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Original Research Article

Optimal Staging and Single-Stage Arthroscopic Management Protocols for Combined ACL/PCL or Posterolateral Corner Injuries: A Prospective Clinical Study

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ABSTRACT
Background: Combined anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), and posterolateral corner (PLC) injuries are technically demanding and may result in persistent multidirectional instability, stiffness, and loss of activity. The preferred timing of reconstruction and the role of single-stage treatment remain debated.
Objective: To evaluate functional recovery, objective stability, range of motion, complications, and timing associations following protocol-based single-stage management of combined ACL/PCL or cruciate-PLC injuries.
Methods: This prospective, single-centre interventional study included 40 adults with ACL+PCL, ACL+PLC, PCL+PLC, or ACL+PCL+PLC injuries. All underwent single-stage arthroscopic cruciate reconstruction, with PLC repair or reconstruction when indicated, followed by structured phase-based rehabilitation. Lysholm, subjective International Knee Documentation Committee (IKDC), and Tegner scores were compared before surgery and at final follow-up using the Wilcoxon signed-rank test. Spearman correlation assessed associations between injury-to-surgery interval and final outcomes.
Results: Mean age was 30.75±8.75 years, and 27 (67.5%) patients were men. Road traffic or motorcycle trauma accounted for 19 (47.5%) injuries. Mean injury-to-surgery interval was 5.35±2.60 weeks, and mean follow-up was 19.95±2.84 months. Lysholm score improved from 29.15±5.61 to 88.15±5.18, subjective IKDC from 31.10±5.30 to 84.68±5.32, and Tegner score from 2.00±0.78 to 6.45±1.47 (all $p<0.001$). Objective IKDC grade A or B was achieved in 34 (85.0%) patients. Nine (22.5%) patients had a recorded complication, most commonly arthrofibrosis. Longer time to surgery correlated with lower postoperative Lysholm ($\rho=-0.699$), IKDC ($\rho=-0.681$), and Tegner scores ($\rho=-0.669$), and with greater motion loss (all $p<0.001$). In the exploratory ≤6-week versus >6-week comparison, the earlier group had better final scores but was also substantially younger and had higher baseline function.
Conclusion: Protocol-based single-stage treatment produced substantial functional improvement and acceptable objective stability at short- to mid-term follow-up. The observed timing relationships were confounded and do not establish an optimal operative threshold or superiority over staged reconstruction.

Keywords: Anterior Cruciate Ligament, Functional Outcome, Multiligament Knee Injury, Posterior Cruciate Ligament, Posterolateral Corner, Single-Stage Reconstruction, Surgical Timing.

INTRODUCTION
Multiligament knee injury represents a heterogeneous spectrum extending from bicruciate disruption to combined cruciate and collateral or corner injuries. Although

uncommon, these injuries carry disproportionate clinical consequences because several stabilising structures fail simultaneously, often after high-energy trauma. The resulting instability may affect more than one plane, and associated meniscal, chondral, neurovascular, or soft-tissue injury can further complicate treatment. Contemporary multicentre evidence also shows substantial variation in presentation, injury pattern, and operative strategy, reflecting the absence of a universally applicable pathway.[1]

A central controversy is whether all injured structures should be addressed in one operation or divided across stages. Single-stage management restores the principal stabilisers during one anaesthetic exposure and may reduce repeated admissions and rehabilitation interruptions. Yet it is technically demanding. Multiple tunnels must be planned without convergence, graft fixation and tensioning require a disciplined sequence, and early motion must be balanced against protection of several reconstructions. Indian single-centre studies have nevertheless reported favourable short-term outcomes after one-stage reconstruction across different multiligament patterns.[2–4]

Timing is equally unsettled. Early reconstruction may limit the period of gross instability and facilitate anatomical identification, whereas delayed intervention allows swelling to settle and preoperative motion to recover. Both approaches have recognised risks. Surgery in a stiff, inflamed knee may increase arthrofibrosis, while prolonged delay may be accompanied by muscle deconditioning, secondary meniscal or chondral damage, and entrenched instability. Published cohorts have not produced a single timing threshold that can be applied without considering soft-tissue condition, range of motion, associated injury, age, and rehabilitation readiness.[5]

The present study evaluated patients with ACL+PCL, ACL+PCL+PLC, PCL+PLC, or ACL+PLC injuries managed in one operative sitting. The primary objective was to quantify change in Lysholm, subjective IKDC, and Tegner scores. Secondary objectives were to describe objective ligament stability, residual motion loss, complications, outcomes across injury patterns, and the unadjusted relationship between injury-to-surgery interval and final functional status.

MATERIALS AND METHODS

Study Design and Setting

This prospective, single-centre interventional study was conducted in the Department of Orthopaedics, in a tertiary care center, Bangalore for a period of18 Months from September 2022 to March 2024.

The cohort comprised 40 patients who underwent single-stage operative management for combined multiligament knee injuries and completed at least 14 months of follow-up.

Study Population and Eligibility

Eligibility was determined using the following predefined criteria.

Inclusion Criteria

- Age between 20 and 45 years.
- Acute multiligament knee injury presenting within three weeks of trauma or chronic injury presenting at three weeks or later.
- Combined ligament pattern involving ACL+PCL, ACL+PLC, PCL+PLC, or ACL+PCL+PLC.
- Grade II or III instability demonstrated on clinical examination and stress-radiographic assessment, with the injury pattern confirmed on magnetic resonance imaging.
- Skeletal maturity with closed physes.
- Willingness to provide written informed consent and comply with the prescribed rehabilitation and follow-up programme.
- No previous ligament surgery on the affected knee.

Exclusion Criteria

- Isolated single-ligament knee injury.
- Inflammatory arthritis or severe radiographic osteoarthritis (Kellgren-Lawrence grade 3 or higher).
- Associated neurovascular injury requiring acute operative repair.
- Active local or systemic infection.
- Contralateral knee instability likely to interfere with rehabilitation or outcome assessment.
- Pregnancy.
- Body mass index greater than 40 kg/m².
- Open physes.

Sample Size

The final analytic sample comprised 40 eligible patients who completed the required follow-up.

Preoperative Assessment and Imaging

Baseline evaluation recorded age, sex, affected side, mechanism of injury, interval from injury to surgery, injury pattern, and preoperative Lysholm, subjective International Knee Documentation Committee (IKDC), and Tegner scores.

Radiographic and Stress-Radiographic Assessment

Standard weight-bearing anteroposterior, lateral, and skyline radiographs were obtained. Varus and valgus stress radiographs were performed at both 0° and 30° of knee flexion using a Telos stress device with an applied force of 15 daN. Posterior tibial translation was quantified on posterior drawer stress radiographs obtained with the same 15-daN force.

Magnetic Resonance Imaging Protocol

Magnetic resonance imaging was performed on a 3.0-T Philips Ingenia system using a dedicated knee coil. T1-weighted, T2-weighted, and proton-density fat-saturated sequences were acquired in sagittal, coronal, and axial planes. All examinations were interpreted by a consultant musculoskeletal radiologist.

Vascular Assessment

Pedal pulses were assessed and documented in every patient. An ankle-brachial index was obtained when pedal pulses were not clearly palpable. Computed-tomographic angiography was selectively performed when arterial injury was suspected clinically.

Clinical Laxity Assessment and Diagnostic Arthroscopy

Immediately before surgery, examination under anaesthesia included the Lachman test, pivot-shift test, posterior drawer test, dial tests at 30° and 90°, reverse pivot-shift test, and varus and valgus stress tests at 0° and 30°. Diagnostic arthroscopy was then used to confirm cruciate and posterolateral or posteromedial instability and to document meniscal tears and cartilage lesions using the Outerbridge grading system.

Operative Technique

All procedures were performed by the same orthopaedic surgeon under general anaesthesia. A pneumatic thigh tourniquet was applied and inflated to 300 mmHg. Intravenous cefazolin 2 g was administered 30 minutes before skin incision. Standard anterolateral and anteromedial arthroscopic portals were used. Posterior-horn meniscal tears were repaired with a FasT-Fix all-inside device when suitable, whereas tears involving the body were treated using an inside-out technique with zone-specific cannulas. Irreparable tears underwent partial meniscectomy with a shaver. Unstable chondral flaps were treated by chondroplasty using a shaver or radiofrequency device, and suitable full-thickness defects underwent microfracture using awls to a depth of 3-4 mm. Torn ACL and PCL fibres were debrided while identifiable native footprints were preserved.

Tunnel Preparation and Anatomical Positions

The PCL tibial tunnel was prepared through a posteromedial portal using a 70° PCL guide centred on the PCL facet approximately 1 cm below the joint line in the PCL fossa; tunnel diameter was matched to the graft and ranged from 8 to 10 mm. The ACL tibial tunnel was positioned in the centre of the native ACL footprint anterior to the PCL tunnel using an elbow aimer set at 55°, with a diameter of 7-9 mm. The PCL femoral tunnel was created by an outside-in technique through a small medial femoral condyle incision, with the guide pin placed at the 1 o'clock position for the right knee or 11 o'clock position for the left knee, 6-8 mm from the articular margin. The ACL femoral tunnel was drilled through the anteromedial portal at the anatomical footprint on the lateral intercondylar wall, with a diameter of 7-9 mm and depth of 30-35 mm.

When PLC treatment was indicated, a 5-cm lateral incision was made over the lateral epicondyle and fibular head. The fibular tunnel was directed from anterolateral to posteromedial just distal to the fibular styloid and measured 5-6 mm. The femoral socket was positioned proximal and posterior to the lateral epicondyle at the isometric point, with a diameter of 7-8 mm and depth of approximately 25 mm.

Graft Selection and Repair-Versus-Reconstruction Criteria

ACL reconstruction used ipsilateral hamstring (semitendinosus and gracilis) or bone-patellar tendon-bone autograft. PCL reconstruction used ipsilateral peroneus longus or quadriceps tendon autograft, or tibialis anterior or Achilles allograft. PLC reconstruction used semitendinosus autograft obtained from the contralateral limb or an available ipsilateral remnant, or an allograft. PLC repair was reserved for injuries presenting within three weeks when popliteus and lateral collateral ligament tissue quality and avulsion morphology allowed secure anatomical reattachment with suture anchors. When these criteria were not met, the PLC was reconstructed using a graft-based technique.

Fixation Devices and Graft-Tensioning Sequence

1. The PCL graft was passed first from tibia to femur using a Beath pin. Femoral fixation was achieved with an 8×23-mm bioabsorbable interference screw at 90° of knee flexion while the normal approximately 1-cm posterior tibial step-off was restored.
2. The ACL graft was passed next. Hamstring grafts were fixed on the femoral side with a cortical suspension device (Endobutton), whereas bone-patellar tendon-bone grafts were secured with a 7×23-mm interference screw. Femoral fixation was performed at approximately 20° of flexion for hamstring grafts and in full extension for bone-patellar tendon-bone grafts.
3. PCL tibial fixation was completed using an interference screw with a supplementary anterior staple post. Fixation was performed at 90° of flexion while an anterior drawer force was applied, followed by 20 cycles of graft conditioning.
4. ACL tibial fixation was performed with an 8×28-mm bio-interference screw at approximately 20° of flexion while a posterior drawer force was applied to avoid graft capture, followed by graft cycling.
5. For PLC reconstruction, the graft was passed through the fibular tunnel and crossed to the femoral socket. The lateral collateral ligament limb was fixed with a 7×23-mm interference screw at 30° of flexion, neutral rotation, and gentle varus correction. A separate popliteofibular limb, when used, was fixed in the fibular tunnel with a 5.5-mm PEEK tenodesis screw. In acute repairable injuries, the popliteus tendon and lateral collateral ligament were reattached with suture anchors.

Postoperative Rehabilitation

Phase I (weeks 0-6): A hinged knee brace was locked in full extension for ambulation. Patients with combined ACL+PCL+PLC reconstruction remained non-weight-bearing for six weeks, or longer when individually indicated. Quadriceps setting, straight-leg raising, ankle-pump exercises, patellar mobilisation, cryotherapy, and limb elevation were started early. Passive prone knee flexion was permitted up to 90°, while active hamstring contraction was avoided to protect the PCL graft.

Phase II (weeks 7-12): The brace was unlocked, and weight-bearing was progressed gradually toward full weight-bearing with crutch support. Closed-chain strengthening, including mini-squats and leg press from 0° to 60°, was introduced. Passive flexion was continued, active-assisted flexion was begun, and isolated hamstring curls remained restricted. Gait training and pool walking were incorporated.

Phase III (months 3-6): The brace was weaned after satisfactory control, and full active range of motion was pursued. Proprioceptive training included wobble-board exercises and single-leg stance. Progressive resisted strengthening was advanced, with stationary cycling and elliptical exercise introduced as tolerated.

Phase IV (months 6-12): Sport-specific drills, plyometrics, and agility training were introduced. Return to non-contact sport was considered after nine months when quadriceps and hamstring strength exceeded 90% limb symmetry and the objective IKDC grade was A or B. Contact sport was deferred until at least 12 months and required clearance by the operating surgeon.

Follow-Up and Outcome Measures

Patients were assessed for 14-24 months. Primary outcomes were paired changes in Lysholm, subjective IKDC, and Tegner scores from preoperative assessment to final follow-up. Secondary outcomes were objective IKDC grade, residual anterior, posterior, and varus laxity, flexion deficit, extension loss, complications, outcomes across injury patterns, and the association between injury-to-surgery interval and final function. Anterior laxity was measured using KT-1000 side-to-side difference at 30° in knees with ACL involvement; posterior drawer was graded manually at 90° in knees with PCL involvement; and varus stress was assessed at 30° in knees with PLC injury. Laxity was reported as grade 0 (0-2 mm), 1+ (3-5 mm), 2+ (6-10 mm), or 3+ (>10 mm). "Not applicable" was used when the corresponding ligament complex was not involved or assessed. Objective IKDC grades were classified as A (normal), B (nearly normal), C (abnormal), or D (severely abnormal).

Statistical Analysis

Categorical variables were summarised as frequency and percentage. Continuous variables were described using mean±standard deviation and median with interquartile range where appropriate. Shapiro-Wilk testing showed non-normal distributions for paired score changes; preoperative and postoperative Lysholm, subjective IKDC, and Tegner scores were therefore compared using the Wilcoxon signed-rank test. Injury-pattern comparisons used the Kruskal-Wallis test. Spearman rank correlation assessed associations between time to surgery and final outcomes. An exploratory comparison of surgery performed within six weeks (≤6 weeks) versus after six weeks (>6 weeks) used the Mann-Whitney U test for continuous variables and Fisher exact test for complications. All tests were two-sided, and $p<0.05$ was considered statistically significant. Analyses were performed using Python 3.13 with pandas and SciPy.

Ethical Considerations

The study protocol was approved by the Institutional Ethics Committee before commencement. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Written informed consent was obtained from every participant before enrolment and surgery, and patient information was anonymised during analysis and manuscript preparation.

RESULTS

Cohort Profile and Injury Characteristics

The study included 40 patients, with a mean age of 30.75±8.75 years (range 20-45). Men constituted 27 (67.5%) and women 13 (32.5%). The right knee was involved in 22 (55.0%). Road traffic or motorcycle trauma was the predominant mechanism, accounting for 19 (47.5%) injuries, followed by sports-related injury in 14 (35.0%). Mean time from injury to surgery was 5.35±2.60 weeks. Mean follow-up was 19.95±2.84 months (range 14-24), and every patient completed at least 14 months of follow-up (Table 1).

Characteristic	Value	Range
Age, years	30.75 ± 8.75	20–45
Male sex	27 (67.5%)	—
Female sex	13 (32.5%)	—
Right knee	22 (55.0%)	—
Left knee	18 (45.0%)	—
Road traffic/motorcycle trauma	19 (47.5%)	—
Sports-related injury	14 (35.0%)	—
Other fall-related injury	5 (12.5%)	—
Industrial injury	2 (5.0%)	—
Time to surgery, weeks	5.35 ± 2.60	2–12
Follow-up, months	19.95 ± 2.84	14–24

Table 1. Demographic and injury characteristics (n=40)

Values are n (%) or mean±SD, as appropriate

ACL+PCL injury was the most frequent pattern (14 (35.0%)), followed by ACL+PCL+PLC (13 (32.5%)), PCL+PLC (7 (17.5%)), and ACL+PLC (6 (15.0%)). The distribution is shown in Figure 1.

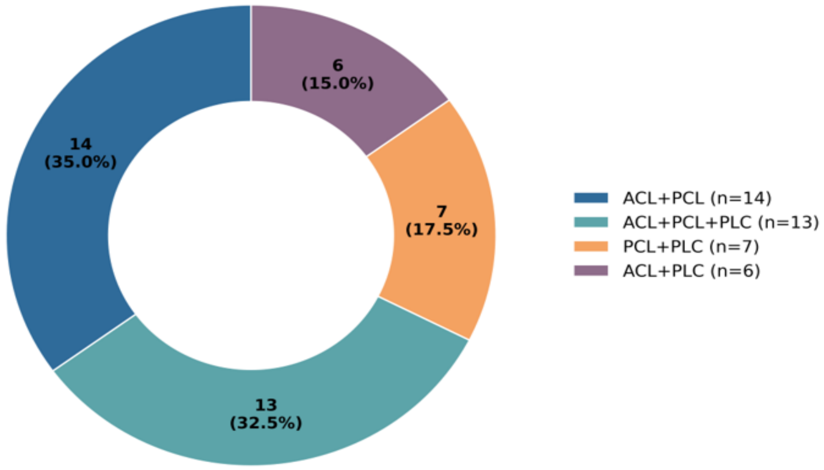

Figure 1. Distribution of combined ligament injury patterns

Segments show patient counts and percentages; total n=40

Operative Procedures

Among the 33 knees requiring ACL reconstruction, hamstring autograft was used in 26 (78.8%), and bone–patellar tendon–bone autograft in 7 (21.2%). Among 34 PCL reconstructions, peroneus longus autograft was most frequent (16 (47.1%)). Of 26 PLC procedures, 20 (76.9%) were reconstructions and 6 (23.1%) repairs. Meniscal preservation by repair was performed in 15 (37.5%), while partial meniscectomy was required in 7 (17.5%). Chondral procedures were performed in nine knees (Table 2).

Procedure domain	Technique/graft	n (%)
ACL graft	Hamstring autograft	26 (78.8%)
ACL graft	BPTB autograft	7 (21.2%)
PCL graft	Peroneus longus autograft	16 (47.1%)
PCL graft	Tibialis anterior allograft	10 (29.4%)
PCL graft	Achilles allograft	5 (14.7%)
PCL graft	Quadriceps tendon autograft	3 (8.8%)
PLC procedure	Reconstruction	20 (76.9%)
PLC procedure	Repair	6 (23.1%)
Meniscal procedure	Repair	15 (37.5%)
Meniscal procedure	Partial meniscectomy	7 (17.5%)
Meniscal procedure	No procedure	18 (45.0%)
Chondral procedure	Microfracture	6 (15.0%)
Chondral procedure	Chondroplasty	3 (7.5%)
Chondral procedure	No procedure	31 (77.5%)

Table 2. Reconstruction grafts and concomitant procedures

Denominators are 33 for ACL grafts, 34 for PCL grafts, 26 for PLC procedures, and 40 for meniscal/chondral procedures. Percentages may not total 100 because of rounding

Patient-reported functional outcomes

All three patient-reported measures improved markedly. Mean Lysholm score increased by 59.00 ± 4.98 points, subjective IKDC by 53.58 ± 4.83 points, and Tegner by 4.45 ± 1.06 points. Each paired comparison was statistically significant (all $p<0.001$; Table 3). Mean preoperative and postoperative Lysholm and IKDC scores are illustrated in Figure 2, while Tegner activity scores are shown in Figure 3.

Outcome	Preoperative mean±SD	Postoperative mean±SD	Mean change±SD	p-value
Lysholm score	29.15 ± 5.61	88.15 ± 5.18	59.00 ± 4.98	<0.001
IKDC subjective score	31.10 ± 5.30	84.68 ± 5.32	53.58 ± 4.83	<0.001
Tegner activity score	2.00 ± 0.78	6.45 ± 1.47	4.45 ± 1.06	<0.001

Table 3. Preoperative and postoperative functional outcomes (n=40)

Wilcoxon signed-rank test; all tests compared postoperative with preoperative values. IKDC: International Knee Documentation Committee

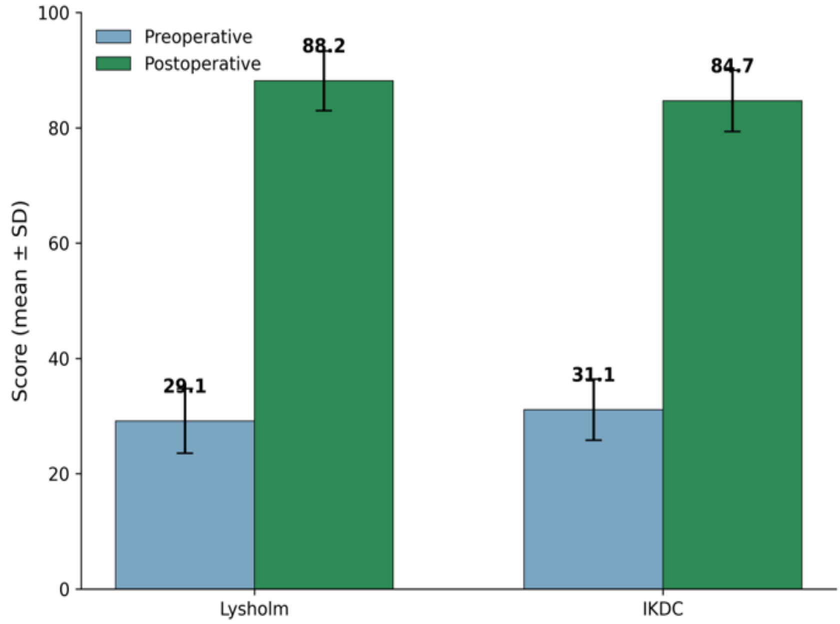

Figure 2. Preoperative and postoperative Lysholm and subjective IKDC scores

Bars show mean±SD; values above bars are point estimates

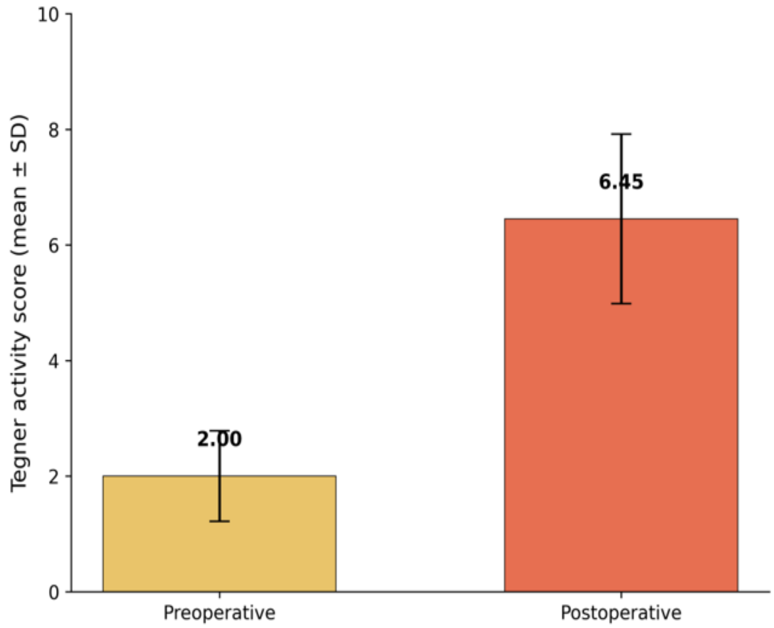

Figure 3. Change in Tegner activity score after single-stage management (bars show mean±SD; p<0.001 by Wilcoxon signed-rank test)

Outcomes According to Injury Pattern

Functional improvement was observed across all four injury patterns. At final follow-up, the PCL+PLC subgroup had the highest mean Lysholm, IKDC, and Tegner values and the smallest motion deficits; however, between-pattern differences did not reach statistical significance. Kruskal–Wallis p-values were 0.490 for Lysholm, 0.495 for IKDC, 0.209 for Tegner, 0.058 for flexion deficit, and 0.173 for extension loss (Table 4).

Pattern	n	Lysholm	IKDC	Tegner	Flexion deficit (°)	Extension loss (°)
ACL+PCL	14	87.79 ± 4.81	84.18 ± 5.00	6.21 ± 1.42	5.07 ± 3.93	1.29 ± 1.68
ACL+PCL+PLC	13	87.31 ± 6.69	84.08 ± 6.91	6.23 ± 1.74	5.62 ± 5.41	1.46 ± 2.07
PCL+PLC	7	91.00 ± 2.31	87.37 ± 2.46	7.43 ± 0.53	0.57 ± 0.79	0.00 ± 0.00
ACL+PLC	6	87.50 ± 4.64	84.00 ± 4.63	6.33 ± 1.51	3.33 ± 3.27	0.83 ± 2.04
Kruskal–Wallis p	—	0.490	0.495	0.209	0.058	0.173

Table 4. Final outcomes across injury patterns

Values are mean±SD except the final row. Comparisons were unadjusted and exploratory

Objective Stability, Range of Motion, and Complications

Objective IKDC grade A was recorded in 20 (50.0%), grade B in 14 (35.0%), and grade C in 6 (15.0%). Thus, 34 (85.0%) achieved grade A or B. Residual anterior laxity was grade 0 or 1+ in 26 (78.8%) of ACL-treated knees; posterior drawer was grade 0 or 1+ in 30 (88.2%) of PCL-treated knees. Every PLC-treated knee had grade 0 or 1+ varus stress at final follow-up (Figure 4). Mean flexion deficit was 4.20 ± 4.36°, and mean extension loss was 1.05 ± 1.75°.

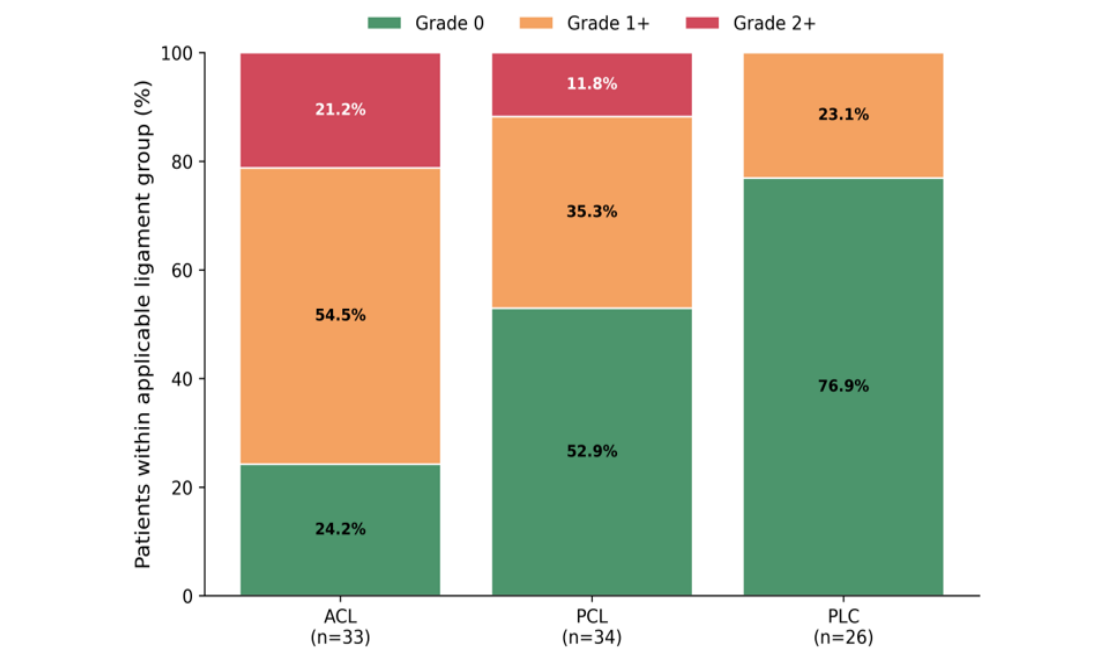

Figure 4. Final clinical laxity grades within each applicable ligament subgroup

ACL denominator n=33; PCL denominator n=34; PLC denominator n=26. Percentages are calculated within each subgroup

No complication was recorded in 31 (77.5%). Arthrofibrosis occurred in 4 (10.0%), superficial infection in 3 (7.5%), ACL graft failure in 1 (2.5%), and extension lag attributed to quadriceps weakness in 1 (2.5%). Recorded management included antibiotics for superficial infection, physiotherapy, manipulation, or arthroscopic release for stiffness where required. Complication frequencies are summarised in Table 5 and Figure 5

Outcome	Value
Objective IKDC grade A	20 (50.0%)
Objective IKDC grade B	14 (35.0%)
Objective IKDC grade C	6 (15.0%)
ACL laxity grade 0/1+	26 (78.8%)
PCL drawer grade 0/1+	30 (88.2%)
PLC varus stress grade 0/1+	26 (100.0%)
Flexion deficit, degrees	4.20 ± 4.36
Extension loss, degrees	1.05 ± 1.75
Arthrofibrosis	4 (10.0%)
Superficial infection	3 (7.5%)
ACL graft failure	1 (2.5%)
Extension lag	1 (2.5%)
No recorded complication	31 (77.5%)

Table 5. Objective stability, motion, and complications

Ligament-specific stability percentages use the number of knees in which that ligament was applicable. Motion values are mean±SD

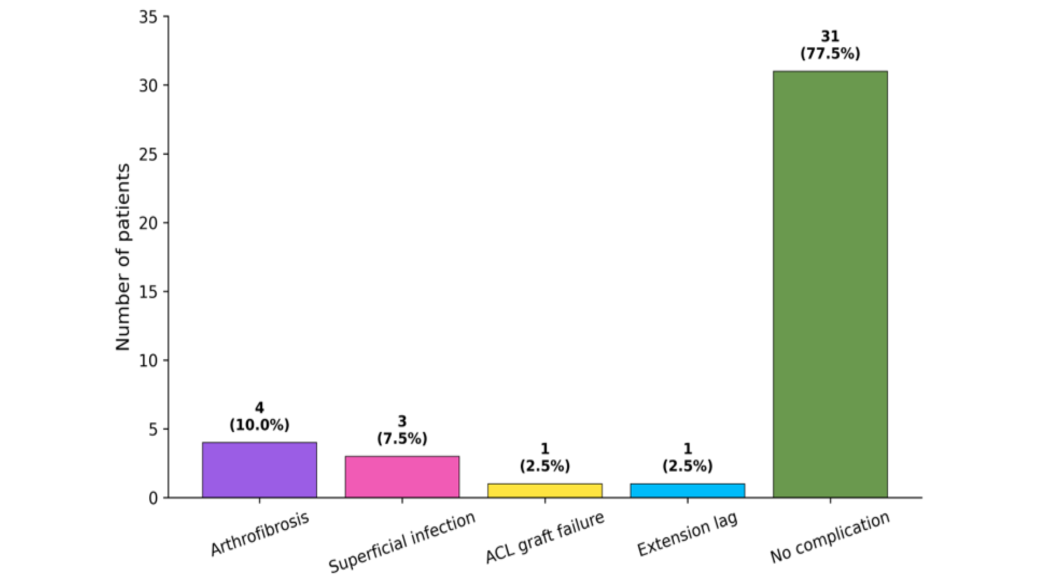

Figure 5. Distribution of recorded postoperative complications

Counts and cohort percentages are shown above bars

Association with Injury-to-Surgery Interval

Longer injury-to-surgery interval was associated with lower postoperative Lysholm (ρ=-0.699), IKDC (ρ=-0.681), and Tegner scores (ρ=-0.669); it was also associated with greater flexion deficit (ρ=0.606) and extension loss (ρ=0.601). All associations were statistically significant (Table 6). Time to surgery also correlated with age (ρ=0.643, p<0.001), indicating important confounding.

Outcome	Spearman ρ	p-value
Postoperative Lysholm score	-0.699	<0.001
Postoperative IKDC score	-0.681	<0.001
Postoperative Tegner score	-0.669	<0.001
Flexion deficit	0.606	<0.001
Extension loss	0.601	<0.001

Table 6. Spearman correlations between time to surgery and final outcomes

Negative coefficients indicate lower functional scores with longer delay; positive coefficients indicate greater motion loss. These are unadjusted associations

In an exploratory dichotomisation, 29 patients underwent surgery within six weeks and 11 after six weeks. Mean postoperative Lysholm scores were 90.52±3.46 and 81.91±3.48, subjective IKDC scores were 87.07±3.67 and 78.37±3.52, and Tegner scores were 7.10±1.08 and 4.73±0.79, respectively. Complications were recorded in 2/29 (6.9%) and 7/11 (63.6%) patients (Fisher exact p=0.001). The groups differed substantially before surgery: mean age was 26.90±6.39 versus 40.91±5.26 years, and the earlier group had higher preoperative Lysholm, IKDC, and Tegner scores (all p<0.001; Supplementary Table S1). This comparison is therefore descriptive and cannot establish a causal six-week threshold (Figure 6).

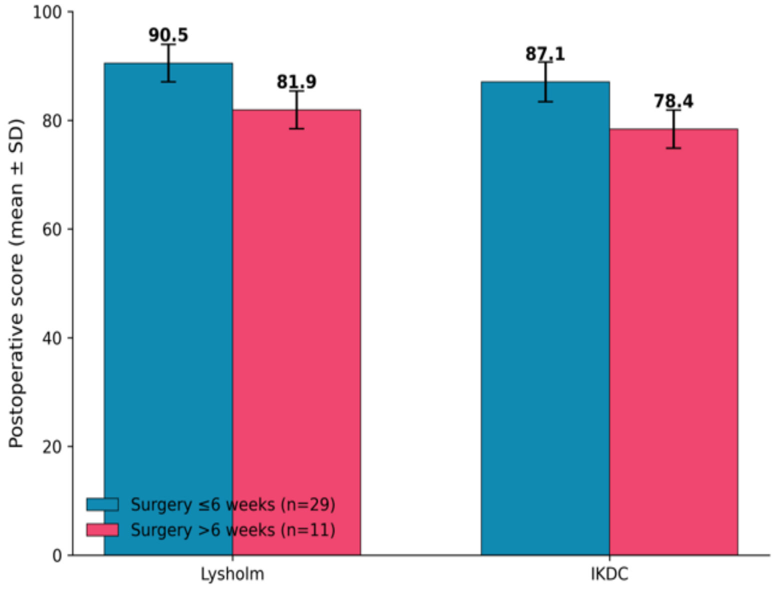

Figure 6. Exploratory postoperative scores according to surgery within or after six weeks (bars show mean±SD; groups were not randomised and differed in age and baseline status)

DISCUSSION

The principal finding was a large improvement in all three patient-reported outcomes after a protocol-based, single-stage approach to complex combined ligament injuries. Mean Lysholm increased by 59 points, subjective IKDC by 53.58 points, and Tegner by 4.45 points. These gains were accompanied by objective IKDC grade A or B in 85% of the cohort and clinically acceptable residual stability in most ligament-specific assessments. The findings support the practical feasibility of completing arthroscopic cruciate reconstruction and indicated PLC repair or reconstruction during one operative episode when soft-tissue condition, preoperative motion, graft availability, technical expertise, and rehabilitation support are favourable.

The postoperative Lysholm and IKDC values are close to those reported by Nagaraj and Shivanna in an Indian tertiary-care cohort treated with single-stage reconstruction.[3] Goyal et al. also observed meaningful improvement after one-stage reconstruction of chronic multiligament injuries using predominantly autograft constructs.[4] In a larger sports-related series, LaPrade et al. documented significant gains across injury patterns and reported an arthrofibrosis reintervention rate of approximately 9%, which is comparable with the 10% stiffness rate in the present cohort.[5] The similarity is clinically reassuring, although direct comparison is limited by differences in injury chronicity, mechanism, surgical anatomy, graft choice, and rehabilitation intensity.

Surgical timing requires a guarded interpretation. In this cohort, longer injury-to-surgery interval showed strong unadjusted correlations with lower final scores and greater motion loss, and the exploratory six-week split produced the same directional pattern. Yet the later group was older and entered surgery with distinctly poorer Lysholm, IKDC, and Tegner scores. The groups were not randomised, and the cut-off was selected for exploratory description rather than as a prespecified biological threshold. The findings therefore show association, not an "optimal" timing boundary. Contemporary evidence also remains mixed. Hoit et al. found no clinically important difference in multiligament-specific quality-of-life outcomes after propensity adjustment, although early surgery was associated with more manipulation for stiffness and less radiographic osteoarthritis.[6] He et al., at five to ten years, similarly found that age and timing interact with functional results and complication patterns rather than producing a universal rule.[7]

The appeal of a single-stage plan is nevertheless understandable in settings where repeated hospitalisation, travel, work absence, and the financial burden of a second operation may impede continuity of care. A large database analysis by Lau et al. found fewer unplanned reoperations, fewer complications, and lower longer-term costs with single-stage treatment than staged care.[8] That evidence does not mean every injury should be reconstructed immediately or in one sitting. Open injury, vascular repair, compromised skin, severe swelling, infection risk, fixed loss of motion, or uncertainty about tissue viability may justify deliberate staging. The operative strategy should remain conditional rather than ideological.

PLC management also deserves attention because unrecognised lateral instability can overload cruciate grafts. In the present series, 20 PLC injuries were reconstructed and six repaired. At follow-up, 76.9% had grade 0 varus stress and the remainder grade 1+, with no grade 2+ laxity. Prospective multicentre data have shown that carefully selected PLC repairs performed with concurrent ACL surgery can achieve outcomes comparable with reconstruction, although activity outcomes may vary.[9] Other cohorts using fibular sling or anatomic single-graft reconstruction have demonstrated improved varus stability and satisfactory knee function in combined injuries.[10,11] The current data support the principle of addressing clinically relevant PLC instability at the same sitting as the cruciate injury, while the choice between repair and reconstruction should depend on injury chronicity, tissue quality, avulsion pattern, and surgeon expertise.

Graft selection in this cohort was heterogeneous, reflecting the practical demands of reconstructing more than one ligament. Hamstring autograft predominated for ACL reconstruction, whereas PCL reconstruction used peroneus longus and quadriceps autograft or tibialis anterior and Achilles allograft. Heterogeneous graft choice is common in multiligament surgery because length, diameter, donor-site morbidity, concurrent ligament requirements, and allograft access must be balanced. Allograft-based single-stage series have reported good functional recovery but also residual laxity and procedure-related complications, reinforcing the need for precise tunnel placement, fixation, and rehabilitation rather than reliance on graft source alone.[12]

Complications were recorded in 22.5% of patients. Arthrofibrosis was most frequent, followed by superficial infection, graft failure, and extension lag. This profile is consistent with the recognised vulnerability of multiligament reconstruction to stiffness and reintervention. Billières et al. reported that one-stage allograft reconstruction improved stability but did not eliminate postoperative laxity or stiffness.[12] Ibrahim et al. likewise emphasised structured reconstruction and rehabilitation in knee dislocation with PLC injury.[13] The phase-based protocol used here combined early quadriceps activation and protected passive motion with delayed hamstring loading, progressive closed-chain strengthening, proprioception, and criteria-based return to sport. Even so, the occurrence of arthrofibrosis in four patients shows that motion recovery requires close surveillance and timely intervention.

No significant outcome difference was found among injury-pattern subgroups. The PCL+PLC group appeared to have higher functional scores and less motion loss, but it included only seven patients. Larger studies have shown that medial- and lateral-sided patterns can behave differently, and that PCL-based injuries may carry distinct functional demands.[2,14] The absence of statistical significance here should therefore be read as imprecision rather than proof of equivalence.

Clinical Implications

For an Indian orthopaedic service, the findings favour an organised single-stage pathway for selected patients: recover acceptable preoperative motion, define every injured stabiliser using clinical examination, stress radiography, MRI, and examination under anaesthesia, secure graft availability, plan tunnels and fixation sequence before incision, preserve repairable meniscal tissue, and institute protected phase-based rehabilitation.

Road traffic trauma accounted for nearly half the cohort, a pattern that may be accompanied by soft-tissue compromise and delayed referral. The pathway must therefore remain adaptable. The central question is not simply "early or delayed?" but whether the knee, patient, surgical team, and rehabilitation environment are ready for a technically complete reconstruction.

LIMITATIONS

Several limitations constrain interpretation. The sample was small and derived from a single centre. There was no staged-treatment control group, so superiority of single-stage management cannot be inferred. The four injury patterns and graft constructs were heterogeneous, and subgroup analyses were underpowered. Timing analyses were unadjusted and strongly confounded by age and baseline function. Objective postoperative stress-radiographic measurements, return-to-work and return-to-sport rates, patient satisfaction, KOOS or multiligament-specific quality-of-life measures, and long-term osteoarthritis outcomes were not available for analysis. Follow-up ranged from 14 to 24 months. Rehabilitation adherence and serial limb-symmetry measurements were also not captured as study variables.

CONCLUSION

Protocol-based single-stage management of combined ACL/PCL and cruciate-PLC injuries produced substantial improvement in Lysholm, subjective IKDC, and Tegner scores, with objective IKDC grade A or B in most patients at short- to mid-term follow-up. Residual stiffness was the most frequent complication. Longer time to surgery was associated with poorer final function and greater motion loss, but the relationship was confounded by marked baseline differences and cannot define an optimal timing threshold. A single-stage strategy is a reasonable option for appropriately selected patients when soft-tissue condition, preoperative motion, graft planning, tunnel and fixation sequence, and postoperative rehabilitation are favourable.

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Conflict of Interest

None declared.

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Supplementary Material

Parameter	≤6 weeks (n=29)	>6 weeks (n=11)	p-value
Age, years	26.90±6.39	40.91±5.26	<0.001
Preoperative Lysholm score	31.45±4.60	23.09±2.81	<0.001
Preoperative subjective IKDC score	33.31±4.22	25.25±2.78	<0.001
Preoperative Tegner activity score	2.34±0.61	1.09±0.30	<0.001

Supplementary Table S1. Baseline comparison of surgery performed within six weeks and after six weeks

Values are mean±SD. Mann-Whitney U test, two-sided. The grouping was exploratory and was not based on random allocation