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Original Research Article

Outcome of Arthroscopic Transportal Single Bundle ACL Reconstruction– An Observational Study

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Abstract

Background: Anterior cruciate ligament (ACL) reconstruction is the treatment of choice for active individuals with ACL insufficiency. Single-bundle arthroscopic reconstruction using the transportal technique remains widely used, but outcome data from this healthcare setting were lacking. This study evaluated the clinical, functional, and radiological outcome of arthroscopic transportal single-bundle ACL reconstruction.

Material and methods: This prospective observational study included 48 patients (32 men, 16 women; mean age 31.81 ± 6.66 years) undergoing arthroscopic transportal single-bundle ACL reconstruction with hamstring autograft. Clinical outcome (VAS, IKDC, Tegner-Lysholm scores) was assessed pre-operatively and at 3 and 6 months; functional outcome (limb symmetry index on four hop tests) and radiological outcome (stress radiography, anterior tibial translation) were assessed at 3 and 6 months. Association with gender, BMI, and age was analysed.

Results: Significant improvement occurred across all clinical outcomes (mean IKDC score 37.92% pre-op to 79.57% at 6 months; Tegner-Lysholm "good" category in 97.9% at 6 months; $p<0.001$ throughout). Hop-test limb symmetry normalised in 97.9–100% of patients by 6 months ($p\leq0.001$). Anterior tibial translation on the operated side (3.71 ± 0.55 mm at 6 months) remained within normal limits though significantly greater than the normal side ($p<0.001$). Complications occurred in one patient (2.1%). Outcome was independent of gender ($p>0.05$) but showed significant inverse association with BMI ($p=0.044$) and age ($p\leq0.002$ for hop tests).

Conclusion: Arthroscopic transportal single-bundle ACL reconstruction yields significant, sustained clinical, functional, and radiological improvement with a low complication rate, though higher BMI and older age were associated with comparatively poorer outcomes.

Keywords: Anterior cruciate ligament, arthroscopic reconstruction, single bundle, IKDC score, hop test, stress radiography.

Introduction

Anterior cruciate ligament (ACL) injury is a common and functionally important knee injury, particularly among physically active individuals exposed to pivoting, cutting, and jumping activities. ACL insufficiency can result in recurrent episodes of instability and may interfere with sporting participation and other demanding activities. Although non-operative rehabilitation is an important component of ACL injury management, treatment selection depends on factors including activity demands, symptoms of instability, patient characteristics, and expectations regarding functional recovery. In highly active individuals with persistent instability, surgical reconstruction remains an established treatment option, particularly when restoration of mechanical stability is required [1,2]. The principal objective of ACL reconstruction is to restore functional knee stability while facilitating recovery of pre-injury activity. Over the years, numerous modifications in graft selection, tunnel positioning, fixation, and reconstruction configuration have been introduced to improve postoperative outcomes. Hamstring tendon autografts remain an extensively used graft option because of their favourable clinical profile and established use in primary ACL reconstruction. Evidence comparing different autograft choices indicates that clinically meaningful differences between graft types may be influenced by patient characteristics and the outcomes being assessed, underscoring the importance of appropriate graft selection for individual patients [3,4].

Single-bundle ACL reconstruction continues to be an important surgical approach, with anatomical tunnel placement considered central to restoration of native ligament biomechanics. The transportal technique permits independent preparation of the femoral tunnel through an anteromedial portal and has been developed to facilitate more anatomically oriented femoral tunnel positioning than conventional transtibial drilling. Comparative evidence has reported favourable clinical and stability outcomes with the transportal approach relative to transtibial single-bundle reconstruction, although differences in patient-reported outcomes may be less pronounced across techniques. A systematic review specifically comparing transportal and all-inside approaches has likewise demonstrated broadly comparable postoperative functional outcomes, supporting the continued clinical relevance of transportal reconstruction [5,6].

Assessment of ACL reconstruction should extend beyond subjective symptoms and conventional clinical scores because restoration of knee function involves both patient-perceived recovery and objective limb performance. Patient-reported instruments such as the International Knee Documentation Committee (IKDC) subjective score and Tegner-Lysholm score provide complementary measures of symptoms and functional status. In addition, single-leg hop tests are widely used to assess postoperative lower-limb performance, with the Limb Symmetry Index (LSI) providing a comparison between the reconstructed and contralateral limbs. Although hop testing has limitations and should not be interpreted as a standalone determinant of successful recovery, it provides useful information regarding functional symmetry following ACL reconstruction [7].

Radiological assessment of anterior tibial translation provides an additional objective measure of sagittal knee stability after reconstruction. Combining patient-reported outcomes, functional performance testing, and assessment of anterior laxity can therefore provide a more comprehensive evaluation of postoperative recovery than reliance on a single outcome measure. Such multidimensional assessment is particularly relevant during the early postoperative period, when clinical improvement may occur progressively and functional deficits may persist despite satisfactory subjective recovery.

Despite the extensive literature on ACL reconstruction, outcomes may vary according to the surgical technique, rehabilitation protocol, patient characteristics, and clinical setting. Evidence regarding transportal single-bundle reconstruction using hamstring autograft, particularly when clinical, functional, and radiological outcomes are assessed concurrently during early follow-up, remains clinically relevant. Therefore, the present study was undertaken to evaluate the clinical, functional, and radiological outcomes of arthroscopic transportal single-bundle ACL reconstruction using a hamstring autograft over a 6-month postoperative period, and to examine whether postoperative outcomes were associated with patient factors including age, sex, and body mass index.

Materials and Methods

Study design and setting: This was a hospital-based, prospective observational study conducted in the Department of Orthopaedics at Apollo Hospitals, Bhubaneswar, India, over a six-month recruitment and follow-up period from December 2017 to May 2018. Patients presenting with an isolated tear of the anterior cruciate ligament (ACL) who were scheduled to undergo arthroscopic transportal single-bundle ACL reconstruction were enrolled consecutively after screening against the eligibility criteria below.

Participants: Patients aged 20–49 years with an isolated ACL tear and no prior history of trauma to the affected knee were eligible for inclusion. Patients were excluded if the ACL injury was accompanied by concomitant ligamentous or meniscal damage, if the procedure was a revision reconstruction, if there was a background of neuromuscular disease, or if any other condition (such as a pre-existing stiff knee) was judged likely to compromise the surgical outcome or its assessment. All participants provided written informed consent prior to enrolment, and the study was approved by the Institutional Ethics Committee.

Sample size: The minimum required sample size was estimated a priori using G*Power (version 3.1.9.2, University of Kiel, Germany), based on a chi-square test for contingency tables with an effect size (w) of 0.5, α of 0.05, statistical power of 0.80, and 4 degrees of freedom.

This yielded a critical χ^2 of 9.49 and a required sample of 48 patients, achieving an actual power of 0.80. Recruitment was ultimately capped at this figure, consistent with the limited enrolment window and the fixed six-month follow-up horizon of the study.

Preoperative assessment: Following counselling and consent, each patient underwent baseline documentation of pain using the Visual Analogue Scale (VAS), and of knee function using the IKDC subjective knee evaluation form and the Tegner-Lysholm knee scoring scale.

Surgical technique: All procedures were performed arthroscopically using the transportal single-bundle technique. Anteromedial and anterolateral portals were established under direct

arthroscopic visualisation, with needle localisation used to position the anteromedial portal low enough to avoid the anterior horn of the medial meniscus while keeping it medial enough to permit near-perpendicular reaming of the lateral wall of the intercondylar notch. An autogenous hamstring graft was harvested through a 3-cm incision medial to the tibial tuberosity; the semitendinosus tendon was doubled to create a quadruple-strand graft, supplemented with the gracilis tendon when the semitendinosus alone measured under 24 cm. The femoral socket was drilled through the low anteromedial portal with the knee held in hyperflexion, using a composite reamer preloaded on a guide pin to control tunnel length and back-wall thickness, followed by preparation of the tibial tunnel and passage of the graft. Fixation was achieved with a suspensory endobutton device on the femoral side and a bioabsorbable interference screw on the tibial side, with the knee cycled through multiple flexion-extension arcs prior to final fixation in extension. Portal incisions were closed over a suction drain, and the knee was supported in a hinged brace postoperatively.

Outcome assessment: Clinical outcome was assessed using the VAS pain score, the IKDC subjective knee evaluation, and the Tegner-Lysholm knee score, each recorded preoperatively and at 3 and 6 months postoperatively. Functional performance was additionally assessed at 3 and 6 months using a battery of four single-legged hop tests — single-leg hop for distance, 6-meter timed hop, triple hop, and cross-over hop — with results expressed as the Limb Symmetry Index (LSI), comparing the operated limb against the contralateral uninjured limb. For each test, patients performed a practice trial followed by two measured trials per limb, beginning with the non-operated side, with the mean of the two trials recorded; a trial was considered failed if the patient lost balance, touched down with the arms or contralateral leg, or took an additional hop on landing.

Radiological outcome was assessed by stress radiography of the operated and contralateral knees using a modified TELOS device, quantifying anterior tibial translation relative to the femur (in mm) at 3 and 6 months postoperatively. Intraoperative and postoperative complications — including neurovascular injury, bleeding, knee stiffness, graft re-rupture, arthrofibrosis, septic arthritis, wound dehiscence, and compartment syndrome — were recorded prospectively for all patients.

Statistical analysis: Data were analysed using IBM SPSS Statistics, version 24.0. Categorical variables (age group, gender, BMI category, mode of injury, pain category, Tegner-Lysholm category, and hop-test outcome category) were summarised as frequencies and percentages, while continuous variables (age, BMI, injury-to-surgery interval, IKDC score, hop-test LSI values, and anterior tibial translation) were summarised as mean ± standard deviation and interquartile range. Change in VAS score and Tegner-Lysholm category over time was assessed using the marginal homogeneity test, while change in IKDC score and anterior tibial translation over time was assessed using the paired-samples t-test. Change in hop-test outcome category between 3 and 6 months was assessed using the McNemar test. Association of IKDC and Tegner-Lysholm scores with gender was assessed using the independent-samples t-test, and their association with BMI category using one-way analysis of variance. Association of hop-test outcomes and anterior tibial translation with age group was assessed using the Kruskal-Wallis test. A p value <0.05 was considered statistically significant throughout.

Results

A total of 48 patients who underwent arthroscopic transportal single-bundle ACL reconstruction were included in this observational study (Table 1). The cohort comprised 32 men (66.7%) and 16 women (33.3%), with a mean age of 31.81 ± 6.66 years; the age distribution did not differ significantly by gender ($\chi^2=1.146$, $p=0.564$). Mean BMI was 25.74 ± 2.66 kg/m², with the majority of patients (54.2%) falling in the normal-weight category, 35.4% overweight, and 10.4% obese; BMI category showed no significant association with gender ($\chi^2=0.449$, $p=0.799$). Sports-related trauma was the leading mechanism of injury (45.8%), followed by road traffic accidents (31.3%) and domestic slips or falls (22.9%). The mean interval between injury and surgery was 54.29 ± 19.92 days (median 55, IQR 35–62).

Progressive and statistically significant improvement was observed across all clinical outcome measures over the follow-up period (Table 2). On the VAS pain scale, over half of patients (52.1%) reported severe pain preoperatively, with the remainder reporting moderate pain; by 3 months, pain had shifted predominantly to the moderate (79.2%) and mild (20.8%) categories, and by 6 months the large majority of patients (91.7%) reported only mild pain (pre-op vs 3 months, $p=0.0001$; 3 vs 6 months, $p=0.0002$). Functional recovery followed a similar trajectory: mean IKDC score rose from 37.92 ± 6.59% preoperatively to 66.78 ± 5.25% at 3 months and 79.57 ± 2.87% at 6 months, with significant improvement at every interval ($p<0.001$ throughout). Tegner-Lysholm scores showed a parallel shift, with all patients categorized as "poor" preoperatively, 85.4% reaching "fair" by 3 months, and 97.9% reaching "good" by 6 months ($p<0.001$ at both intervals).

Limb symmetry index (LSI) values across all four HOP tests improved significantly between 3 and 6 months postoperatively (Table 3). At 3 months, abnormal LSI values were recorded in 22.9–33.3% of patients depending on the specific test, with the cross-over hop test showing the highest proportion of abnormal results. By 6 months, LSI had normalized in nearly all patients: single-leg hop for distance and 6-meter timed hop normalized in 100% of cases, triple hop in 100%, and cross-over hop in 97.9% (all $p \leq 0.001$, McNemar test). Mean LSI values likewise rose across all four tests between 3 and 6 months (single-leg hop: 85.35 ± 1.45% to 88.38 ± 1.55%; 6-m timed hop: 85.04 ± 1.14% to 88.20 ± 1.37%; triple hop: 84.97 ± 1.53% to 87.66 ± 1.58%; cross-over hop: 84.39 ± 1.64% to 87.01 ± 1.53%). Postoperative complications were minimal: 47 patients (97.9%) had an uneventful course, with only one patient (2.1%) developing a superficial infection and no cases of extensor lag. Stress radiography using the modified TELOS device demonstrated that anterior tibial translation on the operated side remained within accepted normal limits (<5 mm) throughout follow-up, though it was significantly greater than the contralateral normal side at both time points (Table 4). Mean anterior translation was 2.04 ± 0.76 mm on the normal side, compared with 2.94 ± 0.66 mm on the operated side at 3 months and 3.71 ± 0.55 mm at 6 months ($p<0.001$ for all pairwise comparisons).

Gender was not significantly associated with clinical outcome at 6 months: mean IKDC scores were comparable between women (79.90 ± 1.89%) and men (79.40 ± 3.27%; p=0.576), as were Tegner-Lysholm scores (86.65 ± 1.67 vs 86.45 ± 1.92; p=0.725) (Table 5). BMI, however, showed a significant inverse relationship with outcome: mean IKDC score declined from 80.06 ± 2.94% in normal-weight patients to 79.24 ± 3.00% in overweight patients and 76.16 ± 1.60% in obese patients (p=0.044), with a parallel significant decline in Tegner-Lysholm score across BMI categories (87.04 ± 1.82 to 86.16 ± 1.64 to 85.00 ± 1.58; p=0.041). Age group showed a significant association with functional outcome on all four HOP tests at 6 months, with younger patients (20–29 years) consistently achieving higher mean LSI values than older patients (40–49 years) across single-leg hop, 6-meter timed hop, triple hop, and cross-over hop testing ($p \leq 0.002$ for all comparisons, Table 6). Anterior tibial translation at 6 months showed a similar downward trend with increasing age (3.24 ± 0.75 mm in the 20–29 year group vs 2.81 ± 0.92 mm in the 40–49 year group), though this difference did not reach statistical significance (Kruskal-Wallis p=0.371).

Table 1: Baseline demographic and injury characteristics (N = 48)

Variable	Female (n=16)	Male (n=32)	Total (n=48)	Statistic
Age 20–29 y, n (%)	9 (56.3)	14 (43.8)	23 (47.9)	χ^2=1.146, p=0.564
Age 30–39 y, n (%)	4 (25.0)	13 (40.6)	17 (35.4)	
Age 40–49 y, n (%)	3 (18.8)	5 (15.6)	8 (16.7)	
Mean age ± SD, y	31.44 ± 7.05	32.00 ± 6.56	31.81 ± 6.66	
BMI – Normal, n (%)	9 (56.3)	17 (53.1)	26 (54.2)	χ^2=0.449, p=0.799
BMI – Overweight, n (%)	6 (37.5)	11 (34.4)	17 (35.4)	
BMI – Obese, n (%)	1 (6.3)	4 (12.5)	5 (10.4)	
Mean BMI ± SD, kg/m²	25.57 ± 3.19	25.83 ± 2.40	25.74 ± 2.66	
Mode of injury – Sports-related, n (%)	22 (45.8)			
Mode of injury – RTA, n (%)	15 (31.3)			
Mode of injury – Slip/fall at home, n (%)	11 (22.9)			
Time from injury to surgery (days), mean ± SD	54.29 ± 19.92			Median 55 (IQR 35–62)

Table 2: Clinical outcome scores across follow-up (N = 48)

Score	Pre-op	Post-op 3 mo	Post-op 6 mo	p value
VAS – Mild, n (%)	0 (0)	10 (20.8)	44 (91.7)	Pre-op vs 3 mo: p=0.0001
VAS – Moderate, n (%)	23 (47.9)	38 (79.2)	4 (8.3)	3 mo vs 6 mo: p=0.0002
VAS – Severe, n (%)	25 (52.1)	0 (0)	0 (0)	(Marginal Homogeneity test)
IKDC score (%), mean ± SD	37.92 ± 6.59	66.78 ± 5.25	79.57 ± 2.87	Pre-op vs 3mo p<0.001; Pre-op vs 6mo p<0.001; 3mo vs 6mo p<0.001
Tegner-Lysholm – Poor, n (%)	48 (100)	7 (14.6)	0 (0)	Pre-op vs 3 mo: p<0.001
Tegner-Lysholm – Fair, n (%)	0 (0)	41 (85.4)	1 (2.1)	3 mo vs 6 mo: p<0.001
Tegner-Lysholm – Good, n (%)	0 (0)	0 (0)	47 (97.9)	(Marginal Homogeneity test)

Table 3: Functional outcome (Limb Symmetry Index) on HOP test battery at 3 and 6 months (N = 48)

HOP test	3 mo — Abnormal, n (%)	3 mo — LSI, mean ± SD	6 mo — Abnormal, n (%)	6 mo — LSI, mean ± SD	p value*
Single-leg hop for distance	11 (22.9)	85.35 ± 1.45	0 (0)	88.38 ± 1.55	0.001
6-m timed hop	12 (25.0)	85.04 ± 1.14	0 (0)	88.20 ± 1.37	<0.001
Triple hop	13 (27.1)	84.97 ± 1.53	0 (0)	87.66 ± 1.58	<0.001
Cross-over hop	16 (33.3)	84.39 ± 1.64	1 (2.1)	87.01 ± 1.53	0.001

*McNemar test, 3 mo vs 6 mo. Complications: no complications in 47 patients (97.9%); 1 patient (2.1%) developed a superficial infection.

Table 4: Radiological outcome: anterior tibial translation relative to femur, normal vs operated side (N = 48)

Side / time point	Mean ± SD, mm
Normal side (reference)	2.04 ± 0.76
Operated side — 3 months	2.94 ± 0.66
Operated side — 6 months	3.71 ± 0.55

Paired t-test: normal vs operated 3 mo, $p<0.001$; normal vs operated 6 mo, $p<0.001$; operated 3 mo vs operated 6 mo, $p<0.001$. All values remained within the normal limit of <5 mm.

Table 5: Association of clinical outcome at 6 months with gender and BMI

Subgroup	N	IKDC score (%), mean ± SD	p value	Tegner-Lysholm score, mean ± SD	p value
Female	16	79.90 ± 1.89	0.576	86.65 ± 1.67	0.725
Male	32	79.40 ± 3.27		86.45 ± 1.92	
BMI – Normal	26	80.06 ± 2.94	0.044	87.04 ± 1.82	0.041
BMI – Overweight	17	79.24 ± 3.00		86.16 ± 1.64	
BMI – Obese	5	76.16 ± 1.60		85.00 ± 1.58	

Table 6: Association of functional and radiological outcome at 6 months with age group

Age group	n	SLH LSI, mean ± SD	6-m TH LSI, mean ± SD	Triple hop LSI, mean ± SD	Cross-over hop LSI, mean ± SD	Anterior tibial translation, mm
20–29 y	23	89.38 ± 1.32	88.83 ± 1.46	88.71 ± 1.46	88.02 ± 1.35	3.24 ± 0.75
30–39 y	17	87.74 ± 1.01	87.90 ± 0.93	86.92 ± 0.92	86.33 ± 0.91	2.98 ± 0.79
40–49 y	8	86.84 ± 1.18	86.99 ± 0.80	86.23 ± 0.88	86.55 ± 1.08	2.81 ± 0.92
Total	48	88.38 ± 1.55	88.20 ± 1.37	87.66 ± 1.58	87.01 ± 1.53	3.04 ± 0.80
p value (Kruskal-Wallis)		0.000	0.002	0.000	0.000	0.371

Discussion

The present study demonstrated significant improvement in clinical, functional, and radiological outcomes following arthroscopic transportal single-bundle ACL reconstruction with hamstring autograft over 6 months. VAS pain scores decreased progressively, while IKDC and Tegner-Lysholm scores improved significantly at both postoperative assessments. Functional recovery also progressed, with limb symmetry on all four hop tests improving between 3 and 6 months. Stress radiography showed that anterior tibial translation on the reconstructed side remained below 5 mm, although it was significantly greater than that of the contralateral knee. Only one patient developed a superficial infection, indicating a low short-term complication rate.

The improvement in patient-reported outcomes is consistent with previous evidence showing substantial functional recovery following ACL reconstruction. Brzeszczyński et al. reported favourable functional outcomes among recreational athletes after ACL reconstruction, although return to pre-injury sporting levels varied across studies and was influenced by follow-up duration [8]. In the present cohort, the progressive increase in IKDC score from 37.92% preoperatively to 79.57% at 6 months, together with the marked improvement in Tegner-Lysholm classification, indicates clinically meaningful recovery during the early postoperative period.

The findings also support the continued clinical relevance of single-bundle reconstruction. Although double-bundle reconstruction may provide advantages for selected measures of anterior or rotational stability, systematic evidence has demonstrated broadly comparable patient-reported outcomes between single- and double-bundle procedures [9]. Similarly, a randomized clinical trial reported no major differences in clinical outcomes between anatomic single-bundle and double-bundle reconstruction at 2 years [10]. Thus, satisfactory outcomes can be achieved with single-bundle reconstruction when appropriate tunnel positioning and graft fixation are employed.

A notable finding was the significant improvement in LSI across all four hop tests. At 3 months, 22.9–33.3% of patients had abnormal results, whereas by 6 months, 97.9–100% demonstrated normalized symmetry. Previous longitudinal research has shown progressive improvement in hop performance during rehabilitation after ACL reconstruction [11]. However, LSI should not be regarded as a sole indicator of complete functional recovery. Kotsifaki et al. demonstrated that apparently symmetrical hop distances may coexist with inter-limb differences in lower-limb biomechanics [12]. Therefore, the favourable hop-test results in the present study indicate improved functional symmetry but do not necessarily establish complete restoration of neuromuscular function.

Anterior tibial translation remained within the normal limit throughout follow-up, increasing from 2.94 ± 0.66 mm at 3 months to 3.71 ± 0.55 mm at 6 months. Although translation remained significantly higher than on the normal side, the absolute values remained below 5 mm. This finding is compatible with evidence that objective laxity and patient-reported functional outcomes do not always demonstrate a direct relationship after ACL reconstruction [9,10].

Higher BMI was significantly associated with lower IKDC and Tegner-Lysholm scores at 6 months. However, this finding should be interpreted cautiously because only five patients were obese. Previous systematic evidence has not consistently demonstrated inferior functional outcomes solely on the basis of increased BMI following ACL reconstruction [13]. Accordingly, the present association may indicate an influence of BMI on early recovery but cannot establish causality.

Age was significantly associated with hop-test performance, with younger patients achieving higher LSI values across all four tests. Nevertheless, older patients can also achieve substantial clinical improvement following ACL reconstruction. Previous studies have reported comparable clinical and functional outcomes in patients above and below 40 years of age [14], while systematic evidence in older patients has similarly demonstrated significant postoperative improvement [15]. The age-related differences observed in the present study may therefore reflect differences in physical performance or rehabilitation capacity rather than failure of reconstruction.

The low complication rate further supports the favourable short-term safety profile of the procedure. Only one patient developed superficial infection, with no graft re-rupture, arthrofibrosis, septic arthritis, or neurovascular complication recorded. However, the 6-month follow-up is insufficient to assess long-term graft survival, recurrent instability, return to sport, or post-traumatic osteoarthritis. Hamstring autografts remain an established option for ACL reconstruction, although graft failure can vary according to patient age, activity level, graft characteristics, and duration of follow-up [16]. The principal strengths of this study include prospective assessment and simultaneous evaluation of subjective clinical outcomes, functional performance, and objective radiological stability. However, the modest sample size, single-centre design, observational methodology, and short follow-up limit generalizability and causal interpretation. In addition, the small number of obese patients reduces the reliability of BMI subgroup comparisons. Larger prospective studies with longer follow-up and more comprehensive assessment of strength, neuromuscular function, return to sport, and graft survival are warranted.

Overall, transportal single-bundle ACL reconstruction using hamstring autograft was associated with significant early improvement in pain, knee function, limb symmetry, and anterior knee stability. The findings support the effectiveness and short-term safety of the technique, while suggesting that age and BMI may be relevant considerations during postoperative rehabilitation and patient counselling.

Conclusion

Arthroscopic transportal single-bundle ACL reconstruction using a quadruple-strand hamstring autograft produced significant and progressive improvement in pain, functional knee scores (IKDC and Tegner-Lysholm), and limb symmetry on hop testing over a 6-month follow-up period, with radiological stress testing confirming restoration of anterior tibial stability within accepted normal limits and a low overall complication rate.

While gender had no measurable influence on outcome, higher BMI and older age were associated with comparatively poorer functional and clinical scores, suggesting these factors merit

consideration during patient counselling and postoperative rehabilitation planning. Overall, the technique appears safe and effective in this cohort, though the modest sample size and relatively short follow-up warrant confirmation in larger studies with extended observation periods.

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