

## Research Article

# Functional Outcomes of Mini-Open Posterior Screw Fixation in Posterior Cruciate Ligament Tibial Avulsion Fractures: A Prospective Study of 10 Patients

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**Abstract: Introduction:** Posterior cruciate ligament (PCL) tibial avulsion fractures are uncommon injuries that may result in persistent posterior instability and impaired knee function if not managed appropriately. Surgical fixation is generally recommended for displaced fractures to restore knee stability and joint biomechanics. This study evaluated the clinical and functional outcomes of mini-open posterior screw fixation in patients with isolated PCL tibial avulsion fractures. **Methods:** A prospective observational study was conducted between January 2021 and December 2024 at a tertiary care orthopaedic centre. Ten patients with isolated displaced PCL tibial avulsion fractures underwent fixation using a mini-open posterior approach. Fractures were classified according to the McKeever classification. Functional outcomes were assessed using the International Knee Documentation Committee (IKDC) subjective score, Lysholm knee score, and knee range of motion (ROM). Patients were followed clinically and radiologically for a mean duration of  $10.8 \pm 1.5$  months. **Results:** All patients achieved radiological union and satisfactory knee stability at final follow-up. The mean IKDC score was  $91.8 \pm 2.1$ , while the mean Lysholm score was  $92.6 \pm 2.5$ . Mean postoperative knee ROM was  $129.5^\circ \pm 5.8^\circ$ . No significant postoperative complications, residual posterior laxity, or extension lag were observed. **Conclusion:** Mini-open posterior screw fixation is a safe, reproducible, and effective technique for the treatment of isolated displaced PCL tibial avulsion fractures. The procedure provides stable fixation, reliable fracture union, and excellent functional outcomes with minimal surgical morbidity.

**Keywords:** Posterior cruciate ligament, tibial avulsion fracture, mini-open fixation, knee instability, screw fixation, functional outcome

## INTRODUCTION

Posterior cruciate ligament (PCL) injuries account for a relatively small proportion of ligamentous injuries around the knee joint; however, tibial avulsion fractures of the PCL represent a clinically significant subset because of their potential to produce persistent posterior instability and long-term functional impairment if inadequately treated. The injury typically occurs following high-energy trauma such as road traffic accidents, dashboard injuries, sports-related trauma, or forced hyperflexion of the knee joint. In these injuries, the PCL is avulsed from its tibial insertion along with a bony fragment from the posterior tibial plateau rather than sustaining a midsubstance tear [1,2].

The posterior cruciate ligament is the primary restraint against posterior translation of the tibia and plays an essential role in maintaining normal knee biomechanics. Failure to restore the anatomical insertion of the ligament may result in chronic posterior tibial sag, altered tibiofemoral contact mechanics, pain, reduced range of motion, quadriceps weakness, and progressive degenerative changes in the knee joint [3]. Untreated or improperly managed PCL avulsion fractures may therefore significantly compromise patient mobility and

quality of life, particularly in young and physically active individuals.

The management strategy for PCL tibial avulsion fractures is primarily determined by the degree of displacement, associated instability, and functional demands of the patient. Minimally displaced fractures with preserved posterior stability may be managed conservatively using immobilization, bracing, and structured rehabilitation protocols [4]. However, displaced avulsion fractures generally require operative fixation to achieve anatomical reduction, restore ligament tension, and prevent chronic instability [5]. Several studies have demonstrated superior functional outcomes and improved knee stability following surgical management of displaced PCL avulsion fractures compared to non-operative treatment [6,7].

A variety of surgical techniques have been described for fixation of PCL tibial avulsion fractures. Traditional open posterior approaches, such as the Burks and Schaffer approach and inverted "L" incision, provide direct visualization of the avulsed fragment and facilitate stable fixation [8]. Nevertheless, these techniques often require extensive soft tissue dissection and carry potential risks of neurovascular injury due to the close proximity of the popliteal vessels and tibial nerve.

Arthroscopic fixation techniques have gained popularity in recent years because they offer the advantages of minimal soft tissue disruption, management of associated intra-articular pathology, and early rehabilitation [9]. Arthroscopic methods may employ screws, sutures, suture anchors, or suspensory fixation devices for stabilization of the avulsed fragment. Despite these advantages, arthroscopic fixation is technically demanding, requires specialized instrumentation, and is associated with a steep learning curve and prolonged operative duration, which may limit its widespread use, especially in resource-constrained healthcare settings [10].

Mini-open posterior approaches have emerged as an effective alternative that combines the benefits of direct fracture visualization with limited surgical morbidity. These approaches utilize natural anatomical intervals, particularly between the medial head of the gastrocnemius and semitendinosus muscles, allowing safe exposure of the fracture while minimizing soft tissue dissection and reducing the risk to neurovascular structures [11]. Previous studies have reported satisfactory clinical and radiological outcomes using minimally invasive posterior fixation techniques with shorter operative time, reduced postoperative pain, and excellent restoration of knee stability [12,13].

The present case series was undertaken to evaluate the functional and radiological outcomes of mini-open posterior screw fixation in isolated PCL tibial avulsion fractures.

## MATERIALS AND METHODS

This prospective observational study was conducted at a tertiary care orthopaedic centre after obtaining approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants. Study Population: A total of 10 patients with isolated displaced PCL tibial avulsion fractures were included in the study.

### Inclusion Criteria

- Isolated PCL tibial avulsion fractures
- Age between 18 and 70 years
- Acute injuries presenting within 3 weeks
- Single displaced avulsion fragment confirmed on CT and MRI

### Exclusion Criteria

- Multi-ligamentous knee injuries
- Meniscal injuries requiring repair
- Mid-substance PCL tears
- Associated distal femoral or proximal tibial fractures
- Severe osteoarthritis of the knee
- Patients medically unfit for surgery

### Preoperative Evaluation

- All patients underwent detailed clinical examination including assessment of posterior

drawer test, knee range of motion, swelling, and instability.

- Functional assessment was performed using the IKDC subjective score and Lysholm knee score.
- Radiological evaluation included anteroposterior and lateral radiographs of the knee. Computed tomography with three-dimensional reconstruction was used to assess fracture morphology and displacement.
- Magnetic resonance imaging was performed to exclude associated ligamentous or meniscal injuries.
- Fractures were classified according to the McKeever classification system.

### Surgical Technique

- All procedures were performed under spinal anaesthesia with the patient in the prone position. A high thigh tourniquet was applied. The knee was maintained in approximately 30° flexion using a support beneath the ankle.
- A vertical incision measuring approximately 5 cm was made along the medial border of the medial head of the gastrocnemius muscle distal to the popliteal crease. Blunt dissection was carried out between the medial head of gastrocnemius and semitendinosus muscles.
- The gastrocnemius muscle along with the popliteal neurovascular structures was gently retracted laterally, while the semimembranosus and semitendinosus were retracted medially. The posterior capsule was incised longitudinally to expose the avulsed fragment.
- The fracture bed was cleared of hematoma and interposed tissue. Anatomical reduction of the avulsed fragment was achieved under direct visualization and temporarily stabilized with Kirschner wires. Definitive fixation was performed using one or two 4 mm partially threaded cannulated cancellous screws with washers under fluoroscopic guidance.
- After confirming satisfactory reduction and fixation, the wound was irrigated and closed in layers. A hinged knee brace maintaining 30°–45° of flexion was applied.

### Postoperative Rehabilitation

- Intravenous antibiotics were administered for 24 hours postoperatively. Early quadriceps strengthening exercises and ankle pump exercises were initiated on the first postoperative day.
- Passive knee mobilization from 0° to 60° was started during the first three weeks. Partial weight-bearing with crutches was allowed during this period.
- Between 4 and 6 weeks, gradual increase in knee flexion up to 90° was permitted along with continued muscle strengthening exercises. Full

weight-bearing was allowed after radiological evidence of fracture union.

- Return to sports and strenuous activities was permitted after approximately 12 weeks depending on clinical and radiological recovery.

**Outcome Assessment: Patients were evaluated at regular follow-up intervals of 6 weeks, 3 months, 6 months, and final follow-up.**

**Clinical assessment included:**

- Knee range of motion
- Posterior drawer test
- Presence of extension lag
- Knee stability

**Functional outcomes were evaluated using:**

- IKDC subjective score
- Lysholm knee score

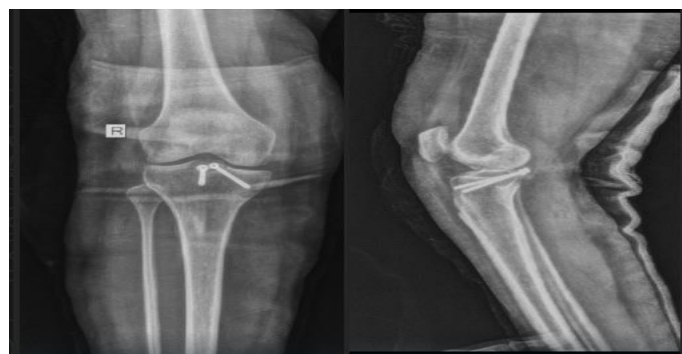
**Radiological union was assessed using serial radiographs.**



**Figure 1: Pre-op x-ray**



**Figure 2: Pre-op MRI**



**Figure 3: Post-op x-ray**

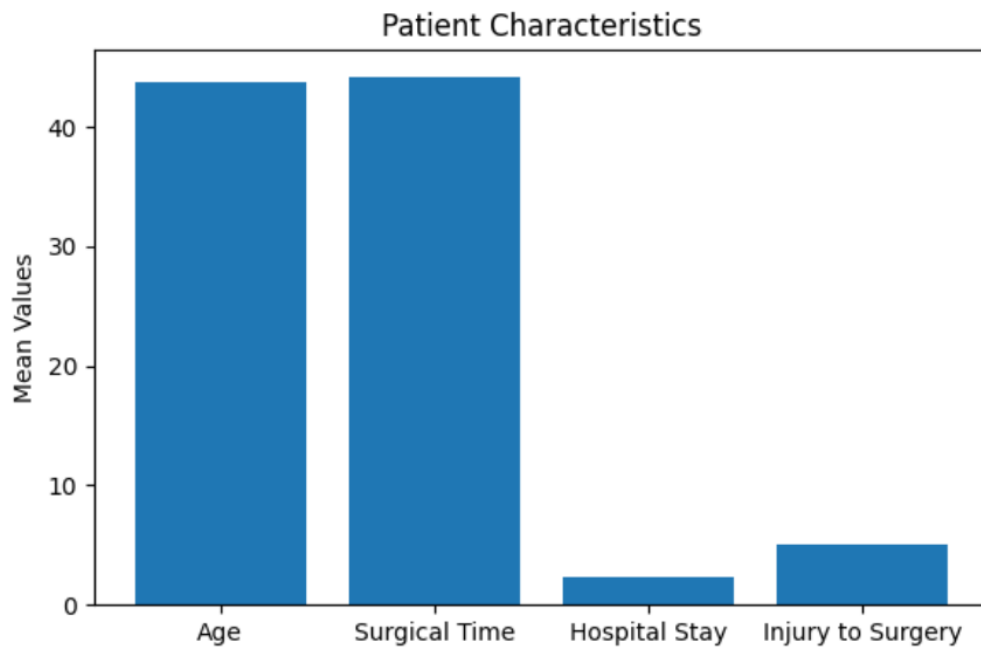
**Statistical Analysis:** Data were analysed using descriptive statistics. Continuous variables were expressed as mean±standard deviation, while categorical variables were expressed as frequencies and percentages.

## RESULTS

The study included 10 patients comprising 7 males and 3 females. The mean age of the patients was  $43.8 \pm 10.6$  years (range: 27–62 years). The average interval between injury and surgery was  $5.1 \pm 1.3$  days. Mean operative time was  $44.2 \pm 5.9$  minutes. The mean incision length was  $5.1 \pm 0.3$  cm, while mean hospital stay was  $2.3 \pm 0.5$  days (table 1).

Table 1: Patient Characteristics

Parameter	Mean $\pm$ SD	Minimum	Maximum
Age (years)	$43.8 \pm 10.6$	27	62
Surgical time (minutes)	$44.2 \pm 5.9$	35	54
Incision length (cm)	$5.1 \pm 0.3$	5.0	5.8
Hospital stay (days)	$2.3 \pm 0.5$	2	3
Injury to surgery interval (days)	$5.1 \pm 1.3$	3	7

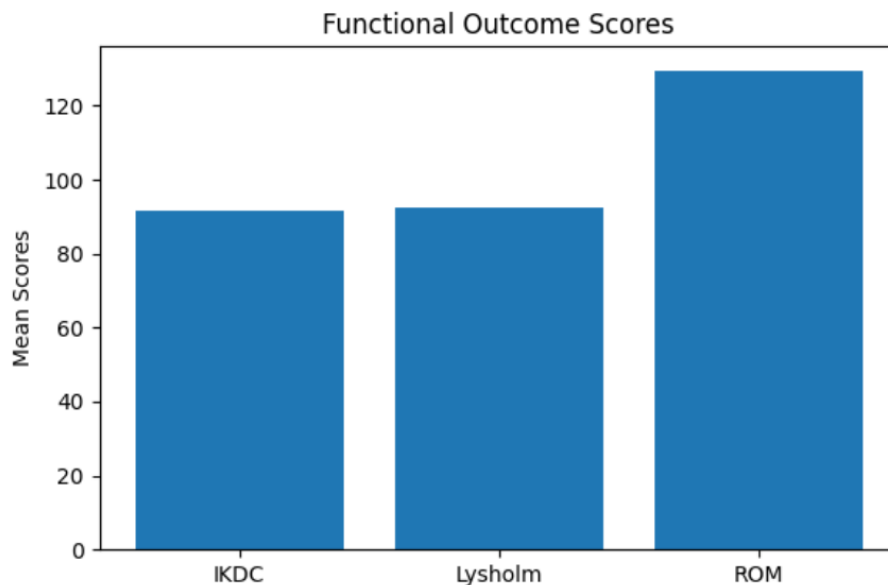


Graph 1

At final follow-up, all patients demonstrated satisfactory clinical and functional recovery. The mean IKDC score was  $91.8 \pm 2.1$ , and the mean Lysholm score was  $92.6 \pm 2.5$ . Mean knee range of motion at final follow-up was  $129.5^\circ \pm 5.8^\circ$ . No patient demonstrated residual posterior instability, flexion contracture, or extension lag.

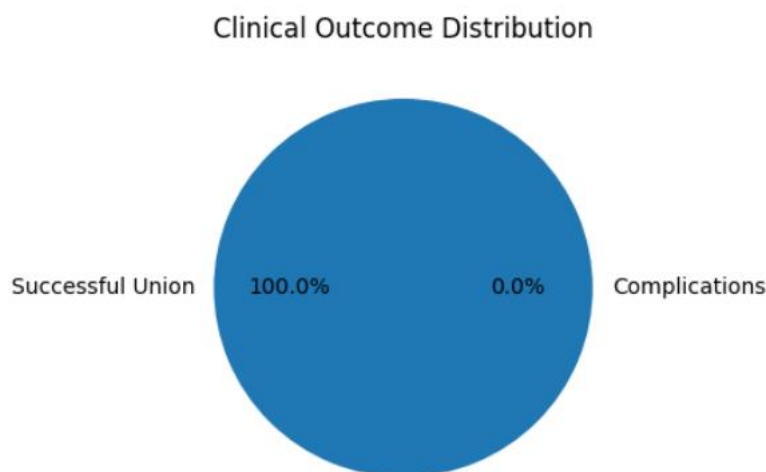
Table 2: Functional Outcomes at Final Follow-Up

Parameter	Mean $\pm$ SD	Minimum	Maximum
IKDC score	$91.8 \pm 2.1$	88	95
Lysholm score	$92.6 \pm 2.5$	89	96
Knee ROM ( $^\circ$ )	$129.5 \pm 5.8$	122	140



**Graph 2**

No major intraoperative or postoperative complications were observed. All fractures achieved radiological union. There were no cases of infection, implant failure, neurovascular injury, or non-union (graph 3).



**Graph 3**

## DISCUSSION

Posterior cruciate ligament tibial avulsion fractures, although relatively uncommon, are important injuries because delayed diagnosis or inadequate treatment may result in persistent posterior instability, altered knee kinematics, and early degenerative changes in the knee joint [1,3]. Surgical fixation is generally considered the preferred treatment modality for displaced PCL avulsion fractures because anatomical reduction and stable fixation are essential for restoration of normal ligament function and prevention of chronic instability [5,6].

In the present study, all patients underwent fixation using a mini-open posterior approach and demonstrated satisfactory clinical and radiological outcomes at final follow-up. Radiological union was achieved in all cases, and none of the patients demonstrated residual posterior

laxity, extension lag, or significant restriction of knee motion. These findings support the growing body of evidence favouring minimally invasive posterior fixation techniques for displaced PCL tibial avulsion fractures.

The mean interval between injury and surgery in the present study was approximately five days. Early operative intervention has been advocated by several authors because delayed surgery may be associated with fibrosis, soft tissue interposition, adhesion formation, and difficulty in reduction of the avulsed fragment [7,11]. Early fixation facilitates easier reduction, allows stable fixation, and may improve postoperative rehabilitation outcomes.

The mini-open posterior approach used in this study demonstrated several procedural advantages. The mean operative duration in the present series was

comparatively shorter than many arthroscopic fixation procedures reported in the literature. Arthroscopic fixation techniques often require longer surgical time because of the technical complexity involved in portal placement, fracture reduction, and suture management [9,10]. Reduced operative time is particularly beneficial in trauma centres and resource-limited settings where surgical efficiency and reproducibility are important considerations.

Another important advantage of the mini-open approach is the reduced risk of iatrogenic neurovascular injury. Traditional posterior approaches involve extensive dissection and direct manipulation of structures within the popliteal fossa, thereby increasing the risk of damage to the popliteal artery, vein, and tibial nerve [8]. In contrast, the mini-open technique utilizes the anatomical interval between the medial head of the gastrocnemius and semitendinosus muscles, with the bulky gastrocnemius muscle serving as a protective barrier for the neurovascular bundle. Similar observations have been reported by Frosch et al. and Gavaskar et al., who described the safety and reproducibility of minimally invasive posterior approaches [11,12].

Functional outcomes in the present study were excellent, with mean IKDC and Lysholm scores exceeding 90 at final follow-up. These findings are consistent with previously published literature. Zhao et al. reported high postoperative IKDC scores following minimally invasive fixation of PCL avulsion fractures, while Huang et al. and Guo et al. demonstrated excellent Lysholm scores and restoration of knee stability using minimally invasive posterior fixation techniques [10,13,14].

The restoration of knee range of motion in our study was also satisfactory, with a mean postoperative ROM of approximately 130°. Similar results have been documented by Gavaskar et al., who reported good functional recovery and near-normal ROM following minimally invasive fixation techniques [12]. A recent systematic review and meta-analysis by Gopinath et al. concluded that both open and arthroscopic fixation methods provide satisfactory clinical outcomes with no significant difference in final postoperative range of motion [15].

Stable fixation of the avulsed fragment remains the most critical factor determining successful outcomes irrespective of the surgical approach used. In the present study, screw fixation provided stable reduction in all patients, resulting in reliable fracture union and restoration of knee stability. Hooper et al., in their systematic review, similarly emphasized that fixation quality and restoration of anatomical alignment are more important determinants of outcome than the specific surgical approach employed [7].

Recent advances in fixation techniques have included the use of suture augmentation, internal bracing, and suture bridge constructs, particularly in cases involving comminuted or osteoporotic fragments [16,17]. Although these techniques may provide additional stability in selected cases, isolated screw fixation was found to be adequate in the present study because all

patients had single, well-defined avulsion fragments suitable for compression screw fixation.

The mini-open posterior approach also demonstrated favourable postoperative recovery. The limited incision length, reduced soft tissue dissection, and minimal surgical morbidity contributed to low postoperative pain scores and shorter hospital stay. Early initiation of rehabilitation exercises further facilitated restoration of quadriceps strength and knee mobility.

The strengths of the study include its prospective design, uniform surgical technique, standardized rehabilitation protocol, and consistent functional assessment using validated scoring systems.

**Limitations:** Despite the favourable results, the present study has certain limitations. The sample size was relatively small, and no comparative group undergoing arthroscopic or traditional open fixation was included. The follow-up duration was limited, and long-term evaluation of degenerative changes or objective stress radiographic measurements of posterior tibial translation was not performed. Furthermore, the findings apply specifically to isolated PCL tibial avulsion fractures and may not be generalizable to patients with comminuted fractures or multi-ligamentous injuries.

Despite these limitations, the study demonstrates that mini-open posterior screw fixation is an effective and reproducible technique with excellent clinical outcomes.

## CONCLUSION

Mini-open posterior screw fixation is a safe and effective technique for the management of isolated displaced PCL tibial avulsion fractures. The procedure provides stable fixation, reliable fracture union, satisfactory restoration of knee stability, and excellent functional recovery with minimal complications. The technique is especially useful in settings where arthroscopic facilities or expertise may be limited.

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