



A COMPARISON BETWEEN THE OPEN POSTERIOR APPROACH AND ARTHROSCOPIC SUTURE FIXATION IN TREATING POSTERIOR CRUCIATE LIGAMENT TIBIAL AVULSION: A SYSTEMATIC REVIEW

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ABSTRACT

Posterior cruciate ligament (PCL) avulsion fractures are rare but significant injuries that can lead to knee instability and degeneration if untreated. Treatment options range from conservative management to surgical fixation. The objective of this study is to evaluate and compare the outcomes of different treatment modalities for posterior cruciate ligament (PCL) avulsion fractures, with a focus on surgical interventions, specifically open surgery and arthroscopy. Methods: A systematic literature search was conducted using the MEDLINE, EMBASE, and Cochrane Library databases from August 17, 2003 to August 17, 2023. Studies included involved patients with PCL avulsion fractures treated via arthroscopic or open fixation. Data was extracted on demographics, surgical approaches, outcomes (Lysholm scores), and complications. The Coleman methodology score was applied to assess study quality by scoring factors like study size, design, follow-up, and outcome measures, and only studies scoring ≥ 60 were included for data analysis. Results: Out of 1,470 studies, 12 met the inclusion criteria. Lysholm scores ranged from 85 to 100 for open approaches and 80 to 100 for arthroscopic approaches. Arthroscopic treatment showed fewer complications, such as infections or hardware irritation, while both approaches demonstrated favorable outcomes. Postoperative limitations in motion were observed in both groups, with a slightly higher incidence in the arthroscopic cohort. Conclusions: Both arthroscopic and open surgical approaches effectively treat PCL avulsion fractures, with arthroscopy showing a slight advantage in postoperative outcomes and fewer complications. However, open surgery with a small open procedure also offers satisfactory results, particularly for complex fractures.

Keywords: arthroscopy; avulsion; lysholm; open approach; PCL

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INTRODUCTION

Avulsion fractures of the PCL are rare but can lead to instability and knee joint degeneration if not treated properly. PCL injuries are less common than ACL injuries and often accompany other knee issues, causing pain, swelling, and mobility problems. Treatment options range from rest, exercises, and supportive devices to surgery, based on the damage extent. (Kim et al., 2019) PCL avulsion fractures resemble intra-substance tears usually caused by dashboard injuries in motor vehicle accidents, especially involving motorcycles. Hyperextension in sports is the second common cause of this injury. Such fractures are more prevalent in regions with high motorcycle use, like China and India. Tibial-side avulsion fractures are common, often with associated meniscal and ligamentous injuries. (Huang et al., 2023) Advantages of the open surgical technique in the context of posterior cruciate ligament (PCL) avulsion. Enables the direct visualization of the fracture site and the structures in its vicinity. Enhanced

accessibility to the fracture site is particularly crucial for bigger or more intricate fractures. It is plausible that certain types of fractures, particularly those exhibiting substantial displacement or comminution, may see enhanced efficacy with this approach.(Li et al., 2024)

Arthroscopes are used to diagnose and treat knee PCL avulsion fractures. Arthroscopy is less invasive than open surgery for PCL avulsion fractures. An open skin incision treats PCL (posterior cruciate ligament) avulsion fractures. Open surgery repairs posterior cruciate ligaments. Dislodged bone fragments can injure the PCL and induce knee instability. Open or arthroscopic PCL avulsion depends on fracture nature and patient desire. Open surgery may work for certain fractures but is riskier and slower. Arthroscopy is less intrusive and has less downtime, appealing to scar-conscious patients. The Lysholm Knee Scoring Scale assesses knee function, pain, instability, and range of motion before and after treating PCL avulsion fractures. Higher scores indicate better function, aiding progress tracking. Studies showed improved scores after treatment.(Seifeldin et al., 2023) Although infrequent, complications may arise following surgery for PCL avulsion fractures. Several potential postoperative consequences that may occur after PCL avulsion repair encompass the following: infection, knee stiffness, reduction in range of motion, implant failure, harm to nerves or blood vessels, as well as persistent discomfort or instability. Adherence to the postoperative rehabilitation plan and regular attendance of follow-up sessions with the surgeon is crucial in monitoring potential problems and facilitating optimal healing and recovery. Thereby, the objective of this study is to evaluate and compare the outcomes of different treatment modalities for posterior cruciate ligament (PCL) avulsion fractures, with a focus on surgical interventions, specifically open surgery and arthroscopy

METHOD

The present work involved conducting extensive online literature searches in the MEDLINE, EMBASE, and Cochrane Library databases from August 17, 2003 to August 17, 2023. Individual modifications were made to the search formula for each database. Keywords used in the database search were "posterior cruciate ligament" OR "PCL" AND "fracture" OR "tibia" OR "avulsion(s)" OR "bone" OR "arthroscopic" OR "open" OR "approach" OR "surgical" OR "fixation". Each selected article underwent a thorough evaluation of its complete text according to the specified inclusion and exclusion criteria. Studies involving patients who underwent isolated fixation or suturing for displaced posterior cruciate ligament tibial avulsion using arthroscopic/open technique, with minimum follow-up period: 1 year, and studies conducted between level I and level IV, conducted in vivo on human subjects, and written in English was included. Meanwhile, studies including patients with a dislocated knee accompanied by posterior cruciate ligament tibial avulsion or patients with prior surgical procedures, patients who went conservative treatment, study with insufficient sample size of less than 5 individuals, tibial avulsion of the posterior cruciate ligament resulting in non-union or delayed union, a Level V evidence (case report, technical comment, letter to editor) studies, biomechanical reports, and review articles, studies involving nonhuman subjects, and article written in other than English are excluded. In a condition that a research investigation involved two or more subjects authored by the same individual, we ascertained whether these were instances of duplication. In situations of duplicate research, we incorporated solely those studies characterized by an extended follow-up duration. Furthermore, the reference lists and bibliographies of the chosen articles were meticulously examined.

Quality Assessment

Utilizing the Coleman methodology score, the analytical quality of each study presented was assessed in terms of its methodology. Each study was evaluated according to each of the

methodology's 10 criteria, yielding a final score that can range between 0 and 100. A study design that completely eliminated chance, numerous biases, and confounding variables would receive a score of 100. Only studies with a Coleman score of less than 60 were used to extract data in order to confirm the validity of the stated findings.(Coleman et al., 2000)

Data Abstraction

We utilized a standardized form to gather data from the publications that included the first author, publication year, publishing journal, study type, demographic characteristics, sample sizes, and research findings. After that, data was extracted and its accuracy was double reviewed. The subjects in the research were split into two treatment groups: those receiving arthroscopic fixation and those receiving the open posterior approach. Data from the study include (1) patient demographics, such as age and gender distribution, (2) operation timing, (3) injuries related to the operation, (4) surgical approach, (5) fixation technique (suture, screw, or any device), and (6) follow-up. The total Lysholm score and complications were the two clinical outcome variables that were retrieved from the investigations. The selected articles were then analyzed using Rayyan application to manage the duplicated articles and helping in reviewing the articles.

RESULT

Literature Search

At first, 1,470 articles were retrieved from the electronic search. After rigorously applying the inclusion and exclusion criteria, the number of studies was narrowed to 12, with 7 focusing on open posterior approaches, 7 focusing on arthroscopic fixation, and 2 comparing open posterior approaches with arthroscopic fixations in direct comparisons. A summary of the study characteristics is provided in Table 1, and Figure 1 illustrates the search methodology.

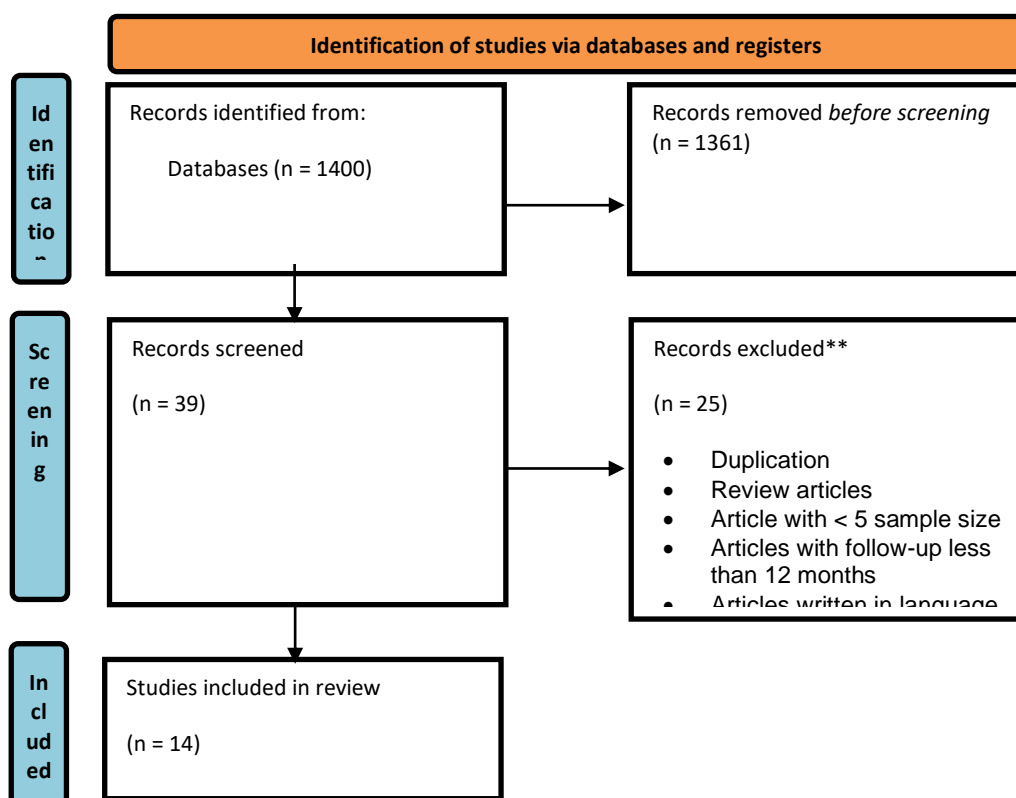


Figure 1. PRISMA flowchart for the included study

Table 1.
Characteristics of Included Studies

Study	Published year	Location (country, city)	Study type	Level of evidence
Open approach				
(Singer and Halawa, 2015)	2015	Egypt, Benha	Retrospective case series	IV
(W. Chen <i>et al.</i> , 2012)	2012	China, Zhangzhou	Retrospective case series	IV
(Inoue <i>et al.</i> , 2004)	2004	Japan, Sapporo	Prospective comparative study	II
(Yang <i>et al.</i> , 2003)	2003	Taiwan, Taoyuan	Retrospective case series	IV
(Chiarapattanakom <i>et al.</i> , 2009)	2009	Thailand, Bangkok	Retrospective case series	IV
(Xiong <i>et al.</i> , 2023)	2023	China	Retrospective case series	IV
(Qi <i>et al.</i> , 2022)	2022	China	Retrospective case series	IV
Arthroscopic approach				
(Zhao, He and Wang, 2006)	2006	China, Shanghai	Retrospective case series	IV
(Huang <i>et al.</i> , 2015)	2015	China, Chongqing	Retrospective case series	IV
(Gui <i>et al.</i> , 2009)	2009	China, Nanjing	Retrospective case series	IV
(S. Y. Chen <i>et al.</i> , 2012)	2012	Taiwan, Taoyuan	Therapeutic case series	IV
(Chen <i>et al.</i> , 2015)	2015	China, Wuhan	Retrospective case series	IV
Comparative study				
(Sabat, Jain and Kumar, 2016)	2016	India, New Delhi	Retrospective comparative series	III
(Pardiwala <i>et al.</i> , 2012)	2012	India	Prospective randomised comparative series	II
(Xu <i>et al.</i> , 2022)	2022	China	Retrospective case series	IV
(Yoon, Park and Lee, 2018)	2016	Korea	Retrospective case series	IV

Quality Assessment

In the included studies, the mean modified Coleman methodology score ranged from 61 to 89 (71±8.3). The mean Coleman methodology score for each criterion is shown in Table 2.

Table 2.
Overall Coleman Methodology Score for Each Criterion

Criteria (maximal score)	Open				Arthroscopic							Comparative				
	Singer and Hala wa ²	Che n et al. ³	Inou e et al. ⁴	Yan g et al. ⁵	Chia rapat tana kom et al. ⁶	Zha ng al. ⁹	Xio et al. ⁷	Qi et al. ⁸	Huan g et al. ¹⁰	Gui et al. ¹¹	Che n et al. ¹²	Che n et al. ¹³	Xu et al. ¹⁶	Yoo n et al. ¹⁷	Sabat et al. ¹⁴	Pardiwa la et al. ¹⁵
Part A																
Study size (10)	0	4	4	0	0	4	4	10	0	4	4	4	4	0	4	4
Mean follow-up (5)	2	5	5	5	5	5	5	2	5	5	5	5	2	5	2	5
No. of procedures (10)	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Type of study (15)	10	0	10	0	0	0	0	0	10	0	10	0	0	0	0	10
Diagnostic certainty (5)	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Surgery description (5)	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Rehabilitation description (10)	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Part B																
Outcome criteria (10)	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Procedure for outcomes (15)	3	6	11	6	11	6	6	6	11	11	15	11	6	6	11	11
Selection process (15)	15	10	10	10	12	13	10	10	10	12	15	15	10	10	15	15
Total score	70	65	80	61	68	68	65	68	76	72	89	75	62	61	72	85

Clinical Outcomes

Lysholm scores were employed to assess subjective outcomes in a total of 13 studies (comprising 6 studies utilizing the posterior open approach, 6 studies employing the arthroscopic approach, and 1 study performing a comparative analysis). The scores recorded

at the final follow-up were subjected to evaluation. The Lysholm score range at the final follow-up was observed to be between 85 and 100 for the open approach, while the arthroscopic approach yielded scores ranging from 80 to 100. Complications No neurovascular injuries or occurrences of compartment syndrome were reported in either cohort. However, there was a single instance of deep infection identified within the open approach group.(Chiarapattanakom *et al.*, 2009) Limitation of motion was documented in 7 instances within the open approach group and in 14 instances within the arthroscopic approach group. Additionally, four patients in the open approach group experienced complications related to reduction loss (2 cases) or metal irritation (2 cases).(Chiarapattanakom *et al.*, 2009; Pardiwala *et al.*, 2012) One patient in the arthroscopic approach group also encountered metal irritation. Furthermore, one case of osteonecrosis of the femoral head was noted in the open approach group (Table 3).

Table 3.
Overall Clinical Outcomes and Complications in Studies

Study	No. of patients	Postop Lysholm Score	Complication
Open			
Singer and Halawa ²	16	92–100	
Chen et al. ³	24	95.3	
Inoue et al. ⁴	16	85–100	
Yang et al. ⁵	16	-	Deep infection: 1 Screw loosening: 1
Chiarapattanakom et al. ⁶	10	85–100	
Xiong et al. ⁷			LOM: 1 Osteonecrosis of the femoral head: 1
	33	80-92	
Qi et al. ⁸	64	91-100	
Arthroscopic			
Zhao et al. ⁹	29	93–100	LOM: 2 Metal irritation: 1
Huang et al. ¹⁰	18		LOM: 2
Gui et al. ¹¹	24	92–100	LOM: 2
Chen et al. ¹²	36	80–100	
Chen et al. ¹³	22	85–96	
Xu et al. ¹⁶	28	89-100	
Yoon et al. ¹⁷	18	85-95	
Comparative			
Sabat et al. ¹⁴			
Open	27	-	LOM: 3 Revision: 1 Removal operation due to irritation: 2
Arthroscopic	20	-	LOM: 1
Pardiwala et al. ¹⁵			
Open	25	-	LOM: 3
Arthroscopic	25	-	LOM: 1

LOM = limitation of motion

The predominant mechanism responsible for posterior cruciate ligament (PCL) avulsion fractures of the tibia during vehicular collisions is typically classified as dashboard impact, wherein a direct force is exerted on the proximal segment of the tibia in an anteroposterior orientation, while the knee is flexed. If not addressed appropriately, this injury can precipitate secondary joint alterations, ultimately resulting in osteoarthritis. Various fixation techniques for PCL avulsion fractures at the tibial insertion have been proposed across multiple studies. This systematic review delineated the outcomes and complications associated with both the open surgical approach and the arthroscopic method for managing displaced PCL avulsion fractures. The posterior cruciate ligament (PCL) exhibits almost twice the strength of the anterior cruciate ligament (ACL) and is widely acknowledged as the most robust ligament within the knee joint. Its significance lies in its crucial contribution to joint stability. The occurrence of PCL rupture is comparatively lower in comparison to other ligaments, a characteristic that can be attributed to its robust fibrous composition. The PCL tibial avulsion fracture is a less common kind of PCL injury as compared to the more normal PCL tear. The management of PCL tibial avulsion fractures can be broadly categorized into conservative and surgical approaches. (Marc A. Raj; Ahmed Mabrouk; Matthew Varacallo, 2023)

Two salient points were identified through this investigation. Firstly, there were merely four direct comparative studies contrasting the open and arthroscopic techniques for displaced PCL avulsions. The included studies revealed considerable heterogeneity, characterized by diverse surgical methodologies, fixation apparatus, dimensions of fracture fragments, and varying durations of follow-up; thus, a statistical comparison between the two approaches or an assessment of comparative efficacy could not be achieved. Secondly, all studies pertaining to both the open and arthroscopic techniques for displaced PCL tibial avulsion fractures demonstrated favorable outcomes, notwithstanding the notable heterogeneity. (Pardiwala *et al.*, 2012; Sabat, Jain and Kumar, 2016; Yoon, Park and Lee, 2018; Xu *et al.*, 2022) In terms of knee outcomes, the postoperative scores at the final follow-up were subjected to analysis. The Lysholm score range at the final follow-up was recorded as 80–100 for the open approach and similarly 80–100 for the arthroscopic technique. A significant distinction was observed between the two cohorts concerning the postoperative Lysholm scores. Multiple studies have been conducted to compare the efficacy of open and arthroscopic approaches in the treatment of PCL avulsion patients. The findings consistently indicate that the arthroscopic approach yields superior outcomes. This conclusion is supported by a comprehensive analysis of seven relevant studies, which revealed that patients who underwent arthroscopy achieved an average Lysholm score of 97.4, whereas those treated solely with open surgery procedures obtained an average Lysholm score of 91.5. Nevertheless, individuals with PCL avulsion injuries who underwent open surgical interventions utilizing a small open technique exhibited comparable Lysholm scores to those who received arthroscopic operations. The patients who have the mini-open procedure exhibit a superior Lysholm value compared to those who undergo the regular open surgery caused by the pull-out suture technique provides safe and reliable fixation for comminuted fractures without metal hardware, allowing tensioning of the PCL to address laxity caused by interstitial damage. This approach is straightforward, avoiding complications and removal procedures. (Katsman *et al.*, 2018; Gopinath *et al.*, 2023)

The evaluation of complication rates between open and arthroscopic interventions indicated that arthroscopic methods yielded relatively superior results. In the open approach cohort, four patients experienced issues related to metal irritation (two cases) and screw loosening (one case). The occurrence of screw loosening can lead to complications, as evidenced by the patient experiencing postoperative discomfort after a period of 6 months. Notably, the symptoms were alleviated with the removal of the screw. One patient in the arthroscopic

approach group experienced metal irritation caused by skin irritation. In the cohort receiving the open surgical intervention, there was a singular instance of severe infection and osteonecrosis affecting the femoral head. No instances of neurovascular compromise or compartment syndrome were observed in either cohort. The predominant complication observed in both the open posterior approach cohort and the arthroscopic approach cohort was a restricted range of motion. This was documented in 7 out of 85 patients in the open approach cohort and 8 out of 115 patients in the arthroscopic cohort, with a higher prevalence noted within the arthroscopic approach cohort. The number of patients with arthrofibrosis in the open and arthroscopic groups was comparable. This finding contradicts our expectations and the 2 comparative investigations, which found 3 occurrences of arthrofibrosis in the open posterior approach group and 1 in the arthroscopic group. This is likely because the open posterior technique exposes the avulsion fracture and repairs only the fragment without trapping tissue.(Guo *et al.*, 2023)

CONCLUSION

The Lysholm score evaluates postoperative outcomes in posterior cruciate ligament (PCL) avulsion patients who had open surgery and arthroscopy. Arthroscopy has more dominance in relation to Lysholm values when compared to open surgery procedures, although open surgery employing a small open procedure method, however it has been seen that the Lysholm score remains consistent across individuals who undergo small open surgical operations and those who undergo arthroscopic treatments. The range of complications observed in postoperative patients undergoing open surgery treatments is broader in comparison to those undergoing arthroscopy.

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