



A Comparative Study of Femoral-Side Aperture Fixation versus Suspensory Fixation in Arthroscopic Anterior Cruciate Ligament Reconstruction

Dr. Palavalasa Pradeep¹, Dr. Alle Ratna Sree², Dr. Vaddi Lakshmi Madan³

¹Assistant Professor, Department of Orthopaedics, Maharajah's Institute of Medical Sciences, Nellimarla, Vizianagaram, Andhra Pradesh-535217, India.

²Final Year Postgraduate, Department of Orthopaedics, Maharajah's Institute of Medical Sciences, Nellimarla, Vizianagaram, Andhra Pradesh-535217, India.

³Final Year Postgraduate, Department of Orthopaedics, Maharajah's Institute of Medical Sciences, Nellimarla, Vizianagaram, Andhra Pradesh-535217, India.



Correspondence:

Dr. Palavalasa Pradeep

Received: February 12, 2026

Revised: February 27, 2026

Accepted: March 10, 2026

Published: March 13, 2026

Abstract

Background: Anterior cruciate ligament reconstruction is widely performed in young active adults, yet the ideal femoral graft fixation method remains debated. Aperture fixation provides graft compression within the tunnel, whereas suspensory fixation offers cortical fixation. **Objectives:** To compare aperture and suspensory femoral fixation in arthroscopic anterior cruciate ligament reconstruction with respect to knee stability, pain, functional recovery, return to sports, and complications. **Methods:** This hospital-based prospective comparative interventional study was conducted over 18 months. Sixty skeletally mature patients with clinically and radiologically confirmed anterior cruciate ligament tears were randomized into two equal groups. Group A underwent suspensory femoral fixation with EndoButton and Group B underwent aperture femoral fixation with BioScrew; tibial fixation was performed with BioScrew in both groups. Patients were evaluated using Lachman, anterior drawer, and pivot shift tests, Visual Analog Scale, Lysholm knee score, and International Knee Documentation Committee score. **Results:** Baseline demographic and injury characteristics were comparable between groups. At 12 weeks, negative Lachman test was observed in 96.7% of the aperture group and 90.0% of the suspensory group, while anterior drawer and pivot shift tests became negative in all patients. Pain scores decreased steadily in both groups. Lysholm and International Knee Documentation Committee scores improved substantially, and most patients achieved excellent or good functional grades by 12 weeks. Return to sports occurred predominantly between 4 and 7 months in both groups. Complications were infrequent, with no significant between-group difference. **Conclusion:** Both aperture fixation and suspensory fixation provided satisfactory early clinical and functional outcomes after arthroscopic anterior cruciate ligament reconstruction. Knee stability, pain reduction, return to sports, and complication rates were comparable during early follow-up. Either technique is an effective femoral fixation option in appropriately selected patients.

Keywords: Anterior cruciate ligament; Arthroscopic reconstruction; Aperture fixation; Suspensory fixation; Lysholm score; IKDC



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INTRODUCTION

Anterior cruciate ligament (ACL) injury is one of the most frequently encountered serious ligamentous injuries of the knee and is particularly common in young, active, and sports-participating individuals [1,2]. Beyond athletic populations, ACL tears are also seen after road traffic accidents, twisting trauma, and falls, especially in regions where vehicular trauma contributes substantially to musculoskeletal injury burden [14]. Epidemiological work has shown that ACL tears remain a common orthopaedic problem, with substantial implications for knee stability, activity restriction, quality of life, and long-term joint health [1,2]. Because untreated ACL deficiency can lead to recurrent instability, secondary meniscal injury, and progressive chondral damage, timely diagnosis and appropriate treatment are essential.

Clinical evaluation remains central to diagnosis. The Lachman, anterior drawer, and pivot shift tests continue to be widely used in routine orthopaedic practice, and systematic reviews have confirmed their important diagnostic role, although their sensitivity and specificity vary with injury chronicity, examiner expertise, and the setting of assessment [3,4]. Magnetic resonance imaging complements physical examination by confirming ligament disruption and identifying associated intra-articular pathology such as meniscal or chondral lesions [2]. After diagnosis, treatment is individualized according to age, activity level, instability symptoms, occupational demand, and associated injuries. For many symptomatic and active patients, arthroscopic ACL

reconstruction has become the standard restorative procedure.

Although graft selection and tunnel placement are critical determinants of outcome, fixation strategy also influences graft behavior during early healing and rehabilitation. Femoral-side fixation commonly employs either aperture fixation, usually with an interference screw placed near the tunnel aperture, or suspensory fixation, in which the graft is secured by a cortical button device. Aperture fixation is believed to reduce graft motion within the tunnel by achieving compression close to the joint line, whereas suspensory fixation offers secure cortical anchorage and technical versatility [9-12]. Comparative literature has reported broadly similar functional outcomes between the two approaches, with some studies suggesting differences in graft integration, tunnel widening, or instrumented laxity but not consistent superiority of one method across all outcome domains [9-12].

Outcome assessment after ACL reconstruction should include both objective stability testing and patient-reported functional measures. The Lysholm score and the International Knee Documentation Committee (IKDC) system are among the most established tools for evaluating knee symptoms and function after ligament reconstruction [5-7]. Return to sports is another clinically meaningful endpoint because it reflects not only mechanical stability but also confidence, rehabilitation progress, and recovery of performance capacity [8]. In view of the ongoing debate regarding the optimal femoral fixation technique, the present study was undertaken to compare femoral-side aperture fixation and suspensory fixation in arthroscopic ACL reconstruction. The objectives of this study were to compare early postoperative knee stability, pain, functional outcomes, return to sports, and complications between the two fixation techniques.

MATERIALS AND METHODS

Study setting and design

This hospital-based prospective comparative interventional study was conducted in the Department of Orthopaedics, Maharajah's Institute of Medical Sciences, Nellimarla, Vizianagaram, over 18 months. After approval from the Institutional Ethics Committee, eligible patients were enrolled following written informed consent. The study was designed to compare two femoral fixation strategies used during arthroscopic ACL reconstruction.

Participants and sample size

Sixty skeletally mature patients were included, with 30 patients allocated to each treatment group. Inclusion criteria were age 18 years or older, willingness to

participate, and clinical as well as radiological evidence of ACL tear. Patients with associated meniscal or chondral pathology were included provided these lesions did not alter the planned rehabilitation protocol. Exclusion criteria were ACL tear with bony avulsion, associated unstable injury to other major knee ligaments, previous knee surgery or prior ACL reconstruction, stiff knee, osteoarthritis, and pregnancy. A structured proforma was used to record demographic data, injury mechanism, side involved, associated injuries, radiographic findings, operative details, and postoperative outcomes.

Preoperative assessment and allocation

All patients underwent clinical evaluation including Lachman test, anterior drawer test, and pivot shift test, together with functional assessment using the Visual Analog Scale (VAS), Lysholm knee score, and IKDC score [5-7]. Standard radiographs and magnetic resonance imaging of the affected knee were obtained to confirm ACL tear and document associated lesions [2-4]. Following eligibility confirmation, patients were randomly assigned into two equal groups. Group A underwent femoral-side suspensory fixation with EndoButton, whereas Group B underwent femoral-side aperture fixation with BioScrew.

Operative procedure and follow-up

All patients underwent arthroscopic ACL reconstruction using autologous grafts through the anteromedial portal technique. In the suspensory fixation group, the graft was fixed on the femoral side with EndoButton, whereas in the aperture fixation group femoral fixation was achieved with BioScrew. In both groups, tibial-side fixation was performed with BioScrew. Postoperative rehabilitation followed institutional protocol. Patients were reassessed at the 6th and 12th postoperative weeks, and return-to-sport timing was recorded from later follow-up and rehabilitation records.

Outcome measures and statistical analysis

The primary outcomes were postoperative knee stability and functional recovery. Stability was assessed by Lachman test, anterior drawer test, and pivot shift test. Pain was quantified using the VAS. Functional outcomes were measured using Lysholm and IKDC scores, and these were also categorized into standard outcome classes [5-7,13]. Additional outcomes included time taken to return to sports and postoperative complications such as anterior knee pain, instability, stiffness, and superficial infection. Categorical variables were compared using the Chi-square test, continuous variables were summarized as mean $\pm$ standard deviation, and a p-value of less than 0.05 was considered statistically significant.

RESULTS

Citation: Pradeep P, Sree AR, Madan VL A Comparative Study of Femoral-Side Aperture Fixation versus Suspensory Fixation in Arthroscopic Anterior Cruciate Ligament Reconstruction. *Int. J. Med.*, 2026;8(3):46-53.

A total of 60 patients underwent arthroscopic ACL reconstruction and completed the planned comparative assessment, with 30 patients in the aperture fixation group and 30 patients in the suspensory fixation group. Baseline demographic characteristics were similar between the two cohorts. Most participants were young adults, and males predominated in both groups. The distribution of age, sex, side of injury, and interval from injury to surgery did not differ significantly, indicating satisfactory baseline comparability (Table 1).

Table 1. Baseline demographic and clinical characteristics of the study groups

Variable	Category	Aperture Fixation (n = 30)	Suspensory Fixation (n = 30)	Total (N = 60)	p-value
Age group	18–30 years	21 (70.0%)	15 (50.0%)	36 (60.0%)	0.28
	31–40 years	8 (26.7%)	13 (43.3%)	21 (35.0%)	
	41–50 years	1 (3.3%)	2 (6.7%)	3 (5.0%)	
Sex	Female	7 (23.3%)	6 (20.0%)	13 (21.7%)	0.75
	Male	23 (76.7%)	24 (80.0%)	47 (78.3%)	
Side of injury	Left	14 (46.7%)	15 (50.0%)	29 (48.3%)	0.80
	Right	16 (53.3%)	15 (50.0%)	31 (51.7%)	
Time from injury to surgery (months)	Mean ± SD	5.43 ± 2.91	5.03 ± 1.79	—	0.52

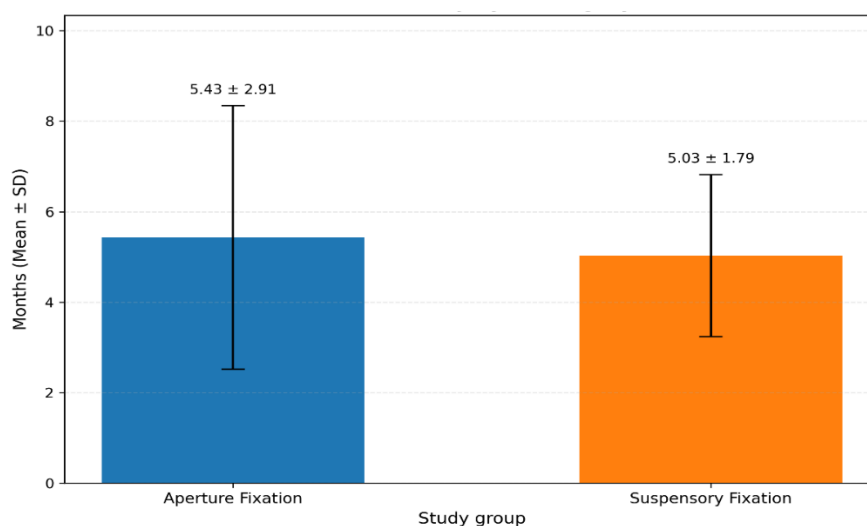


Figure 1: Time from Injury to Surgery

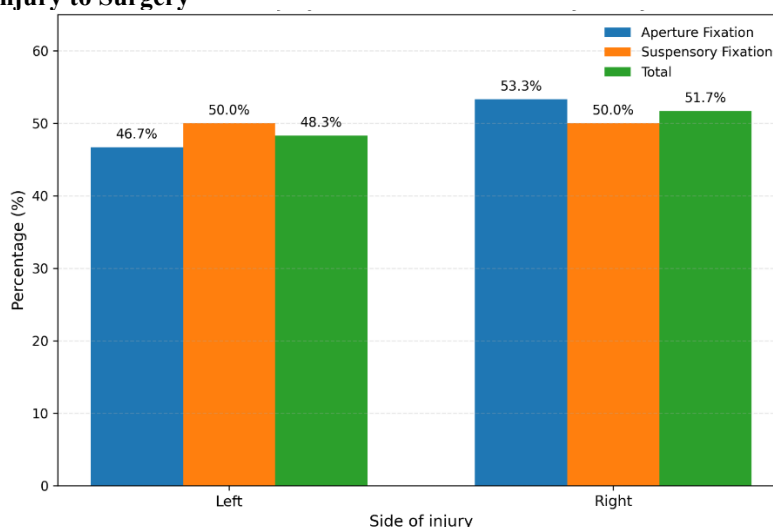


Figure 2: Side of Injury Distribution of the Study Groups

Table 2. Baseline injury profile in the two groups

Variable	Category	Aperture Fixation (n = 30)	Suspensory Fixation (n = 30)	Total (N = 60)	p-value
Mode of injury	Fall from height	0	1 (3.3%)	1 (1.7%)	0.27
	Fall from stairs	0	3 (10.0%)	3 (5.0%)	
	Others	2 (6.7%)	2 (6.7%)	4 (6.7%)	
	RTA	14 (46.7%)	15 (50.0%)	29 (48.3%)	
	Self-fall	3 (10.0%)	4 (13.3%)	7 (11.7%)	
ACL grade	Sports injury	11 (36.7%)	5 (16.7%)	16 (26.7%)	0.48
	Grade 2	3 (10.0%)	3 (10.0%)	6 (10.0%)	
	Grade 3	22 (73.3%)	25 (83.3%)	47 (78.3%)	
Associated injury	Grade 4	5 (16.7%)	2 (6.7%)	7 (11.7%)	0.31
	Both menisci	2 (6.7%)	1 (3.3%)	3 (5.0%)	
	Lateral meniscus	3 (10.0%)	5 (16.7%)	8 (13.3%)	
	Medial meniscus	5 (16.7%)	10 (33.3%)	15 (25.0%)	
	None	20 (66.7%)	14 (46.7%)	34 (56.7%)	

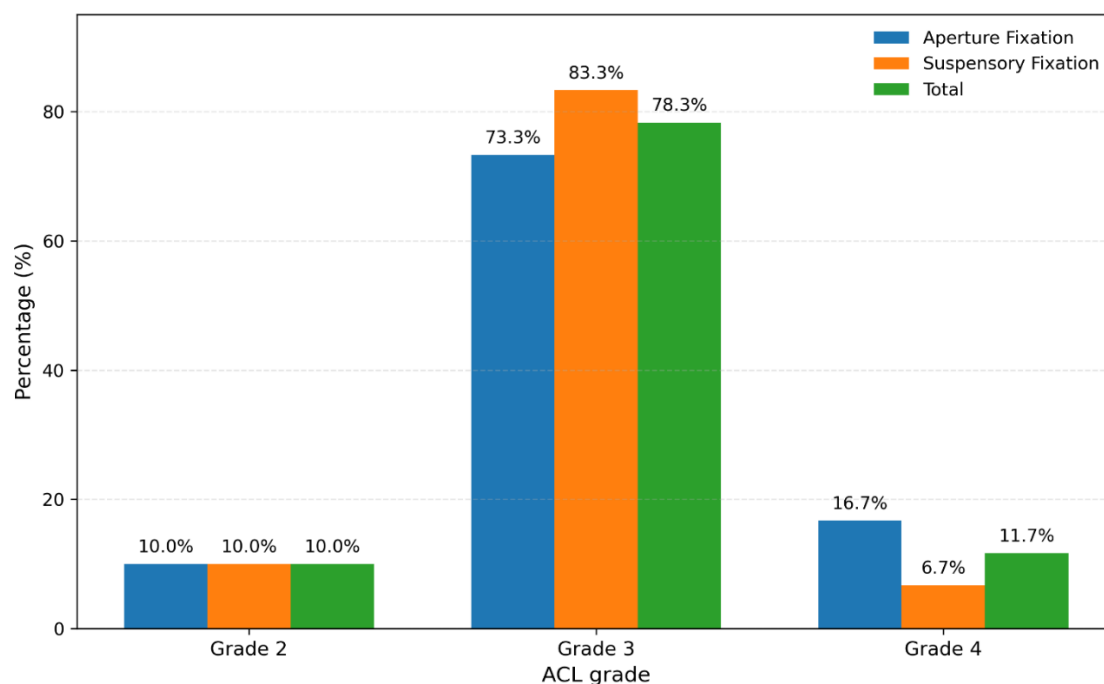


Figure 3: Distribution of ACL Grades in the Study Groups

Objective knee stability improved markedly after reconstruction in both groups. Before surgery, all patients demonstrated anterior laxity on Lachman and anterior drawer testing, while most had a positive pivot shift test. At 12 weeks, a negative Lachman test was present in 96.7% of the aperture fixation group and 90.0% of the suspensory fixation group, with no significant difference between them. Anterior drawer and pivot shift tests became negative in all patients in both groups by 12 weeks, reflecting restoration of anterior and rotatory stability. Pain scores also declined progressively from the preoperative period to 12 weeks in both cohorts. Mean Lysholm and IKDC scores improved substantially over time, with only small absolute differences between groups at postoperative assessment (Table 3).

Table 4. Functional outcome classification, return to sports, and complications

Variable	Category	Aperture Fixation (n = 30)	Suspensory Fixation (n = 30)	Total (N = 60)	p-value
Lysholm classification, 6 weeks	Excellent	3 (10.0%)	2 (6.7%)	5 (8.3%)	0.79
	Good	7 (23.3%)	9 (30.0%)	16 (26.7%)	
	Fair	20 (66.7%)	19 (63.3%)	39 (65.0%)	
	Poor	0	0	0	
Lysholm classification, 12 weeks	Excellent	27 (90.0%)	25 (83.3%)	52 (86.7%)	0.45
	Good	3 (10.0%)	5 (16.7%)	8 (13.3%)	
	Fair/Poor	0	0	0	
IKDC classification, 6 weeks	Excellent	3 (10.0%)	2 (6.7%)	5 (8.3%)	0.79
	Good	7 (23.3%)	9 (30.0%)	16 (26.7%)	
	Fair	20 (66.7%)	19 (63.3%)	39 (65.0%)	
	Poor	0	0	0	
IKDC classification, 12 weeks	Excellent	4 (13.3%)	3 (10.0%)	7 (11.7%)	0.77
	Good	20 (66.7%)	20 (66.7%)	40 (66.7%)	
	Fair	6 (20.0%)	6 (20.0%)	12 (20.0%)	
	Poor	0	1 (3.3%)	1 (1.7%)	
Return to sports	3 months	0	2 (6.7%)	2 (3.3%)	0.38
	4 months	8 (26.7%)	7 (23.3%)	15 (25.0%)	
	5 months	6 (20.0%)	8 (26.7%)	14 (23.3%)	
	6 months	9 (30.0%)	4 (13.3%)	13 (21.7%)	
	7 months	6 (20.0%)	6 (20.0%)	12 (20.0%)	
	8 months	1 (3.3%)	3 (10.0%)	4 (6.7%)	
Complications	Anterior knee pain	3 (10.0%)	1 (3.3%)	4 (6.7%)	0.52
	Instability/giving way	1 (3.3%)	2 (6.7%)	3 (5.0%)	
	Knee stiffness	1 (3.3%)	4 (13.3%)	5 (8.3%)	
	Superficial infection	2 (6.7%)	2 (6.7%)	4 (6.7%)	
	None	23 (76.7%)	21 (70.0%)	44 (73.3%)	

Categorical functional outcomes further illustrated the extent of recovery. At 6 weeks, most patients in both groups were classified as fair on both Lysholm and IKDC grading. By 12 weeks, the majority had improved to excellent Lysholm grades and good IKDC grades, with no statistically significant difference between techniques. Return to sports occurred chiefly between 4 and 7 months in both groups. Postoperative complications were infrequent, and the majority of patients remained complication-free. Knee stiffness was somewhat more frequent in the suspensory group, whereas anterior knee pain was slightly more common after aperture fixation, but the overall complication profile remained comparable (Table 4).

Baseline injury characteristics were also comparable between the study arms. Road traffic accidents were the most common mechanism of injury overall, followed by sports-related trauma. Grade 3 tears constituted the majority of ACL injuries in both groups. Concomitant meniscal pathology was present in a subset of patients, although most individuals had no associated meniscal injury. None of these baseline injury variables showed a statistically significant intergroup difference (Table 2).

Table 3. Comparison of clinical stability tests and functional scores

Outcome	Timepoint	Aperture Fixation	Suspensory Fixation	p-value
Lachman test	Pre-operative negative	0	0	—
	12 weeks postoperative negative	29 (96.7%)	27 (90.0%)	0.30
Anterior drawer test	Pre-operative negative	0	0	—
	12 weeks postoperative negative	30 (100.0%)	30 (100.0%)	—
Pivot shift test	Pre-operative positive	27 (90.0%)	28 (93.3%)	0.64
	12 weeks postoperative negative	30 (100.0%)	30 (100.0%)	—
VAS score (Mean ± SD)	Pre-operative	6.07 ± 0.83	6.57 ± 0.77	0.08
	2 weeks postoperative	3.63 ± 0.85	3.90 ± 0.92	0.25
	6 weeks postoperative	1.67 ± 0.99	2.03 ± 0.72	0.11
	12 weeks postoperative	0.63 ± 0.76	0.70 ± 0.79	0.74
Lysholm score (Mean ± SD)	Pre-operative	31.63 ± 3.65	30.90 ± 3.80	—
	6 weeks postoperative	81.53 ± 5.92	83.57 ± 4.36	<0.001*
	12 weeks postoperative	92.63 ± 2.43	92.07 ± 2.60	<0.001*
IKDC score (Mean ± SD)	Pre-operative	44.60 ± 7.20	46.43 ± 6.87	—
	6 weeks postoperative	72.03 ± 4.68	71.89 ± 6.33	<0.001*
	12 weeks postoperative	84.37 ± 5.45	82.90 ± 6.34	<0.001*

*Postoperative p-values for Lysholm and IKDC scores are reproduced as provided in the source dataset.

DISCUSSION

The present study compared femoral-side aperture fixation and suspensory fixation in arthroscopic ACL reconstruction and found that both techniques produced favorable early outcomes. The groups were well matched at baseline with respect to age, sex, side of injury, mechanism, tear grade, associated meniscal lesions, and time from injury to surgery. The demographic profile, marked by a predominance of young adult males, is consistent with the known epidemiology of ACL injury in active populations [1,2]. The injury pattern, with road traffic accidents leading and sports trauma second, also resembles South Asian data reported by Joshi et al. [14].

Clinical recovery was marked in both groups. Preoperatively, nearly all patients demonstrated instability on standard ligament tests, whereas by 12 weeks most had regained firm endpoints and negative stability tests. This aligns with the established utility of the Lachman, anterior drawer, and pivot shift tests as clinically relevant measures of ACL deficiency and postoperative restoration of stability [3,4]. The complete normalization of anterior drawer and pivot shift findings in both groups, with only minimal residual Lachman positivity, suggests that either fixation strategy can provide satisfactory early graft control when combined with appropriate surgical technique and rehabilitation.

Pain reduction and functional improvement were substantial in both cohorts. The steady decline in VAS scores and the postoperative rise in Lysholm and IKDC values are in keeping with the expected trajectory after successful ACL reconstruction [5-7,13]. Although some reported p-values for postoperative mean functional scores were statistically significant, the absolute between-group differences were small and the categorical outcome distributions remained similar; therefore, the findings are best interpreted as clinically comparable early recovery rather than clear superiority of one fixation method. This interpretation is supported by prior comparative literature. Lubowitz et al. reported no significant differences in knee anteroposterior stability or other major outcomes between cortical suspensory button fixation and aperture interference screw fixation [9]. Browning et al. likewise found no meaningful differences in IKDC, Lysholm, Lachman, or pivot-shift outcomes [10]. Crum et al. also concluded that suspensory and aperture fixation appear equally efficacious on available short-term clinical data [11].

The return-to-sport distribution in the present study, concentrated between 4 and 7 months, indicates satisfactory rehabilitation progress in both groups, although return to preinjury performance was not independently verified. Published evidence shows that

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return to sport after ACL reconstruction depends on time, strength recovery, functional testing, and psychological readiness rather than fixation method alone [8]. Complication rates were low in both groups, further supporting the short-term safety of both techniques. Tunnel biology and long-term graft incorporation remain important considerations, and Eichinger et al. showed that fixation technique can influence tunnel widening even when clinical outcomes appear similar [12]. Overall, the present findings suggest that both aperture fixation and suspensory fixation are acceptable femoral fixation options, with choice likely influenced by surgeon preference, graft characteristics, implant availability, and technical considerations.

Limitations

This study was conducted at a single center with a relatively small sample size and short primary follow-up for clinical and functional assessment. Instrumented laxity measurements and imaging-based evaluation of graft incorporation or tunnel widening were not performed. Surgeons were not uniform across all procedures, and return-to-sport outcomes were based on recorded timing rather than comprehensive sport-specific performance testing. These factors restrict long-term generalizability.

CONCLUSION

In this prospective comparative study, femoral-side aperture fixation and suspensory fixation yielded similar early outcomes after arthroscopic ACL reconstruction. Both techniques restored clinical stability, reduced pain, improved Lysholm and IKDC scores, enabled return to sports within a broadly similar time frame, and were associated with low complication rates. The absence of major clinically meaningful differences between groups indicates that either fixation strategy can be used effectively in appropriately selected patients. Larger multicenter studies with longer follow-up, standardized rehabilitation, instrumented laxity assessment, and imaging correlation are required to clarify whether one fixation method offers superior long-term graft incorporation, tunnel behavior, or functional durability.

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Citation: Pradeep P, Sree AR, Madan VL A Comparative Study of Femoral-Side Aperture Fixation versus Suspensory Fixation in Arthroscopic Anterior Cruciate Ligament Reconstruction. *Int. J. Med.*, 2026;8(3):46-53.

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