Postoperative course after PCL-R

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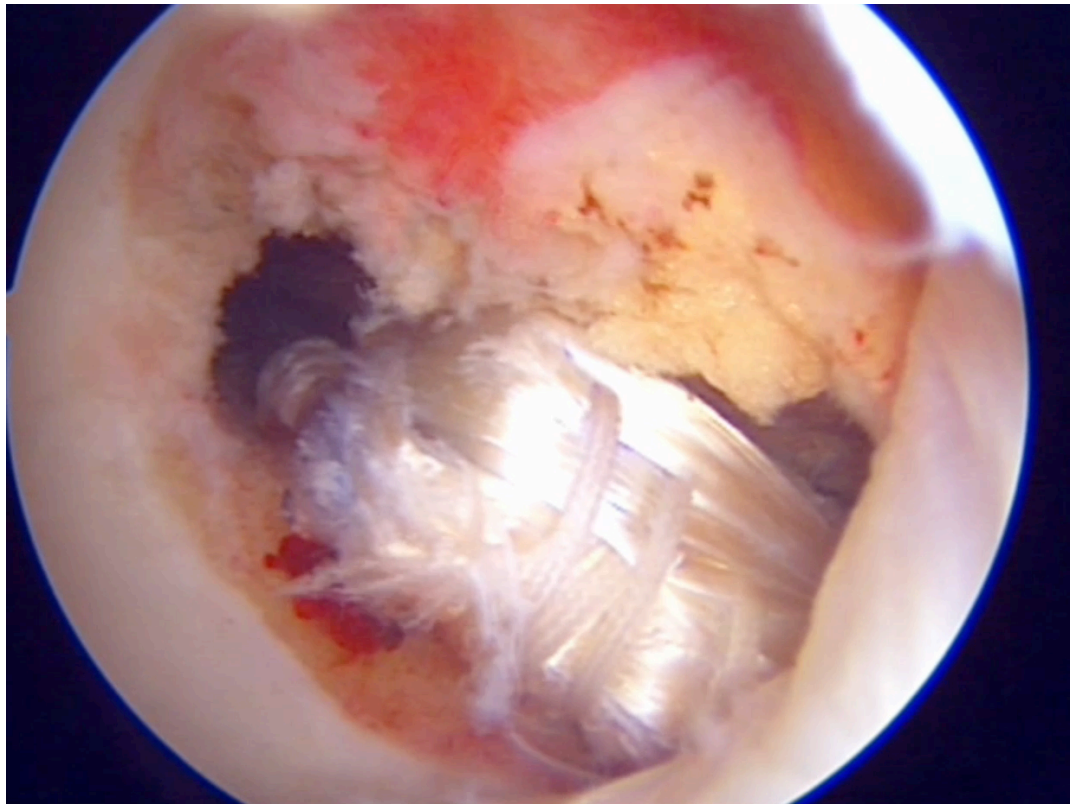
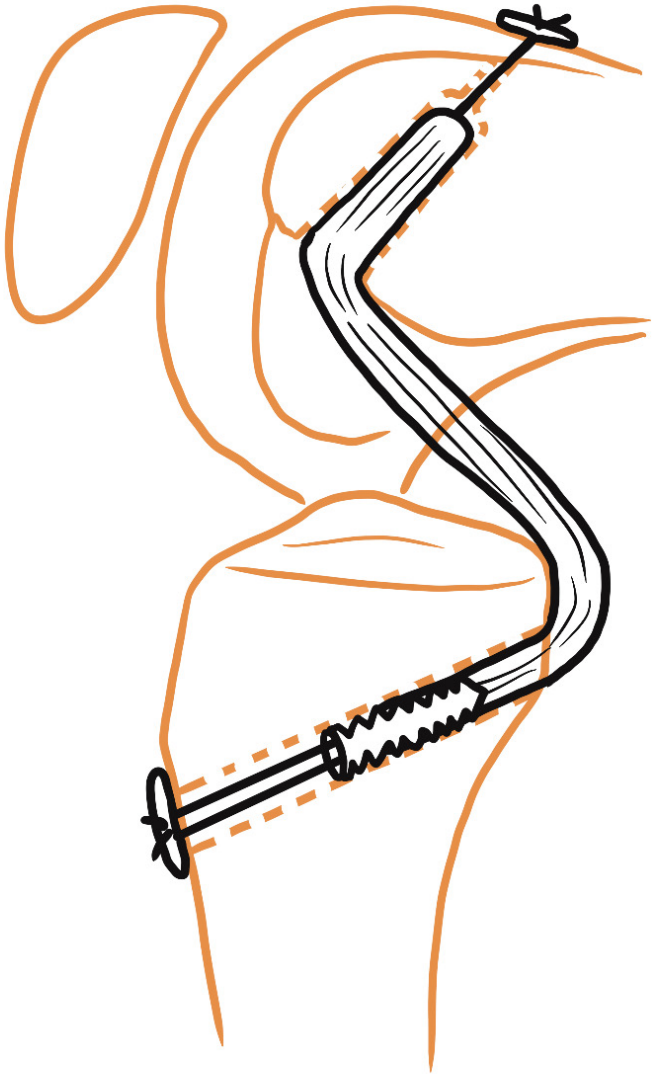
One of the first objectives

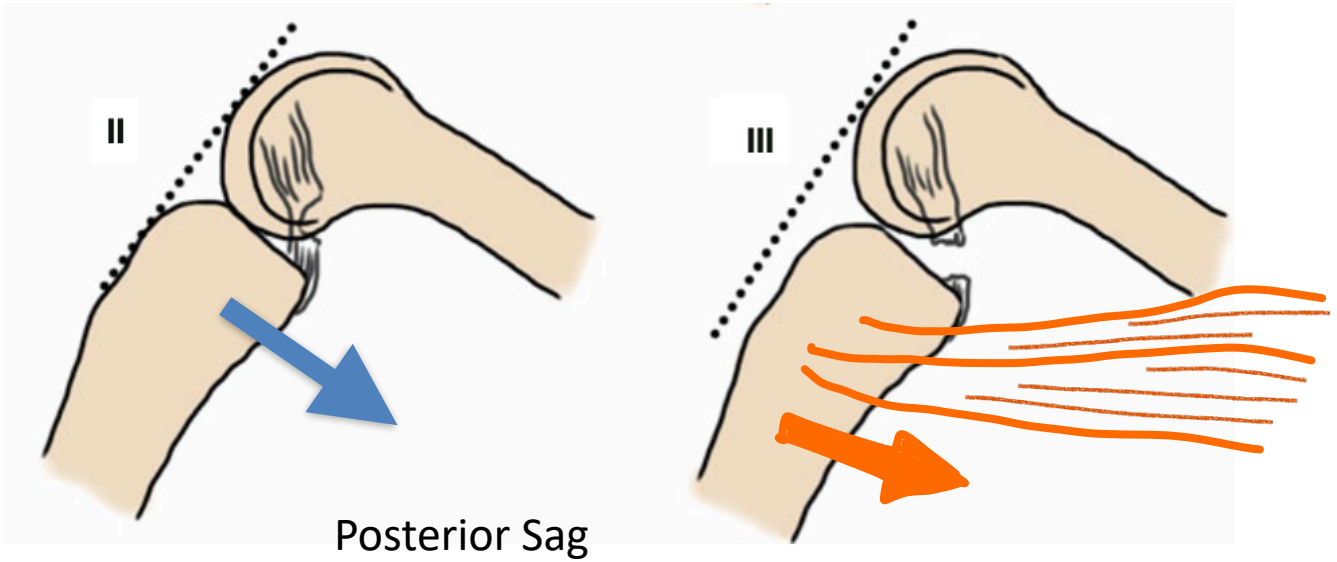
- PCL graft healing / tunnel integration





The specific enemies of early PCL healing

- **Gravity in dorsal decubitus**

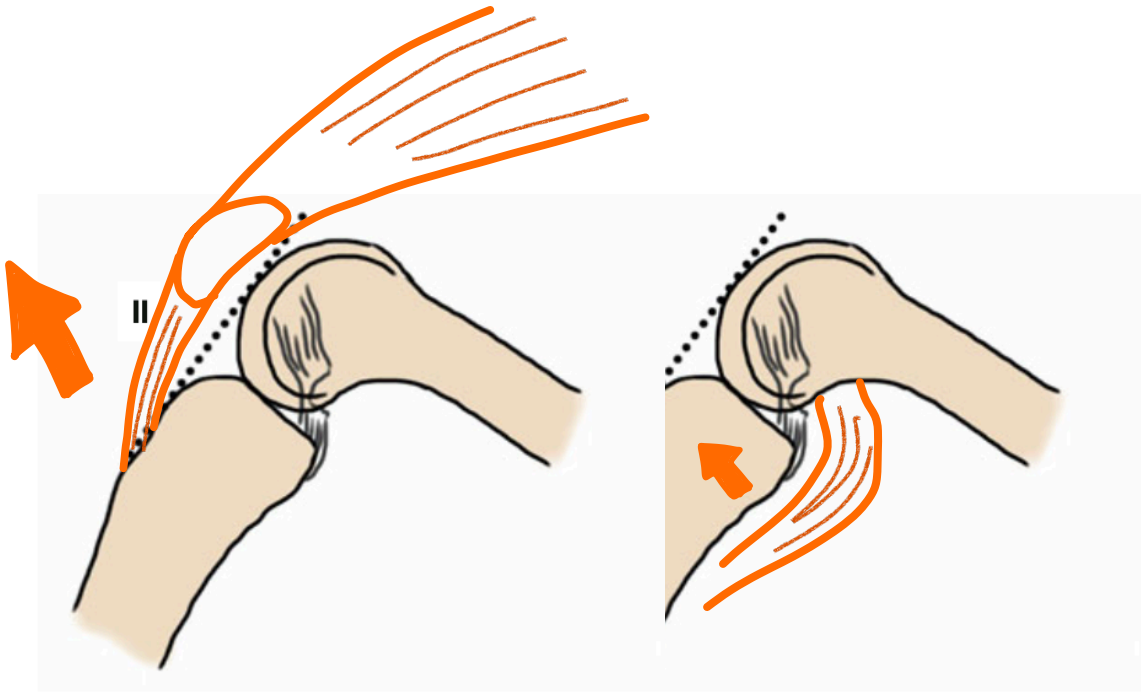


Posterior Sag

- **Hamstrings**
  - Hamstrings act at antagonists to the PCL by pulling the proximal tibia posteriorly, and this action increases as the knee flexion angle increases

The specific allies of PCL healing

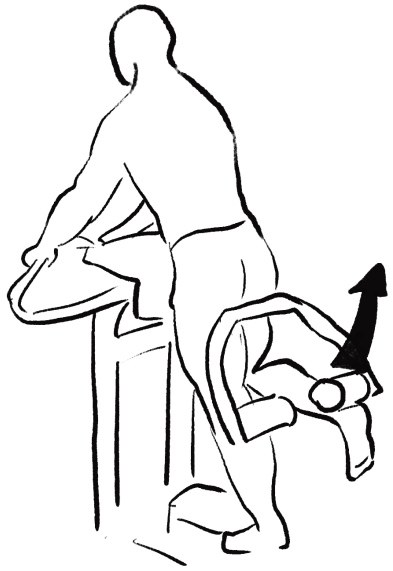
- **Procubitus**
- **Quadriceps**
  - The **quadriceps** is the main agonist to the PCL by pulling the proximal tibia anteriorly between 0° and 60° of knee flexion,
  - The **gastrocnemius** is a secondary agonist muscle.

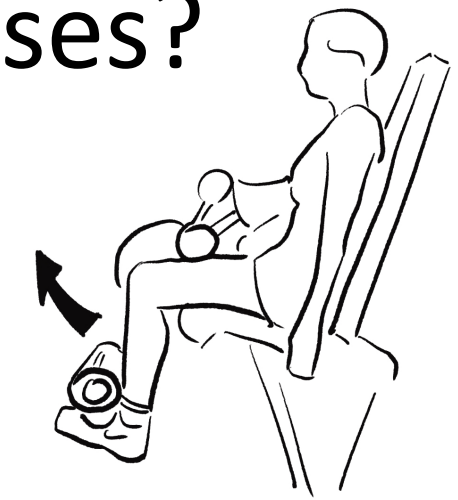


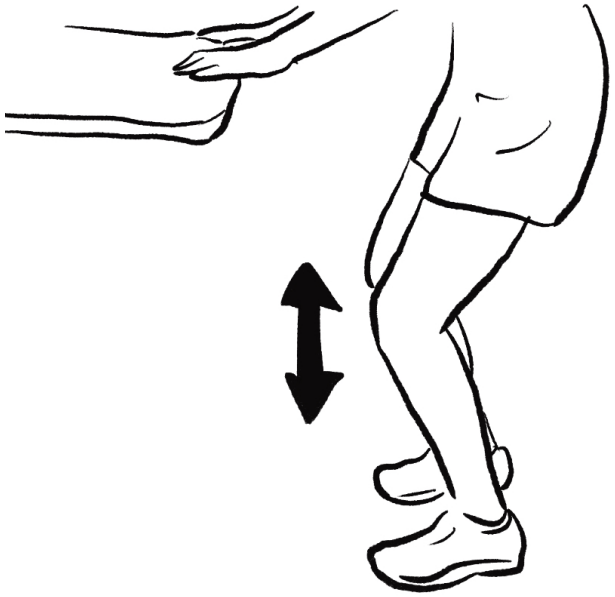
Markolf KL, O'Neill G, Jackson SR, McAllister DR (2004) Effects of applied quadriceps and hamstrings muscle loads on forces in the anterior and posterior cruciate ligaments. Am J Sports Med 32(5):1144–1149

Open of close kenetic exercises?

- **Open kinetic chain (OKC)** hamstring strengthening should be postponed until the advanced phase of rehabilitation.
- All **closed kinetic chain (CKC)** exercises result in a posterior glide of the tibia that increases as the angle of knee flexion increases.







Wilk KE, Escamilla RF, Fleisig GS, Barrentine SW, Andrews JR, Boyd ML (1996) A comparison of tibio-femoral joint forces and electromyographic activity during open and closed kinetic chain exercises. Am J Sports Med 24(4):518–527

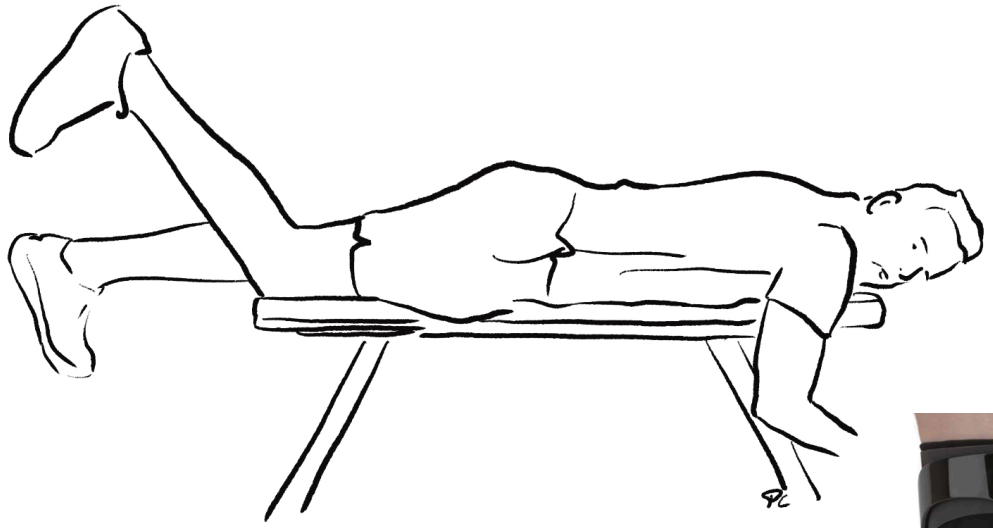
Neuromuscular control

- **Proprioception and neuromuscular control** of the knee are compromised after PCL injury. Therefore, a regular strengthening and neuromuscular training programme should be continued after return to sport to maintain the knee performance

Grassmayr MJ, Parker DA, Coolican MR, Vanwanseele B (2008) Posterior cruciate ligament deficiency: biomechanical and biological consequences and the outcomes of conservative treatment. A systematic review. J Sci Med Sport 11(5): 433–443

Phase 1: Protection & Early Motion (Weeks 0-6)

- **Protection of the PCL graft healing**
  - Maintain a minimum ROM : Gentle passive ROM exercises (0–60°) starting in prone to avoid the posterior sag
  - Initiate quadriceps control and then strengthening
  - Brace: worn at all times including sleeping and rehabilitation (dynamic PCL brace ideally). Which ROM?







Jansson KS, Costello KE, O'Brien L, Wijdicks CA, Laprade RF (2013) A historical perspective of PCL bracing. Knee Surg Sports Traumatol Arthrosc 21(5): 1064–1070

Phase 1: Protection & Early Motion (Weeks 0-6)

- **Protection of the PCL graft healing**
  - Weight-bearing? Locked in extension?, slight flexion?
  - Avoid knee hyperextension
  - Precautions: Avoid hamstring activation to prevent stress on PCL graft

Jansson KS, Costello KE, O'Brien L, Wijdicks CA, Laprade RF (2013) A historical perspective of PCL bracing. Knee Surg Sports Traumatol Arthrosc 21(5): 1064–1070

Phase 1: Protection & Early Motion (Weeks 0-6)

- Decrease pain and swelling, Patellar mobilization, cryotherapy
- Prepare for normal gait

Jansson KS, Costello KE, O'Brien L, Wijdicks CA, Laprade RF (2013) A historical perspective of PCL bracing. Knee Surg Sports Traumatol Arthrosc 21(5): 1064–1070

Phase 2: Progressive Loading (Weeks 7-12)

- **Goals: Increase ROM, improve weight-bearing, strengthen muscles.**
- **Weight-bearing**: Transition to partial, then full with brace.
- **ROM progression**: 0°-130° by week 12.
- **Key Exercises**:
- - Closed-chain exercises (leg press, wall squats).
- - Proprioceptive training (balance boards).
- - Cycling (ROM >110°).
- Criteria for progression: No swelling, pain-free SLR (straight leg raise), normal patellar mobility.

Kew ME, Cavanaugh JT, Elnemer WG, Marx RG. Return to Play after Posterior Cruciate Ligament Injuries. Curr Rev Musculoskelet Med. 2022 Dec;15(6):606-615

Phase 3: Strengthening & Neuromuscular Control (Months 4-6)

- **Goals: Restore strength, improve dynamic stability, functional movement patterns.**
- **Key Exercises**:
- - Squats, lunges (progressive resistance).
- - Step-downs and lateral step-ups.
- - Single-leg balance and proprioception.
- - Plyometric progression begins. Jogging.
- Criteria: No swelling, full ROM, >85% strength compared to contralateral leg.

Kew ME, Cavanaugh JT, Elnemer WG, Marx RG. Return to Play after Posterior Cruciate Ligament Injuries. Curr Rev Musculoskelet Med. 2022 Dec;15(6):606-615

Phase 4: Sport-Specific Training (Weeks 25+)

- **Goals: Reintegrate into sports, improve agility and endurance.**
- **Exercises**:
- - Cutting, pivoting, acceleration/deceleration drills.
- - Progressive plyometrics and agility work.
- - Sport-specific movements tailored to patient goals.
- Criteria: >90% limb strength, psychological readiness, passing functional tests.

Kew ME, Cavanaugh JT, Elnemer WG, Marx RG. Return to Play after Posterior Cruciate Ligament Injuries. Curr Rev Musculoskelet Med. 2022 Dec;15(6):606-615

Return to sport Decision



- “When can I go back to play…without any risk?”



- “You mean: with the same risk than before!”

ACL

BJSM

2016

Likelihood of ACL graft rupture: not meeting six clinical discharge criteria before return to sport is associated with a four times greater risk of rupture

Polyvios Kyritsis,[1] Roald Bahr,[1,2] Philippe Landreau,[1] Riadh Miladi,[1] Erik Witvrouw[1,3]

- **158 male professional athletes** who underwent an ACL reconstruction and returned to their previous professional level of sport were included.

- Before players returned to sport, they underwent a **battery of discharge tests** (isokinetic strength testing at 60°, 180° and 300°/s, a running T test, single hop, triple hop and triple crossover hop tests).

- Athletes were monitored for ACL re-ruptures once they returned to sport (median follow-up **646 days**, range 1-2060).

Re-rupture

- We concluded that **athletes who did not meet the discharge criteria before returning to professional sport had four times greater risk on sustaining an ACL graft rupture** compared with those who met all six RTS criteria. In addition, hamstring to quadriceps strength ratio deficits were associated with an increased risk of an ACL graft rupture.





Discharge tests and criteria

Table 1 Discharge tests and criteria used during the study period

Six-part return to sport tests	Discharge permitted when each of these criteria was met
Isokinetic test at 60, 180 and 300°/s	Quadriceps deficit <10% at 60°/s
Single hop	Limb symmetry index >90%
Triple hop	Limb symmetry index >90%
Triple crossover hop	Limb symmetry index >90%
On-field sports-specific rehabilitation	Fully completed
Running t test	<11 s

Criteria were set according to the literature at the start of the study.



Strength

Discharge tests and criteria

Table 1 Discharge tests and criteria used during the study period

Six-part return to sport tests	Discharge permitted when each of these criteria was met
Isokinetic test at 60, 180 and 300°/s	Quadriceps deficit <10% at 60°/s
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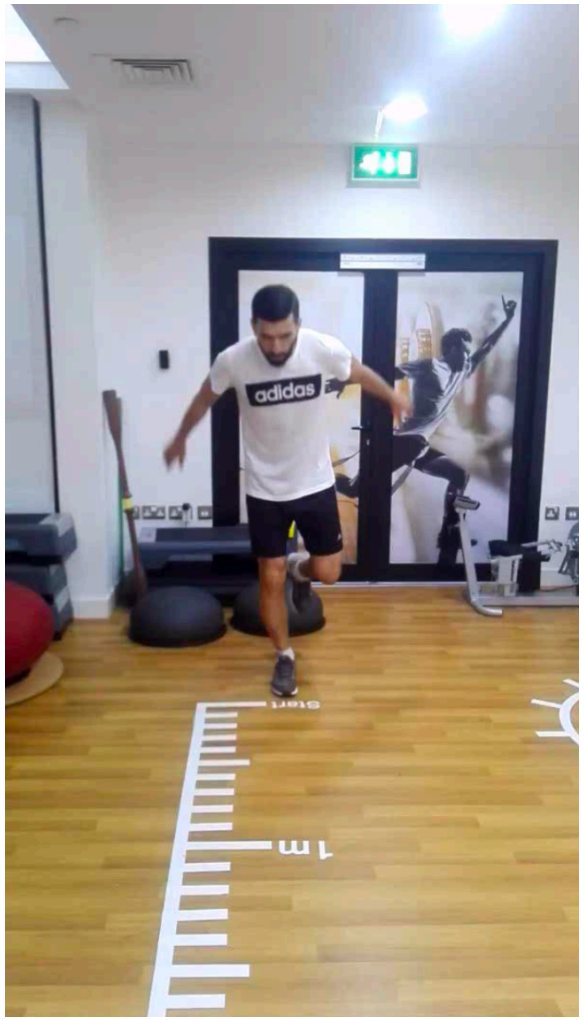
Triple hop	Limb symmetry index >90%
Triple crossover hop	Limb symmetry index >90%
On-field sports-specific rehabilitation	Fully completed
Running t test	<11 s

Criteria were set according to the literature at the start of the study.

Hop performance



Discharge tests and criteria

Table 1 Discharge tests and criteria used during the study period

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Triple crossover hop	Limb symmetry index >90%
On-field sports-specific rehabilitation	Fully completed
Running t test	<11 s

Criteria were set according to the literature at the start of the study.

Sports-specific

Cross (static) Cross (dynamic)



Shooting scenarios Maximum shoots

Discharge tests and criteria

Table 1 Discharge tests and criteria used during the study period

Six-part return to sport tests	Discharge permitted when each of these criteria was met
Isokinetic test at 60, 180 and 300°/s	Quadriceps deficit <10% at 60°/s
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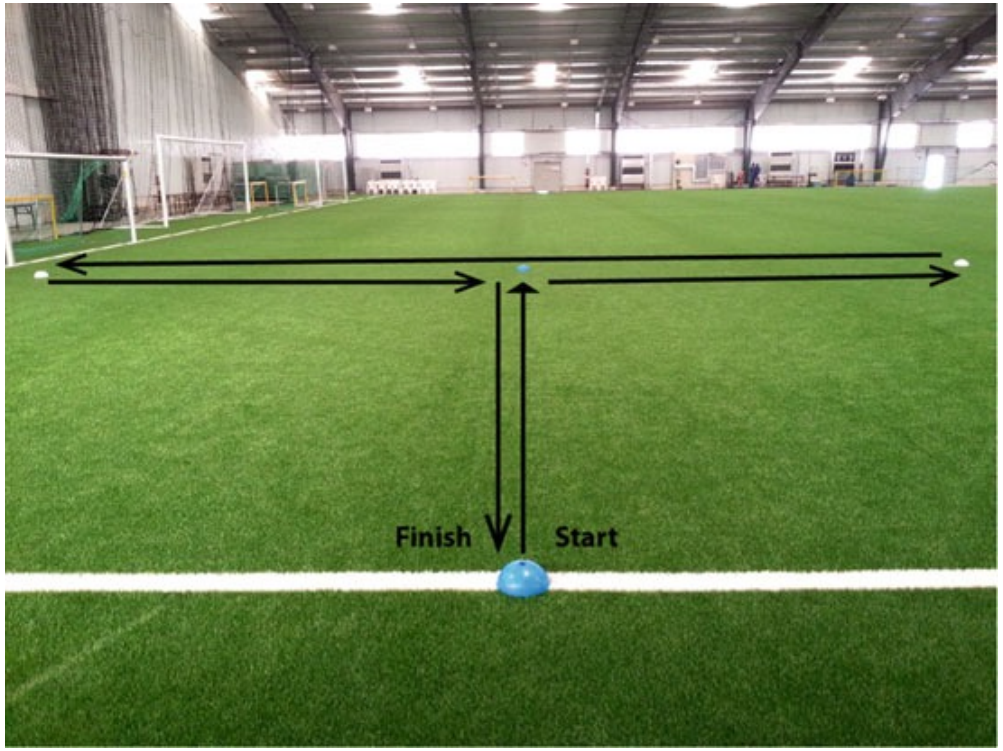
Triple crossover hop	Limb symmetry index >90%
On-field sports-specific rehabilitation	Fully completed
Running t test	<11 s

Criteria were set according to the literature at the start of the study.



Agility

Return to Sport Testing

- Strength tests (isokinetic assessment >90%).
- Hop tests: Single-leg, triple hop, crossover.
- Functional movement screening.
- Psychological readiness: Athlete confidence and fear assessment.

Kew ME, Cavanaugh JT, Elnemer WG, Marx RG. Return to Play after Posterior Cruciate Ligament Injuries. Curr Rev Musculoskelet Med. 2022 Dec;15(6):606-615

Schreier FJ, Banovetz MT, Rodriguez AN, LaPrade RF. Cutting-Edge Posterior Cruciate Ligament Reconstruction Principles. Arch Bone Jt Surg. 2021 Nov;9(6):607-617

Key Milestones in Rehabilitation

- **6 weeks:** Achieve full weight-bearing with proper gait mechanics without compromising PCL graft healing
- **12 weeks:** Restore functional ROM, begin dynamic exercises.
- **16 weeks:** Initiate running progression if strength criteria met.
- **24+ weeks:** Return to high-level training with no restrictions if functional criteria are validated.

Common Challenges & Solutions

- **Quadriceps weakness**: Emphasize NMES, progressive loading.
- **Persistent swelling**: Modify activity levels, improve icing protocols.
- **Psychological readiness**: Incorporate gradual exposure to sports.
- **Residual laxity**: Focus on proprioception and neuromuscular training.

Isolated PCL injury; SFA Symposium 2004
Michel Boussaton & Pierre Chambat
"After reconstruction of isolated PCL rupture, the residual differential posterior laxity was significantly improved with a mean gain of 6 mm.
A 50% improvement in the initial laxity!

Conclusion

- **Phased approach** critical for optimal recovery.
- **Close monitoring of biomechanics, strength, function, and psychological readiness.**
- **Multidisciplinary approach** involving physiotherapists, trainers, and surgeons.

PCL Lesion

19

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19.1 Introduction

Posterior cruciate ligament (PCL) injuries are less common in sport tha
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limited than for ACL inju
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Football-related PCL
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critical to accurately diag
their associated injuries
treatment and prognosis.

Injuries of the PCL car
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associated injuries (isola
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still a topic of debate.

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P. Volpi (ed.), *Football Traum*

19.2 Anatomy

The PCL is a large ligament extending from the

Table 19.1 (continued)

Progression criteria to move to next phase	Minimal or no swelling
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Intermediate phase (week 4–8)	
Goals	]
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ROM	]
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Strengthening and endurance	(
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Core stability	]
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Table 19.1 (continued)

Cardiovascular	Continue as for early phase: increase intensity and time
Progression criteria to move to next phase	No swelling or pain
	No increase in laxity
	Full pain-free ROM
	Less than 20% deficit in isokinetic test
	Completed intermediate exercise programme
	No feeling of instability
Advanced phase (8–12 weeks)	
Goals	Less than 10% deficit in isokinetic test for both hamstrings and quadriceps
	Achievement of the running and sports-specific progression without problems
	Good stability and self-confidence with the exercises
	Continue the moderate phase programme
	Focus on power and endurance
Strengthening	Add hip extension resistance placed over the knee
	Single leg CKC
	Add hamstrings OKC strengthening if the deficit persists on isokinetic testing: heel digs, supine bridge, theraband, weights
	Single dead lifts with weights
	We may associate hamstrings retraining with an anterior tibial glide (MWM)
Proprioception	Balance squat
	Internal/external perturbations
	Star excursion exercises/add perturbation (e.g. ball tasks tubing resistance on waist)
	Biodex balance (increase complexity)
Running progression	Straight line running
	Progress in speed, acceleration, deceleration
	Changing direction, cutting, figure-8 running
Jumping progression	Bilateral to unilateral hops: anterior-posterior and lateral hop, triple hop, cross-over hop
	Step up/step down
	Bilateral jumps and progress to unilateral
Functional/sports-specific	Single planar agility to multi-planar agility exercises

Current Reviews in Musculoskeletal Medicine (2022) 15:606–615
https://doi.org/10.1007/s12178-022-09794-z

SPORTS INJURIES AND REHABILITATION: GETTING ATHLETES BACK TO PLAY (R GALLO, SECTION EDITOR)

Return to Play after Posterior Cruciate Ligament Injuries

Michelle E. Kew[1] · John T. Cavanaugh[2] · William G. Elnemer[1] · Robert G. Marx[1]

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Abstract
Purpose of Review Posterior cruciate ligament injuries can be treated conservatively with a structured rehabilitation program or with surgical reconstruction. Treatment algorithms are based on a variety of factors including the patient's presentation, physical exam, and desired level of activity. The goal is to return the patient to their athletic pursuits with a stable and pain-free knee. Return to play and activities should be individualized based on the patient's injury and progression through rehabilitation. This article provides a review of the current treatments for posterior cruciate ligament injuries and the respective rehabilitation protocols, outcomes after each treatment option, and specific return to play criteria.
Recent Findings Current research shows excellent outcomes and return to play with conservative treatment of isolated posterior cruciate ligament injuries. Return to play algorithms stress the importance of quadriceps strengthening throughout the recovery process and emphasize inclusion of plyometrics and sport-specific training.
Summary Rehabilitation plays a critical role in the outcome after posterior cruciate ligament injury and the ability to return to athletics. The primary focus of post-injury or post-operative rehabilitation is to restore function, as it relates to range of motion, strength, and proprioception, while mitigating swelling and pain. The patients' desired sport and level of play dictate return to play timelines. The literature supports the use of non-operative management of isolated PCL injuries in athletes and non-athletes with excellent functional and patient-reported outcomes.

Keywords Posterior cruciate ligament injury · Posterior cruciate ligament reconstruction · Rehabilitation · Return to play

Introduction

Isolated posterior cruciate ligament (PCL) injury is uncommon with an estimated annual incidence of 2 per 100,000 [1]. These injuries typically present as multi-ligament injuries, specifically grade III PCL tears, with involvement of the collateral ligaments and or the anterior cruciate ligament [2]. The most common mechanism of isolated PCL injury is direct anterior trauma to a flexed knee and typically involves motor vehicle accidents, with one study showing that 57% of PCL injuries were a result of traffic accidents [3]. PCL injury can also occur in contact sports or with a fall directly on the front of the knee with the ankle in plantarflexion. PCL tears account for 2% of all high school knee injuries [4].

Traditionally, isolated PCL injuries have been managed non-operatively and surgical reconstruction is recommended for persistent instability or multi-ligamentous knee injuries [5]. Chronic PCL deficiency can lead to altered knee biomechanics and studies show increased arthrosis in 10% of patients [6]. Outcomes after surgical treatment of PCL insufficiency are mixed, likely due to low numbers of procedures performed, complex anatomy, and the constant posterior gravity force on the PCL at rest [7]. There is limited data as this injury remains relatively rare [8] and, as a result, many studies on the management of PCL injuries and outcomes report on a low number of patients with little consensus.

Rehabilitation plays a critical role in the outcome of either treatment option or the ability to return to athletics. The primary focus of post-injury or post-operative rehabilitation is to restore function, as it relates to range of motion, strength, and

This article is part of the Topical Collection on *Sports Injuries and Rehabilitation: Getting Athletes Back to Play*

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Thank you

