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Short-term Functional Outcomes After Operative Management of Posterior Cruciate Ligament Injuries: A Prospective Cohort Study

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Abstract

Background

Posterior cruciate ligament or PCL injuries are a relatively rare but clinically important type of knee ligament injury that can result in prolonged instability and a functional disability and, if not treated appropriately, early degenerative changes. While operative management has been suggested for symptomatic (high-grade) or combined injuries of the ligament, evidence on short-term functional status after surgical treatment is scarce.

Purpose

To review clinical and functional outcomes after operative management of posterior cruciate ligament injuries with validated patient-reported outcome measures.

Methods

The cohort study we conducted was prospective and was performed at a tertiary care center from July 2022 through to May 2024. Twenty-four skeletally mature patients with traumatic PCL injuries receiving operative management were included here. Surgery consisted of single-bundle arthroscopic PCL reconstruction or fixation of tibial avulsion fracture based on injury morphology. Functional outcomes were assessed using the International Knee Documentation Committee (IKDC) score and the Tegner–Lysholm knee score. The patients were followed up for six months postoperatively. Pre- and postoperative functional scores were compared using statistical analysis.

Results

An analysis of 24 patients (19 males and 5 females) and a mean age of 32.4 ± 8.6 years were analysed. The most common mechanism of injury was road traffic accidents. Both functional outcome measures showed significant improvements. The mean IKDC score was 53.88 ± 7.80 preoperatively and 87.50 ± 5.99 postoperatively ($p < 0.01$). In the same manner, the mean Tegner–Lysholm score increases from 56.17 ± 7.71 to 85.63 ± 6.49 ($p < 0.01$). No significant differences were observed between outcomes based on laterality or mechanism. Complications were rare and mostly minor.

Conclusion

Operative response to posterior cruciate ligament injury had a significant short-term positive effect on the functional knee outcome. Surgical stabilization following treatment with structured rehabilitation provided a reliable restoration of knee function in isolated or combined ligament injuries.

Level of Evidence

Level II – Prospective cohort study.

INTRODUCTION

Posterior cruciate ligament (PCL) injuries comprise approximately 3% of outpatient knee ligament injuries and can be diagnosed in up to 38% of patients with acute traumatic knee hemarthrosis [1,2]. Despite the importance in clinical practice, PCL injuries are often underdiagnosed at the initial presentation and are more frequently seen when ligamentous or osseous injury occur concurrently, leading to delayed treatment and also long-term morbidity for the patients [3]. The PCL is the most important restraint to posterior tibial translation and is a vital secondary stabilizer against force applied for rotation to maintain normal knee kinematics and load distribution [4,5]. Decreased PCL integrity results in a change to joint mechanics with elevated contact forces on the medial tibiofemoral and patellofemoral compartments [6].

PCL tears alone have an overall low prevalence (1–6%) and most of them develop as a co-occurring ligament injury pattern mainly to the posterolateral corner [7]. PCL injuries are frequently linked to high energy mechanisms such as (but not limited to) road traffic and sports-related injury, even though low-velocity mechanisms have recently been increasingly documented as well [7]. The typical history of untreated or less-medicated PCL injuries is progressive instability, anterior knee pain, decreased stair climbing abilities, meniscal injury, and early degenerative joint deterioration [8]. Chronic PCL deficiency has been linked to rapid osteoarthritic changes, especially in the medial and patellofemoral compartments [9].

Management of PCL injuries is controversial. Although selected low-grade injuries may be treated non-operatively, symptomatic grade III injuries and those involving many ligaments are referred to operative management [10,11]. Although published articles were limited in scope and retrospective and heterogeneous; the functional outcomes reported following surgical management are scarce [12]. Thus, the goal of this study is to assess the clinical and functional effects of an operatively managed posterior cruciate ligament repair for isolated, as well as for multiligament, injuries based on the score of the International Knee Documentation Committee and the Tegner–Lysholm knee score. We posit that a significant improvement in functional outcomes can be achieved by operative management regardless of injury pattern.

MATERIALS AND METHODS

This prospective interventional study was carried out in the Department of Orthopaedics, Acharya Vinoba Bhave Rural Hospital, Sawangi (Meghe), from July 2022 to May 2024. Approval of the study had been obtained from the Institutional Ethics Committee (IEC approval number: DMIMS(DU)/IEC/2022/42). Informed written consent was obtained from the patients prior to enrolment after explaining the surgical procedure, rehabilitation protocol, and possible complications.

Patients who visited the outpatient department with clinically and radiologically confirmed posterior cruciate ligament (PCL) injury were screened for inclusion. Twenty-four skeletally mature, symptomatic patients with traumatic PCL injuries who underwent operative management were included in the study.

Patients with bony avulsion of the PCL from the tibial or femoral attachment were also included. Patients with PCL injuries associated with infection, tumour, osteoarthritic changes, congenital or metabolic disorders, or those managed conservatively were excluded from this trial.

Standard preoperative evaluation for all patients was performed consisting of detailed history, clinical examination and radiologic evaluation. Clinical examination was focused on instability, pain, swelling, gait abnormality and functional limitations. Special tests including posterior drawer test, quadriceps active test, dial test, varus–valgus stress testing were performed to evaluate the PCL integrity and related ligamentous injuries. Radiological evaluation was performed with plain radiographs of the knee, magnetic resonance imaging to confirm diagnosis, grade the injury, and assess associated ligamentous or meniscal injuries. All patients were subjected to routine laboratory investigations and pre-anaesthetic assessment.

Surgical Technique

All procedures were carried out under regional anesthesia; the patient was in the supine position with a pneumatic tourniquet on the proximal thigh. Standard arthroscopic portals were applied.

Fixation of Bony Avulsion Injuries

In PCL avulsion fractures the fixation technique was determined based on fragment size and morphology. Avulsion fragments larger than 2 cm were fixed with 4-mm partially threaded cannulated cancellous screws, and comminuted fragments were managed with non-absorbable suture fixation (Ethibond No. 2).

Arthroscopic Single-Bundle PCL Reconstruction

Ligamentous PCL injuries had been treated with arthroscopic single-bundle reconstruction. Knee arthroscopic assessment was performed using the standard anterolateral and anteromedial portals. The posterior cruciate ligament was visualised, and ligament integrity was evaluated through fibre continuity, tension, and attachment to the femoral footprint. PCL fibres were subjected to intraoperative disruption and fraying (Figure 1). Femoral and tibial tunnels were formed by common arthroscopic procedures, similar to the anterolateral bundle footprint.

Graft Selection

Autologous tendon grafts were utilized in all instances. The semitendinosus and gracilis tendons were used for isolated ligamentous injuries, and peroneus longus tendon was used in selected multiligament injury patterns or when additional graft length was required.

Graft Fixation

Graft fixation was performed on the femoral side with endobutton loops and interference screws or suture disc fixation on the tibial side depending on bone quality and injury pattern. Proper graft tension

was verified arthroscopically prior to fixation.

At the end of the procedure, extensive arthroscopic lavage was carried out and wounds were closed in layers under sterile conditions. Finally, a long knee immobiliser was placed with full extension of the knee to prevent posterior tibial sag and retain the reconstructed posterior cruciate ligament. Limb was well aligned and the brace was fixed to stabilize the neutral tibial position. The immobiliser was placed during the immediate postoperative period, particularly during ambulation and rest, for stabilization and to decrease stress to the graft/fixation construct during the general recovery after the reconstruction phase.

Rehabilitation strategy

During postoperative rehabilitation, a specific approach based on the phase structure was used with early quadriceps activation, management of edema, protected range of motion, and slow advancement of weight-bearing. The exact rehabilitation protocol is detailed in Table 1.

Table 1. Rehabilitation protocol for PCL Avulsion and Ligamentous PCL Injuries

Injury Type	Phase	Weight Bearing	Brace	ROM	Key Rehabilitation Focus
PCL Avulsion	0–3 weeks	Non–weight bearing	Knee immobiliser in full extension	No active ROM	Quadriceps sets, SLR with brace, patellar mobilization, core isometrics
	3–6 weeks	Partial from 4th week	Continued	Assisted ROM → ~120°	Progressive quadriceps strengthening
	>6 weeks	Full as tolerated	Discontinued	Full ROM	Progressive strengthening; return to activity after radiological union
Ligamentous PCL	Phase 1 (0–8 weeks)	NWB 3–4 weeks → partial	Brace in full extension	Passive ROM after 4th week	Quadriceps activation; avoid hamstring strengthening
	Phase 2 (8–16 weeks)	Progressive	Discontinued	Active flexion → ~110°	Closed-chain exercises, cycling, proprioception
	Phase 3 (4–6 months)	Full	None	Full ROM	Progressive strengthening; hamstrings ≥6 months; agility/plyometrics

Patients were monitored postoperatively at 1, 3, and 6 months. Pain, swelling, stability, range of motion, wound status, and any complications at each followup visit were assessed clinically. Functional

outcomes were evaluated by validated patient-reported outcome measures, such as the International Knee Documentation Committee (IKDC) and Tegner–Lysholm knee scores. Radiographic investigation was used where appropriate to examine fracture union in avulsion injuries and to assess implant position and integrity in ligament reconstruction cases.

Statistical Analysis

Data collected were logged in a standardised database and subsequently analyzed using SPSS software (version 27). Continuous variables were presented as mean ± standard deviation. Statistical analysis was conducted using Student's t-test and Pearson's correlation analysis as appropriate. The 95% confidence interval was used and a p value < 0.05 was defined as statistically significant.

RESULTS

A total of 24 patients with posterior cruciate ligament injuries were included in the study. In this cohort, males were predominantly represented (79.2%), while females accounted for 20.8% of cases. Road traffic accidents were the most common mechanism of injury, followed by twisting injuries and falls. The side involved was equally distributed between right and left knees. Table 2 summarizes baseline demographic and injury information of the study population.

Table 2. Baseline demographic and injury characteristics

Variable	Value
Total patients	24
Male	19 (79.2%)
Female	5 (20.8%)
Right knee involvement	12 (50.0%)
Left knee involvement	12 (50.0%)
Road traffic accident	11 (45.8%)

In terms of the type of PCL injury, full-thickness PCL tears were the most frequent presentation (12 patients, 48.0%), followed by PCL avulsion fractures with ligament injury (5 patients, 20.0%), mid-substance partial-thickness tears (4 patients, 16.0%), and near full-thickness tears with subluxation (3 patients, 12.0%). Only a small percentage (1 patient, 4.0%) had MRI findings that suggested PCL injury without a well-defined tear morphology. Associated injuries were often seen. Anterior cruciate ligament (ACL) involvement was present in 15 (62.5%) patients and meniscal injury was observed in 13 (54.2%) of patients. In addition, collateral ligament involvement was noted in a few patients. Just 2 patients (8.3%) had isolated PCL injury without ligamentous or meniscal pathology. Most patients had the use of an arthroscopic procedure while open reduction and internal fixation had been carried out for patients with

avulsion fractures. The most commonly used graft was peroneus longus tendon; semitendinosus and gracilis tendon grafts followed. The diameters of grafts most commonly ranged between 8 and 10 mm. Table 3 summarizes operative procedures and graft characteristics.

Table 3. Operative procedure and graft characteristics

Variable	n (%)
Arthroscopic reconstruction	22 (91.7%)
ORIF for avulsion fracture	2 (8.3%)
Peroneus longus graft	11 (45.8%)
Semitendinosus + gracilis graft	10 (41.7%)
Fiber tape augmentation	1 (4.2%)
No graft required	2 (8.3%)

Postoperative radiographic assessment revealed that implant placement was satisfactory with implant fixation intact for all operated cases. Postoperative radiographs in patients with PCL avulsion injuries addressed with cannulated cancellous screws confirmed stability of reduction and proper screw placement. Likewise, subjects experiencing arthroscopic PCL reconstruction displayed adequate tunnel alignment and preserved the integrity of the implant, without signs of loosening or displacement. Representative postoperative radiographs demonstrating fixation constructs are shown in Figure 2.

Functional outcome assessment demonstrated significant improvement following operative management. The mean IKDC subjective score improved from 53.88 ± 7.80 preoperatively to 87.50 ± 5.99 postoperatively. Similarly, the mean Tegner–Lysholm knee score increased from 56.17 ± 7.71 to 85.63 ± 6.49. The improvement in functional outcome scores is illustrated in Figures 3 and 4

Subgroup analysis confirmed that functional outcomes did not differ significantly between right- and left-sided injuries. Similarly, the mechanism of injury had little effect on postoperative IKDC or Lysholm scores. Pearson correlation analysis was performed to assess potential postoperative predictors of functional outcomes. Age, side of injury, mechanism of injury, associated injuries, graft diameter, and duration of surgery were analyzed. There was no statistically significant association between these variables and postoperative IKDC or Lysholm scores ($p > 0.05$). In Table 4, we show the results of the correlation analysis.

Table 4. Correlation analysis of clinical variables with postoperative functional outcomes

Variable	Post-operative IKDC Score (r)	p value	Post-operative Lysholm Score (r)	p value
Age	−0.18	0.41	−0.15	0.48
Mode of injury	0.21	0.32	0.19	0.37
Side involved	0.12	0.56	0.1	0.63
Associated injuries	−0.26	0.21	−0.24	0.26
Graft diameter	0.31	0.14	0.28	0.18
Duration of surgery	−0.09	0.67	−0.11	0.6

Postoperative complications were uncommon. Thirteen patients in this group (54.2%) did not have any complications, while the other patients developed mild complications such as quadriceps weakness (3 patients, 12.5%), persistent pain (2 patients, 8.3%), and stiffness associated with quadriceps weakness (2 patients, 8.3%). One of each (4.2%) presented isolated complications (eg, infection, loss of sensation, or stiffness). No major complications were observed in the follow-up or recovery of grafts. Generally, operative management of PCL injuries led to notable functional gains and low rates of secondary complications, and favourable short-term clinical outcomes post-surgical stabilisation with guided rehabilitation were observed.

DISCUSSION

Posterior cruciate ligament (PCL) injuries are a difficult subset of knee ligament injury given their low frequency, tendency to occur in conjunction with other ligamentous injuries, and wide variation in clinical presentation. While restoring the stability of the posterior knee is the main aim of surgical treatment, functional recovery depends on many aspects, like injured ligaments and rehabilitation protocols.

In the current study, functional responses to operative management for PCL injuries manifested significant improvement in both the IKDC subjective score and Tegner–Lysholm knee score. These results are congruent with those of previous evidence for surgical intervention in symptomatic PCL injuries. Chen et al. [13] reported significant gains in Lysholm scores and good IKDC grades for surgically repaired knee, demonstrating successful knee function repair. Similarly, Zhao et al. [14] showed large postoperative improvements of IKDC and Lysholm scores in patients undergoing both isolated and combined PCL reconstructions.

The postoperative functional scores in the current series are similar to findings of Patel et al. [15], who assessed the mean Lysholm and IKDC scores with 85.2 ± 10 and 84 ± 12.3, respectively, following the operative management . Zhao et al. [14] improved IKDC scores from 51.65 ± 12.35 preoperatively to 84.52 ± 6.42 postoperatively, and Lysholm scores from 53.90 ± 11.86 to 85.68 ± 4.99, all close to the functional gains observed in this particular study. By neither side affected nor the mechanism of the

injury, statistically significant differences in functional outcomes were observed. This is consistent with Lu et al. [16] who demonstrated no significance of an injury mechanism that resulted in changes in IKDC and Lysholm scores post PCL injury after the appropriate stabilization of the operating room and rehabilitation. This shows that posterior stability restoration and rehabilitation could have a greater impact on functional recovery than injury features alone.

The demographic characteristics of the present cohort, with predominantly young adult males predominating and road traffic accidents accounting for the most frequent form of injury, is in line with Chen et al. and Zhao et al. [13,14], especially in areas with excessive motor vehicle injuries burden. In comparison, sports-related injury has been established as the most common cause in other population groups, underscoring regional variation in epidemiology [17]. Ligamentous and meniscal related injuries were repeatedly noticed, further emphasizing that isolated PCL lesions are rare.

Nevertheless, the complication rate was fairly low and complications for the most part minor similar to the low observed complication rates in Chen et al. [13]. Yet a small sample size and non-operative control group precludes definitive conclusions over time. Wang et al. [18] have emphasized the need to conduct long-term follow-up studies to evaluate degenerative effects after PCL reconstruction.

All in all, the results of this investigation also provide evidence that operative management of PCL injuries when appropriately recommended and in conjunction with structured rehabilitation, is associated with a large recovery in function, and similar outcomes to what we have observed in the current literature.

Study limitations

There are constraints on this study. For a start, the findings are not widely applicable, and the sample size, although small, limits the generalization and reduces statistical power to identify patterns with the subgroup differences. Second, the 6-month duration of the follow-up represents primarily short-term functional recovery, without scope for evaluation of other long-term outcomes such as graft durability, recurrent instability, or degenerative joint changes. Third, the patients involved were heterogeneous in patterns of injury including single PCL tears, avulsion fractures and combination ligament tears, which may affect functional outcomes. Finally, objective biomechanics including instrumented posterior laxity measurement was not performed. Studies involving larger cohorts in the future, standardized surgery, standardized method of operation of PCL, and longer follow-up are needed to further clarify successful management strategies regarding PCL injuries.

CONCLUSION

Treatment of posterior cruciate ligament injuries provided a marked improvement in functional knee outcomes as evidenced by large improvement in International Knee Documentation Committee and Tegner–Lysholm scores at short- to mid-term follow-up. Both single and combined ligament injury patterns yielded favorable results, and injury laterality and mechanism did not significantly influence postoperative functional recovery. Complications were low and mainly non-severe, suggesting a safe

application of traditional surgical approaches in the context of proper management of rehabilitation protocols. Small sample size and short follow-up period were the limitations of the current study but the present study contributes another evidence for the effective rehabilitation of knee mobility and stability via appropriate surgical procedures in PCL injuries. Additional prospective studies using larger cohorts and long-term follow-up are necessary to establish long-term outcomes and enhance therapeutic algorithms.

Abbreviations

ACL – Anterior Cruciate Ligament

ANOVA – Analysis of Variance

IKDC – International Knee Documentation Committee

MRI – Magnetic Resonance Imaging

NWB – Non–Weight Bearing

ORIF – Open Reduction and Internal Fixation

PCL – Posterior Cruciate Ligament

PLC – Posterolateral Corner

ROM – Range of Motion

SLR – Straight Leg Raise

DECLARATIONS

Ethics Approval

The study gained approval from the Institutional Ethics Committee of Datta Meghe Institute of Higher Education and Research (Approval number: DMIMS(DU)/IEC/2022/42). All procedures conducted in this study on humans were conducted in full accordance with institutional and national ethical standards and with the 1964 Helsinki Declaration and its subsequent amendments.

Consent to Participate

Written informed consent was obtained from all participants included in the study.

Consent for Publication

All authors consent to the publication of this manuscript.

Conflict of Interest

The authors declare that they have no conflict of interest.

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Author Contributions

Study design, data analysis, manuscript preparation: A.S., S.D., K.D., S.G.

Data collection, surgical management, manuscript review: A.S., K.D.,

REFERENCES

1. Fanelli GC, Edson CJ. Posterior cruciate ligament injuries in trauma patients. **Arthroscopy.** 1995;11:526–529.
2. Schulz MS, Russe K, Weiler A, et al. Epidemiology of posterior cruciate ligament injuries. **Am J Sports Med.** 2003;31:173–178.
3. Loos J, et al. Diagnostic challenges in posterior cruciate ligament injuries. **Knee Surg Sports Traumatol Arthrosc.** 2005;13:425–430.
4. Harner CD, Höher J. Evaluation and treatment of posterior cruciate ligament injuries. **Am J Sports Med.** 1998;26:471–482.
5. Gupte CM, Bull AMJ, Thomas RD, et al. Biomechanics of the posterior cruciate ligament. **Knee.** 2003;10:219–225.
6. Skyhar MJ, Warren RF, Ortiz GJ, et al. The effects of posterior cruciate ligament deficiency on knee joint mechanics. **Am J Sports Med.** 1993;21:54–60.
7. Schulz MS, et al. Mechanisms and patterns of posterior cruciate ligament injury. **Am J Sports Med.** 2003;31:173–178.
8. Boynton MD, Tietjens BR. Long-term follow-up of the untreated isolated posterior cruciate ligament-deficient knee. **Am J Sports Med.** 1996;24:306–310.
9. Keller PM, Shelbourne KD, McCarroll JR, Rettig AC. Nonoperatively treated isolated posterior cruciate ligament injuries. **Am J Sports Med.** 1993;21:132–136.
10. Rubinstein RA, Shelbourne KD. Nonoperative treatment of isolated posterior cruciate ligament injuries. **Am J Sports Med.** 1999;27:550–554.
11. Harner CD, et al. Surgical management of posterior cruciate ligament injuries. **J Bone Joint Surg Am.** 2000;82:139–152.
12. Jari S, Shelbourne KD. Current controversies in PCL injury management. **Clin Sports Med.** 2004;23:659–674.

13. Chen Y, et al. Arthroscopic fixation techniques for PCL avulsion fractures. **Arthroscopy.** 2012;28:143–149.
14. Zhao J, et al. Clinical outcomes after posterior cruciate ligament reconstruction. **Knee Surg Sports Traumatol Arthrosc.** 2016;24:208–214.
15. Patel DV, Allen AA, Warren RF, et al. Outcomes following posterior cruciate ligament reconstruction. **Am J Sports Med.** 2007;35:1921–1927.
16. Lu H, et al. Functional outcomes following operative treatment of PCL injuries. **Knee Surg Sports Traumatol Arthrosc.** 2015;23:295–302.
17. Rasmussen MT, et al. Epidemiology of sports-related knee ligament injuries. **Clin Sports Med.** 2013;32:183–194.
18. Wang D, et al. Long-term outcomes following posterior cruciate ligament reconstruction. **Knee Surg Sports Traumatol Arthrosc.** 2018;26:135–142.

Figures

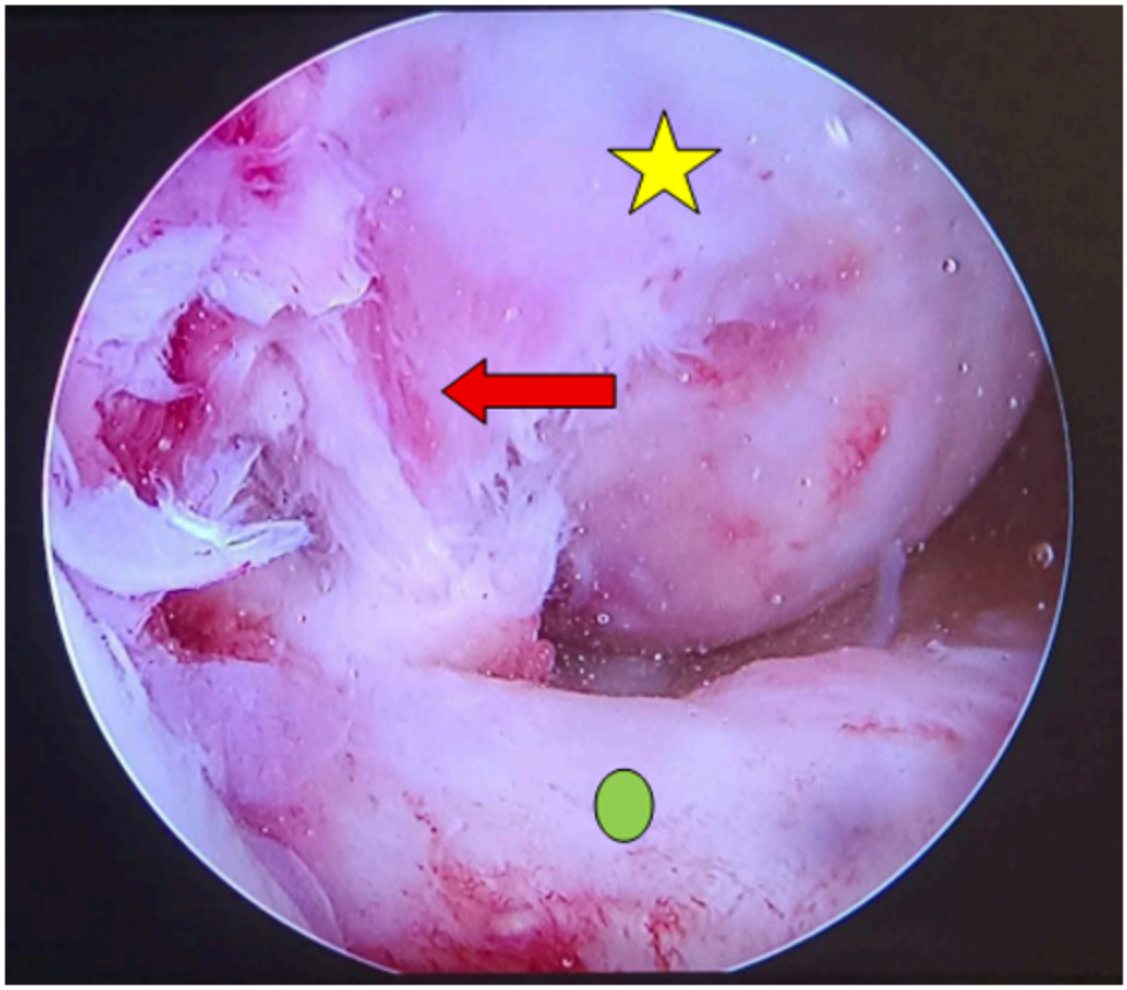


Figure 1

Arthroscopic view of the knee demonstrating a torn posterior cruciate ligament. The **red arrow**indicates disrupted and frayed PCL fibers with loss of normal tension. The **yellow star** marks the femoral attachment region, while the **green circle**denotes the posterior tibial surface, providing anatomical orientation.

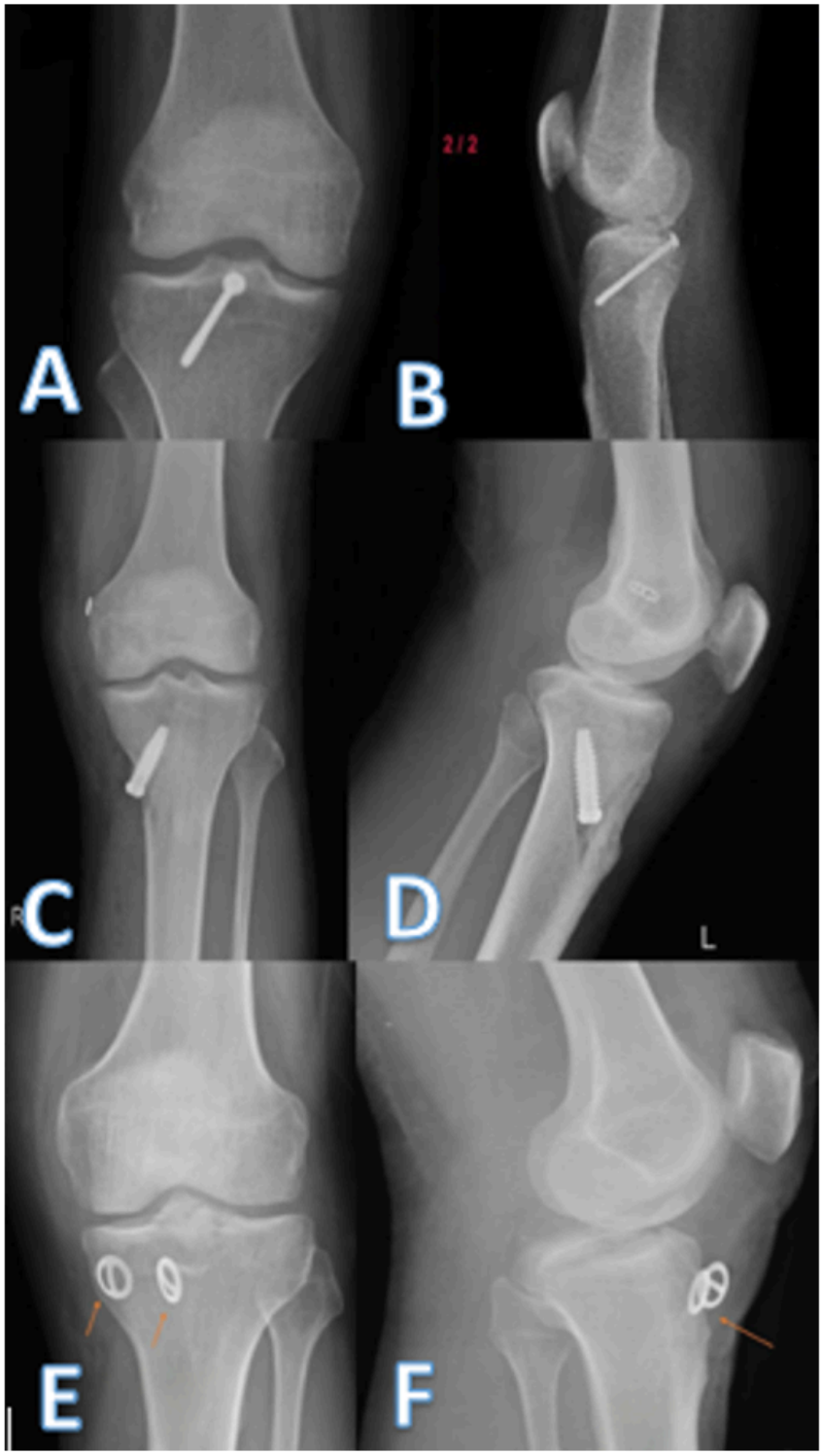


Figure 2

Postoperative radiographs demonstrating fixation constructs used for posterior cruciate ligament injuries. (A, B) Anteroposterior and lateral views showing stable cannulated cancellous screw fixation for tibial PCL avulsion. (C, D) Anteroposterior and lateral views showing interference screw fixation following posterior cruciate ligament reconstruction, with maintained implant position. (E, F) Anteroposterior and lateral views demonstrating arthroscopic suture disc fixation for bicruciate tibial avulsion fracture, with maintained implant position.

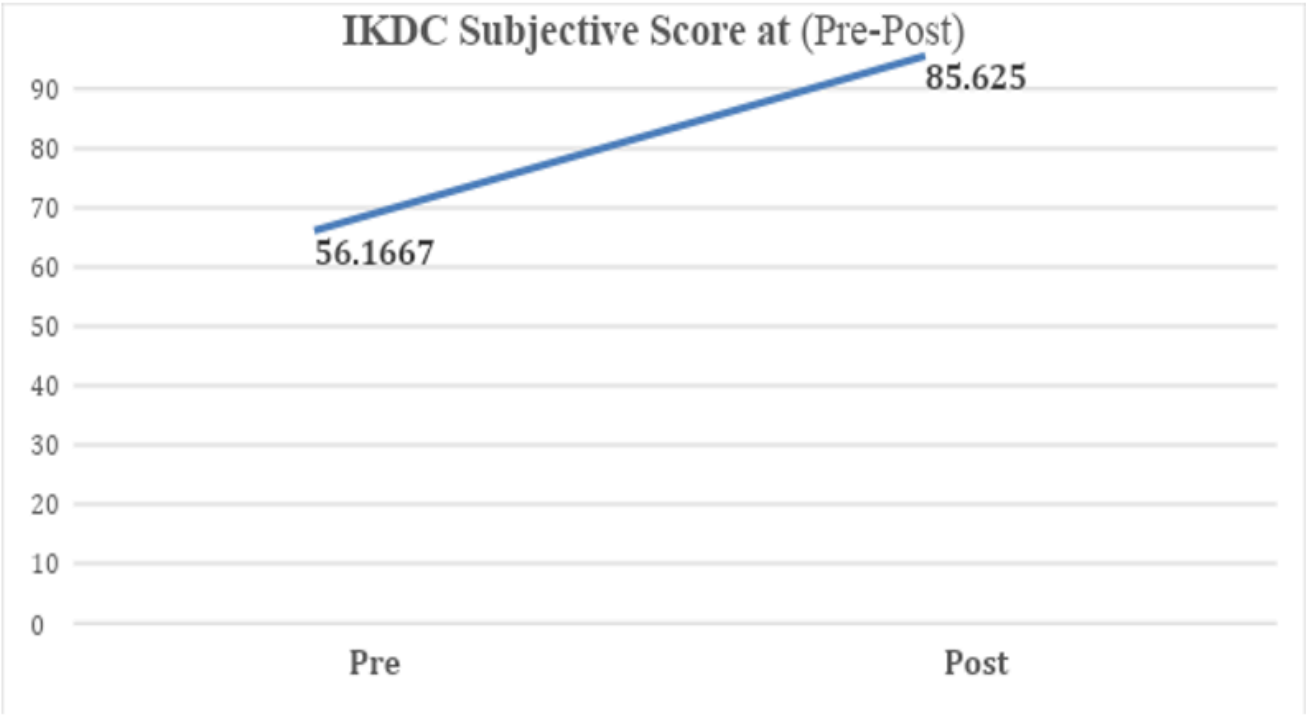


Figure 3

Comparative evaluation of IKDC Subjective Score at two different timelines (post) among the study participants

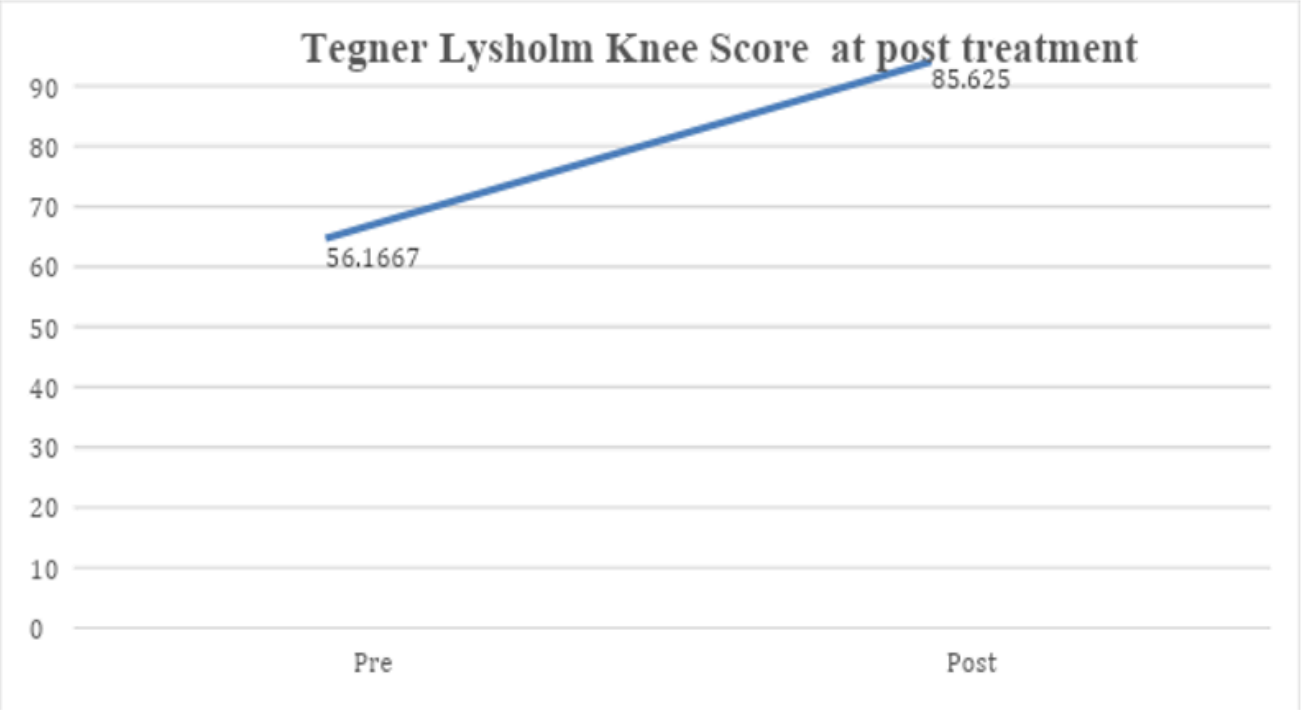


Figure 4

comparative evaluation of Tegner Lysholm Knee Score at two different timelines (post treatment) among the study participants