad belly + motor point)

Electrotherapy (Grading) :

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.For instance, when NMES is added as an adjunct to standard rehabilitation beginning several weeks post-surgery, no additive benefit to improve strength has been noted. In this context,NMES would mitigate muscle fiber atrophy and prevent contractile dysfunction secondary to disuse and trauma related to both the ACL injury and surgery when instituted earlier post-surgery

NMES was performed using Kneehab equipment.

It stimulates muscles around the knee mainly quadriceps muscles

Electrotherapy (Grading) :

The neuromuscular stimulation parameters:
frequency: 70 Hz
Stimulation-pulse duration:
(pulse wide) was 300 µs to 400 µs, 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

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

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Electrotherapy (Grading) :

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.

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

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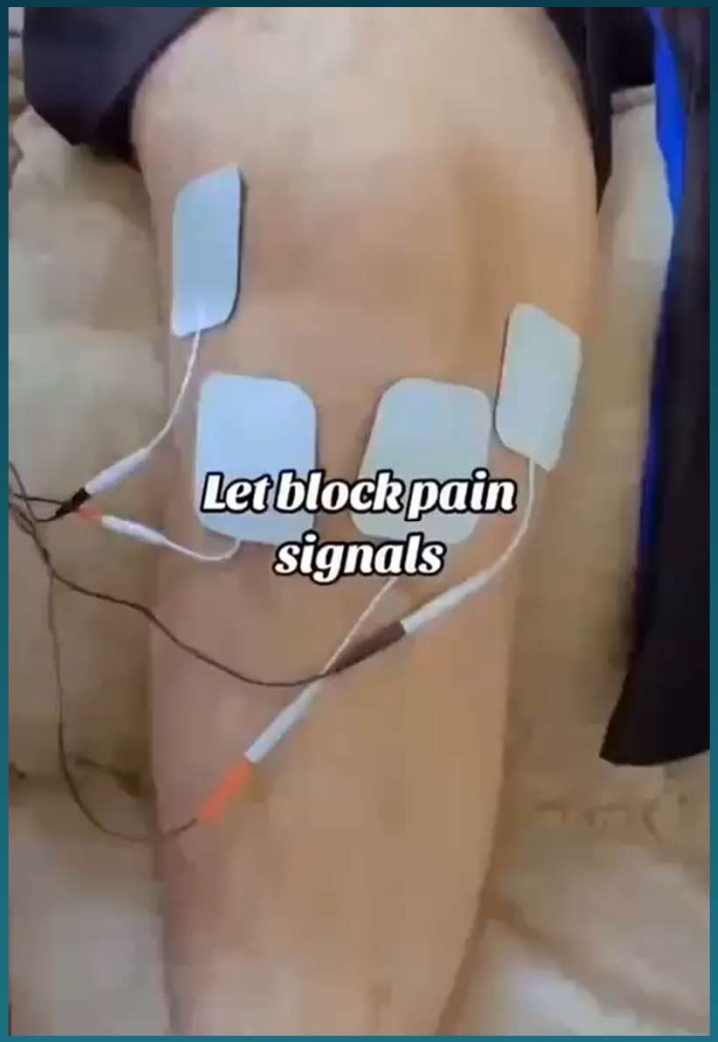

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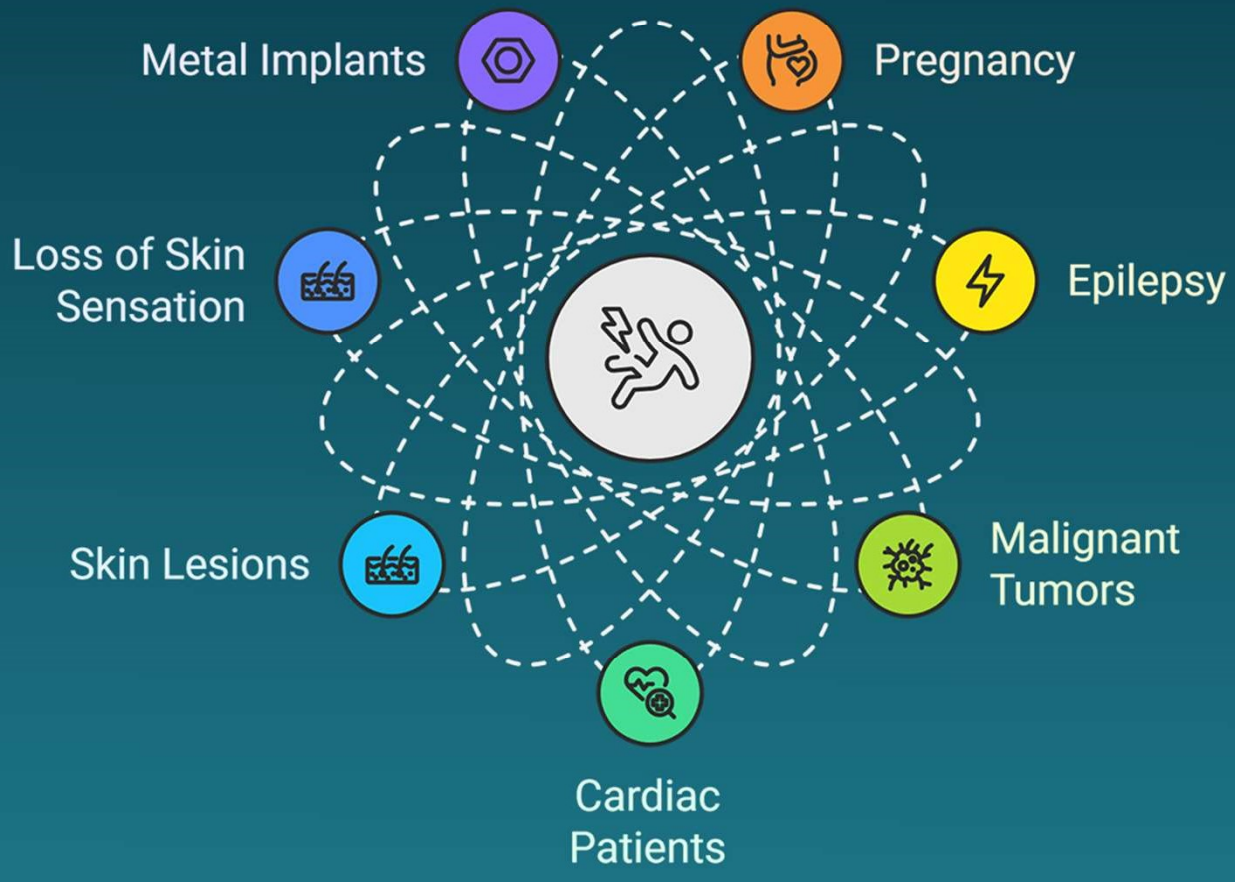
Contraindications for Electrotherapy

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