Research Letter

INTERNATIONAL JOURNAL OF SURGERY

OPEN

Management of posterior cruciate ligament injuries: an expert consensus from 17 countries

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Background: Posterior cruciate ligament (PCL) injury is a relatively common musculoskeletal condition. However, there is currently a lack of consensus on decision-making, treatment and postoperative management for such injuries.
Objectives: To use the modified Delphi method to reach expert consensus on the management of PCL injury.
Methods: A literature search of PubMed, Cochrane Library, Embase, and Web of Science for articles up to 17 October 2024, to support the development of recommendation statements. An Expert Panel of 90 experienced clinicians from orthopedics and sports medicine participated in a two-round Delphi process. Each statement was evaluated in two parts: the first part assessed content appropriateness (score of 7–9 indicating appropriateness and 4–6 indicating possible appropriateness), while the second part assessed agreement (score of 5–9 indicating agreement).
Results: The panel members developed 11 statements using the Delphi process, addressing the following topics: (1) clinical decision-making, (2) treatment, and (3) postoperative management about PCL injuries. The final consensus was reached on 11 statements and we eventually translated these statements into a corresponding table of expert recommendations.
Conclusion: Consensus was reached on 11 statements regarding three aspects of PCL injury management. These findings provide a foundation for developing evidence-based guidelines that can enhance clinical decision-making, improve treatment strategies, and optimize postoperative care for patients with PCL injuries.

Keywords: consensus, diagnosis, posterior cruciate ligament, treatment

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Introduction

Posterior cruciate ligament (PCL) injury is a relatively common musculoskeletal condition, which accounts for up to 17% of all knee injuries[1]. However, many existing recommendations primarily address general knee ligament injuries, lacking consideration for the specific characteristics of PCL injuries[2,3]. Given that symptoms of PCL injuries are often atypical and can be easily missed, diagnosis requires a combination of medical history, physical examination, and imaging studies[4]. Treatment plans need to be personalized based on the severity of the injury and the individual needs of the patient, including both conservative and surgical

HIGHLIGHTS

- Experts emphasize the importance of individualized treatment for PCL injuries, highlighting the need for further research into surgical techniques and graft choices.
- Experts highlight the importance of personalized rehabilitation protocols for PCL injury recovery, urging further research on recovery timelines and effective rehabilitation strategies.
- Experts stress the significance of early diagnosis in enhancing outcomes for PCL injuries, advocating for additional studies on diagnostic methods and their influence on treatment decisions.

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International Journal of Surgery (2025) 111:4080–4085

Received 22 January 2025; Accepted 11 April 2025

Supplemental Digital Content is available for this article. Direct URL citations are provided in the HTML and PDF versions of this article on the journal's website, www.lww.com/international-journal-of-surgery.

Published online 25 April 2025

http://dx.doi.org/10.1097/JS9.0000000000002416

options[5]. To fill this gap, we employed a two-round modified Delphi method involving 90 relevant experts to develop clinical consensus statements covering clinical decision-making, indications for surgery, surgical strategies, postoperative management, aimed at enhancing the clinical treatment standards for PCL injuries while also assisting in decision-making.

Method

Two senior authors co-chaired the panel and recruited 90 experienced clinicians from top-tier hospitals. Panel members were recognized clinical experts in sports medicine or orthopedics. The demographic summary of the expert panel was shown in Supplemental Digital Content, Table 1 (available at: http://links.lww.com/JS9/E71). In a modified Delphi process, panelists participated in two consecutive web-based surveys described below.

We conducted a literature search on 17 October 2024, across PubMed, Cochrane Library, Embase, and Web of Science, summarizing the latest advances in diagnosis, treatment and postoperative management. These findings were provided to an expert panel, which proposed 11 consensus statements related to diagnosis and treatment. These statements and supporting evidence were then sent to 26 experts via an online survey for rating and feedback on appropriateness, agreement, and potential modifications. Based on feedback from 26 experts, 11 statements were revised and sent to 30 additional experts for rating their appropriateness and agreement.

Results

Literature review and clinical experience

Assessment and diagnosis

Symptomatic PCL lesions are common in acute tears with other injuries or chronic tears, presenting with pain, swelling, and activity limitations. It is advisable to first examine the unaffected knee for comparison and to build trust with the patient. Ecchymosis and hematoma in front of the tibia are common, especially in dashboard injuries. Several maneuvers can aid in diagnosis when PCL injury is suspected (Supplemental Digital Content, Figure 1, available at: http://links.lww.com/JS9/E71 and Table 2, available at: http://links.lww.com/JS9/E71).

Radiographs are used initially to detect fractures or dislocations, while stress radiography can assess posterior laxity and predict posterolateral corner injuries[1]. Computerized tomography is useful for evaluating PCL injuries with fractures or avulsions[1]. Magnetic resonance imaging (MRI) is highly recommended for diagnosing PCL injuries and identifying associated ligament, meniscus, tendon, and cartilage damage[1]. Figure 1 shows the MRI of the injured PCL. However, MRI cannot assess knee function and may be unreliable for chronic tears with scar tissue.

Physical examination alone is insufficient for diagnosing isolated PCL injuries. Combining physical exams with imaging techniques provides a comprehensive diagnosis.

Treatment

The choice of treatment depends on the severity of the PCL injury, the presence of multiple ligament injuries, the existence of severe associated injuries, the patient's understanding of different treatment options, and the patient's specific needs for

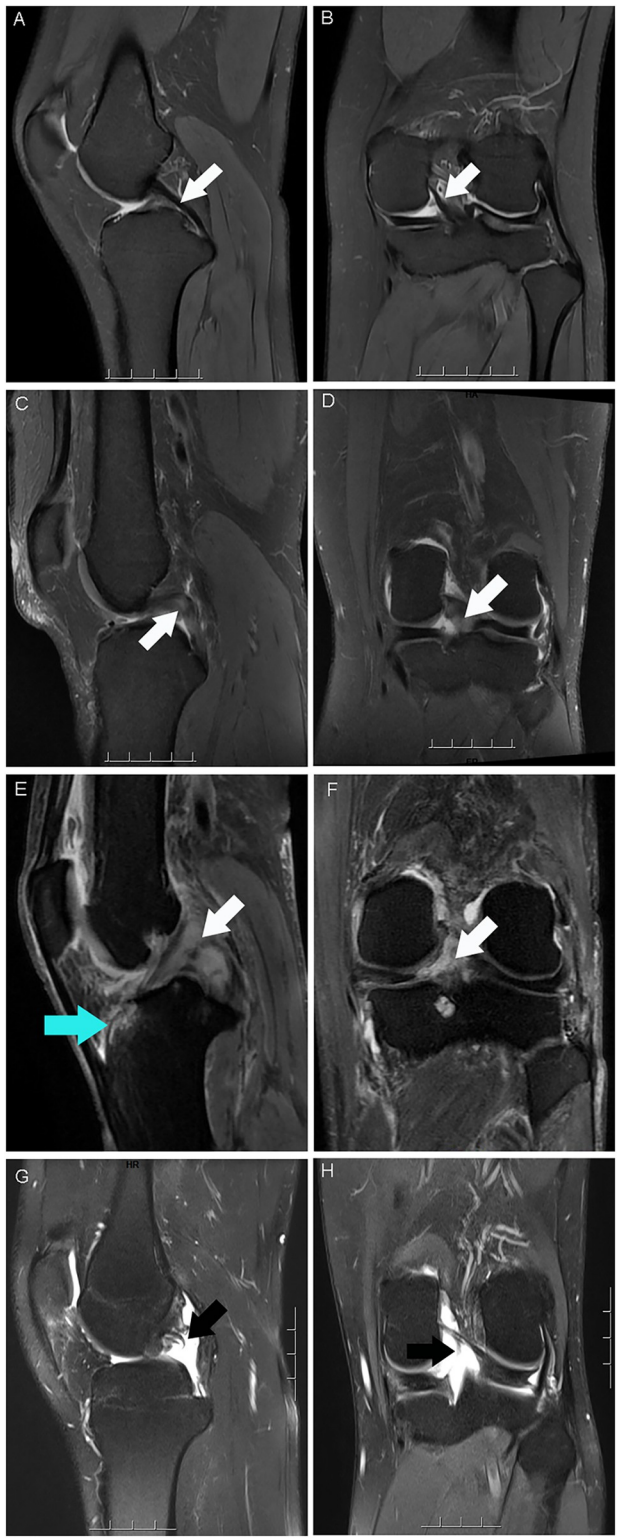

Figure 1. MRI of normal, partial tear, femoral insertion avulsion, and total tear of posterior cruciate ligament. A normal posterior cruciate ligament (PCL) is shown in a sagittal image in Panel A (white arrow) and a coronal image in Panel B (white arrow). A partial tear of PCL is shown in Panel C (white arrow) and Panel D (white arrow). A femoral insertion avulsion of PCL is shown in Panel E (white arrow) and Panel F (white arrow). A total tear of PCL is shown in Panel G (black arrow) and Panel H (black arrow).

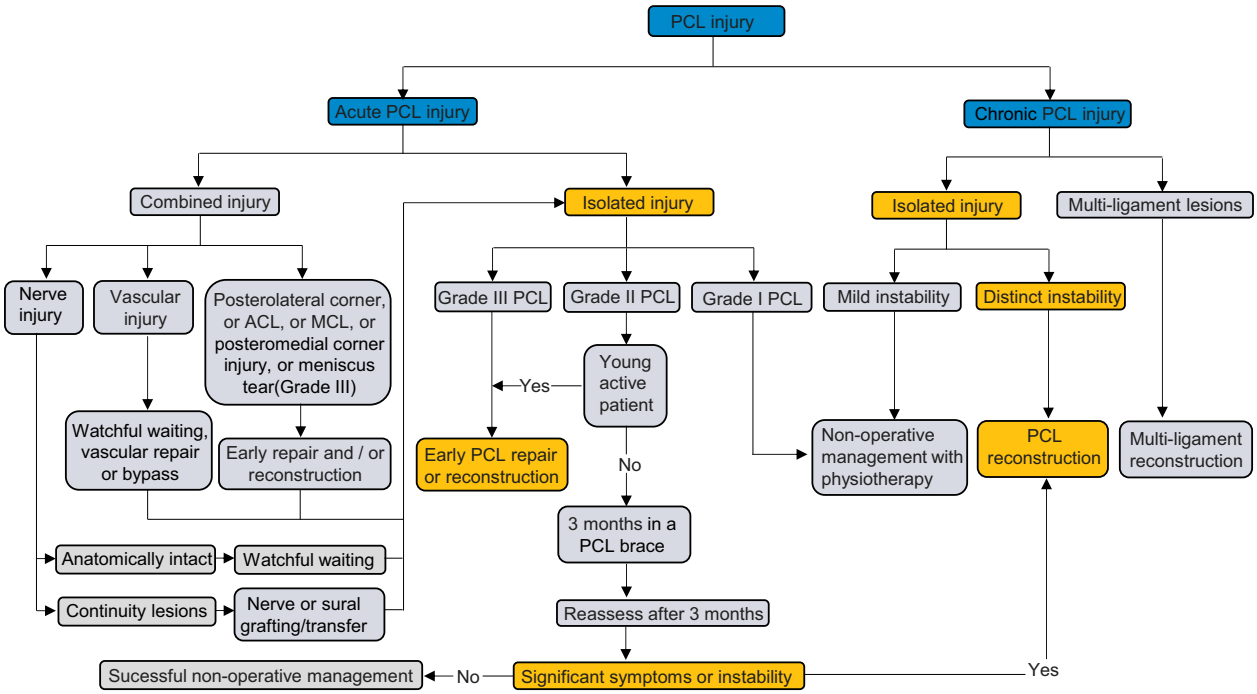

Figure 2. Algorithm for the management of posterior cruciate ligament injuries.

physical activity. The algorithm for the management of PCL injuries is concluded in Fig. 2. The indications of non-operative and operative treatment were showed in Supplemental Digital Content, Table 3 (available at: http://links.lww.com/JS9/E71). Nonoperative therapy includes 3 months of supervised physiotherapy, anti-inflammatory medications, range-of-motion training, gradual strengthening of the quadriceps, hamstrings, hip adductors, and core muscles, and a progressive return to activity[6]. Usually after week 15, clinical examination and/or stress radiograph are performed to objectively verify the healing of PCL[6]. The details about timing and surgical technique of PCL surgery were shown in Supplemental Digital Content, Table 4 (available at: http://links.lww.com/JS9/E71).

Complications of PCL injury

Most of the initial injury complications are a neurovascular injury from a multiligament injury, not an isolated PCL injury[7]. Complications from nonoperative treatment include laxity, stiffness, knee pain, degenerative joint disease, and reflex sympathetic dystrophy[7]. Intraoperative complications of PCL reconstruction include neurovascular injury, medial femoral condyle osteonecrosis, tibial or patella fracture, compartment syndrome, and tourniquet complications[7]. Postoperative complications include continued laxity, stiffness, anterior knee pain, painful hardware, heterotopic ossification, and infection[7].

Rehabilitation

Whether through conservative treatment or PCL reconstruction, the initial 1–6 weeks are the protective phase, followed by a transitional phase from 6 to 12 weeks for functional recovery[5]. Continuous knee function assessment during this period is crucial to ensure structural healing and a safe transition to subsequent functional phases[5,6]. Rehabilitation involves using a knee brace to prevent tibial posterior displacement and lock the knee in full extension initially, followed by a functional brace for ligament insufficiency, allowing daily activities and progression to higher-level activities[5,6].

Both open and closed kinetic chain exercises are essential in rehabilitation. Initially, open kinetic chain exercises for the quadriceps are prioritized, while hamstring open chain exercises should be avoided[5,6]. Closed-chain exercises like squats and leg presses play a key role in later stages, with leg presses recommended earlier due to their lower PCL tensile forces[5]. Once quadriceps strength reaches 90% of the uninjured side, patients can transition to more progressive activities[5].

Return to play

Due to the complex nature of PCL injury, no clear timeline exists for return to play after conservative treatment. Patients typically require at least 9 months of physical therapy and quadriceps strength recovery post-reconstruction before resuming sports[8]. Return to activity is advised once they regain painless motion and sufficient strength[8]. There is no consensus on assessing readiness, but functional tests like the single-leg hop, vertical jump, figure-8 run, and isokinetic testing can help evaluate safety[8].

Injury prevention

Most PCL injuries cannot be fully prevented. However, maintaining good strength and flexibility during sports activities can help reduce the risk of PCL injuries[9]. A prophylactic knee brace may be beneficial in preventing or limiting the severity of future injuries, particularly in knees that have previously been injured

Table 1

Experts assessment of appropriateness and agreement on ten recommendations

Category		Guidance statement*	Appropriateness	Agreement
Decision-making	1	If history and physical examination indicate PCL injury, MRI is recommended for diagnosis of PCL tear and confirmation of concomitant injury.	8.45 (1.15)	8.45 (1.25)
	2	Management of the PCL-injured should be an individualized shared clinical decision-making process approach between the treating medical clinician and the patient.	8.21 (1.25)	8.18 (1.22)
Treatment	3	Considering limited studies showing comparable outcomes of initial PCL reconstruction and conservative treatment for grade I (1–5 mm posterior tibial translation) and grade II (6–10 mm posterior tibial translation) isolated PCL tear, we recommend supervised, structured, and accelerated rehabilitation protocol as a replacement for initial reconstruction.	7.46 (1.62)	7.36 (1.87)
	4	If knee laxity is successively greater than grade II (6–10 mm posterior tibial translation), surgery is recommended then to prevent further damage to cartilage and meniscus.	7.38 (1.59)	7.16 (1.87)
	5	For individuals with posterior instability of the knee who have a demand for physical activity, PCL reconstruction is recommended, especially for athletes.	8.04 (1.41)	7.89 (1.57)
	6	Timing of early PCL reconstruction in isolated PCL tears should be based on clinical status rather than time from injury.	7.22 (1.86)	7.38 (1.71)
	7	Allografts or LARS can be considered a suitable alternative to autografts for PCL reconstruction.	6.55 (2.10)	6.27 (2.32)
	8	PCL reconstruction can consider single-bundle or double-bundle techniques, but the double-bundle technique has better knee stability and biomechanics. However, it's worth noting that double-bundle reconstruction surgery entails greater technical difficulty and a higher incidence of complications for beginners.	7.07 (1.78)	6.68(2.06)
Postoperative management	9	In initial rehabilitation, continuous evaluation of knee function for first 3 months is necessary.	7.89 (1.42)	7.91 (1.46)
	10	A thorough clinical and imaging evaluation is essential before athletes return to play whether accepting conservative or surgical treatment to reduce the risk of second injury, contralateral injury, or both.	8.38 (1.13)	8.45 (0.96)
	11	Long-term follow-up is recommended for patients undergoing PCL surgery. Knee function recovery and the presence of complications should be assessed at 1, 3, 6, and 12 months postoperatively. Subsequently, annual evaluations should include monitoring knee stability, assessing return to sports, and screening for osteoarthritis. For high-risk individuals, such as athletes and obese patients, muscle strength, knee stability, and balance testing every 6–12 months is advised.	7.76(1.49)	7.82 (1.62)

PCL: posterior cruciate ligament. MRI: magnetic resonance imaging.
Appropriateness: 1–3 inappropriate, 4–6 possibly appropriate, 7–9 appropriate.
Agreement: 1–4 disagree, 5–9 agree.
Decimal scores between rating intervals will be categorized as the lower bound of the adjacent interval.
*86 experts rated the statement 1; 85 experts rated the statement 2–10; 76 experts rated the statement 11.

or subjected to excessive forces during certain activities[8]. Populations such as post-injury athletes or participants in high-risk sports may particularly benefit from the use of knee braces[9]. Additionally, neuromuscular training, quadriceps strengthening, and proprioceptive exercises should be considered as preventive strategies[9].

Recommendations

These 11 recommendations involve clinical decision-making (1, 2), treatment (3–8), and postoperative management (9–11) about PCL injury. The consensus results indicated relatively lower appropriateness and agreement for the 7th recommendation and lower agreement for the 8th recommendation (Table 1). The detailed description of each recommendation was shown in Supplemental Digital Content, Table 5 (available at: http://links.lww.com/JS9/E71).

Discussion

Consensus was reached on 11 statements regarding three aspects of PCL injury management. Regarding the selection of grafts and reconstruction methods, it is considered that the appropriateness of the content and agreement is relatively low.

Clinical experts have limited endorsement of allografts or LARS as alternatives to autografts for PCL reconstruction, possibly due to several factors. The reliability of LARS remains uncertain, and its use is restricted when tissue remnants are absent, limiting its role as a scaffold[5]. Allografts carry higher risks of infection and rejection, requiring extensive screening[10]. In contrast, autografts offer better clinical outcomes, higher patient satisfaction, greater availability, and lower costs.

Clinical experts have limited endorsement of double-bundle reconstruction, possibly due to its greater complexity, higher complication risk, and increased cost compared to the single-bundle technique.

The literature lacks comprehensive guidelines and expert consensus. Few long-term randomized controlled trials compare conservative vs. surgical treatment, initial vs. delayed surgery, and single-bundle vs. double-bundle reconstructions. Further research is essential to assess the effectiveness of emerging treatments, including platelet-rich plasma augmentation, stem cell therapy, and primary PCL repair, in improving patient outcomes.

This manuscript presents evidence-based recommendations to guide the diagnosis and management of PCL injuries. These recommendations aim to assist clinicians in making informed decisions, administering treatment, and managing postoperative care for patients with PCL injuries.

Ethical approval

Ethical approval was not required for this study.

Consent

Consent was not required for this study.

Sources of funding

The National Key Research and Development Plan (2022YFC3601900, 2022YFC2505500), National Clinical Research Center for Geriatric Disorders, Xiangya Hospital (2021KFJJ06), Hunan Provincial Natural Foundation of China (2021JJ30040), and Science and Technology Innovation Program of Hunan Province (2023SK2024).

Author contributions

G.L., J.W., and S.G. contributed to the design and development of the study, as well as the formulation of statements and questions. All authors collaborated in refining the statements and questions, conducting surveys, interpreting the results, and jointly writing and revising the manuscript.

Conflicts of interest disclosure

There were no conflicts of interest.

Research registration unique identifying number (UIN)

Registration was not required for this study.

Guarantor

Guanghua Lei and Shuguang Gao.

Provenance and peer review

Not invited.

Data availability statement

The datasets generated and/or analyzed during the current study are available upon reasonable request.

Acknowledgements

The authors gratefully acknowledge the guidance in methodology provided by statistical experts Jie Wei, Ziying Wu, Haochen Wang, and Yilun Wang.

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