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FUNCTIONAL OUTCOMES AFTER ARTHROSCOPIC ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION USING HAMSTRING AUTOGRAFT: A PROSPECTIVE STUDY

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Abstract

Background: Arthroscopic anterior cruciate ligament (ACL) reconstruction with a quadrupled hamstring tendon autograft is a widely used technique for the ACL-deficient knee, but functional recovery and return-to-sport in a consecutive prospective cohort deserve continued documentation.

Objectives: To evaluate functional, clinical and stability outcomes at 6 and 12 months after arthroscopic ACL reconstruction using hamstring autograft, and to describe return to sport and complications.

Methods: A prospective cohort of 120 patients undergoing primary arthroscopic single-bundle ACL reconstruction with a four-strand semitendinosus–gracilis autograft was assessed preoperatively and at 6 and 12 months. Outcomes included the International Knee Documentation Committee (IKDC) subjective score, Lysholm score, visual analogue scale (VAS) for pain, Tegner activity level, range of motion, single-leg-hop and isokinetic limb-symmetry indices (LSI), Lachman and pivot-shift tests, return to sport and complications. Paired comparisons used the paired t test.

Results: The cohort (mean age 26.9 ± 6.4 years; 69.2% male) improved markedly from baseline to 12 months. Mean IKDC rose from 50.0 ± 9.4 to 89.7 ± 5.3 and Lysholm from 59.4 ± 8.8 to 92.8 ± 4.1 (both $p < 0.001$); VAS pain fell from 4.4 ± 1.6 to 0.9 ± 0.5 ($p < 0.001$). At 12 months, 71.7% had a negative Lachman and 75.8% a negative pivot-shift test; mean single-leg-hop LSI was 92.5 ± 7.6%. Return to sport at any level occurred in 48.3%, and 42.5% returned to their pre-injury Tegner level at 12 months. Complications occurred in 7 patients (5.8%) and graft failure in 2 (1.7%).

Conclusion: Arthroscopic hamstring-autograft ACL reconstruction produced large, statistically significant improvements in knee-specific function, pain and stability by 12 months, with a low complication rate; recovery of pre-injury sporting level within one year remained incomplete, underscoring the value of structured rehabilitation and realistic counselling.

Keywords: anterior cruciate ligament; hamstring autograft; arthroscopy; IKDC; return to sport; limb symmetry

Introduction

Rupture of the anterior cruciate ligament (ACL) is among the most common sports-related knee injuries, producing rotatory instability, functional limitation and an elevated risk of secondary meniscal and chondral damage in the active population [2]. In young and athletically active individuals, arthroscopic ACL reconstruction is the accepted standard of care, aiming to restore anteroposterior and

rotatory stability and to allow a return to demanding activity [2]. The two autograft tissues used most frequently are the bone–patellar-tendon–bone graft and the quadrupled semitendinosus–gracilis (hamstring) graft, and the relative merits of each have been debated for two decades [3,7].

Comparative evidence has accumulated from randomised trials, systematic reviews and meta-analyses. Meta-analyses suggest that hamstring grafts are associated with lower donor-site morbidity — notably less anterior knee pain and kneeling pain — while some analyses detect marginally greater residual laxity on instrumented or clinical testing with hamstring grafts, without a consistent difference in graft-failure rates [3,4,5,6]. A systematic review concluded that graft type may not be the primary determinant of a successful outcome, drawing attention instead to surgical technique, fixation and rehabilitation [7]. Consistent with these findings, single-cohort series using four-strand hamstring autograft have reported large improvements in functional scores with acceptable stability and failure rates [1].

Despite this evidence base, functional recovery is not synonymous with graft integrity. Return to the pre-injury level of sport is achieved by only a proportion of patients within the first year, and physical recovery alone does not fully explain who returns; psychological readiness and activity motivation also contribute [8,10,12]. Limb-symmetry indices derived from hop and isokinetic testing have become important functional benchmarks for readiness, complementing knee-specific patient-reported scores [10]. Documenting these outcomes together in a consecutive prospective cohort remains valuable, particularly where local case-mix, graft configuration and fixation differ from published trials.

The present study therefore prospectively evaluated functional, clinical and stability outcomes at 6 and 12 months after arthroscopic single-bundle ACL reconstruction using a four-strand hamstring autograft. The objectives were to quantify improvement in the IKDC and Lysholm scores, VAS pain and Tegner activity level; to describe range of motion, limb-symmetry indices and ligament-stability tests; and to report return to sport and complications.

Methods

Participants

One hundred and twenty patients undergoing primary arthroscopic ACL reconstruction were included. Eligible patients had a symptomatic, arthroscopically confirmed ACL tear with clinical instability and were scheduled for single-bundle reconstruction using a hamstring autograft. Revision reconstructions, multiligament injuries and grafts other than hamstring were outside the scope of this cohort.

Surgical technique

All reconstructions used an autologous four-strand semitendinosus–gracilis graft harvested through a standard pes anserinus approach and prepared to the required diameter. Femoral fixation used a cortical suspensory button or adjustable-loop device, and tibial fixation used an interference screw, with supplementary backup fixation where indicated. Meniscal and chondral lesions were addressed at the same sitting. A standardised, progressive rehabilitation protocol emphasising early range of motion, quadriceps and hamstring strengthening, neuromuscular control and criterion-based advancement was followed.

Outcome measures

Patients were assessed preoperatively and at 6 and 12 months. Primary outcomes were the IKDC subjective knee score (0–100) and the Lysholm score (0–100). Secondary outcomes were VAS pain (0–10), Tegner activity level (0–10), knee flexion and extension deficit, single-leg-hop LSI and isokinetic quadriceps and hamstring LSI, Lachman and pivot-shift grades, return to sport and time to return, return to pre-injury Tegner level, complications and graft failure at 12 months.

Statistical analysis

Continuous variables are summarised as mean ± standard deviation and categorical variables as counts and percentages. Preoperative-to-12-month changes in IKDC, Lysholm and VAS pain were tested with the paired *t* test, with two-sided $p < 0.05$ considered significant. Analyses were performed in Python (pandas, SciPy).

Results

Baseline characteristics

The cohort comprised 120 patients with a mean age of 26.9 ± 6.4 years; 83 (69.2%) were male and the right knee was affected in 67 (55.8%). Mean BMI was 24.6 ± 2.8 kg/m². The mechanism was a non-contact pivot in 60 (50.0%), contact in 28 (23.3%) and landing in 18 (15.0%); football was the most common sport (41 patients). Mean time from injury to surgery was 6.4 ± 3.8 months. Meniscal injury was present in 62 patients (medial 31, lateral 21, both 10) and a chondral lesion in 25. Baseline characteristics are shown in Table 1.

Surgical variables

Mean graft diameter was 8.2 ± 0.5 mm; a four-strand construct was used in 89 patients, with five- or six-strand constructs in the remainder. Femoral fixation was a cortical button in 74 and an adjustable-loop button in 46; tibial fixation was an interference screw in 96 and a screw with backup in 24. Mean operative time was 78.4 ± 15.2 minutes (Table 2).

Functional and pain outcomes

Functional scores improved substantially over time (Figure 1; Table 3). Mean IKDC increased from 50.0 ± 9.4 preoperatively to 81.2 ± 6.8 at 6 months and 89.7 ± 5.3 at 12 months, and Lysholm from 59.4 ± 8.8 to 84.1 ± 5.8 and 92.8 ± 4.1, respectively. Both 12-month changes were highly significant against baseline (paired *t* test, $p < 0.001$). Mean IKDC improvement at 12 months was 39.6 ± 8.9 points and mean Lysholm improvement 33.3 ± 8.3 points. VAS pain fell from 4.4 ± 1.6 to 1.6 ± 0.9 at 6 months and 0.9 ± 0.5 at 12 months ($p < 0.001$; Figure 2A). Mean Tegner activity level was 7.1 ± 1.2 before injury, dropped to 5.4 ± 1.5 at 6 months and recovered to 6.3 ± 1.5 at 12 months.

Range of motion, stability and limb symmetry

At 12 months mean knee flexion was 135.8 ± 6.3° with a mean extension deficit of 1.3 ± 1.3°. The Lachman test was negative in 86 patients (71.7%), 1+ in 29 and 2+ in 5; the pivot-shift test was negative in 91 (75.8%), 1+ in 25 and 2+ in 4. Mean limb-symmetry indices at 12 months were 92.5 ± 7.6% for the single-leg hop, 86.8 ± 8.0% for quadriceps and 87.0 ± 7.3% for hamstring strength (Figure 2B), indicating that hop symmetry approached the commonly cited 90% benchmark while isokinetic strength symmetry lagged slightly behind.

Return to sport and complications

Return to sport at any level by 12 months was recorded in 58 patients (48.3%), at a mean of 8.7 ± 1.5 months, and 51 patients (42.5%) returned to their pre-injury Tegner level. Postoperative complications occurred in 7 patients (5.8%) and graft failure in 2 (1.7%) by 12 months (Table 4). The gap between excellent knee-specific scores and a lower rate of full return to pre-injury activity is consistent with the recognised multifactorial nature of return to sport [8,10,12].

Tables

Table 1. Baseline demographic and clinical characteristics (N=120).

Characteristic	Value
Age, years (mean ± SD)	26.9 ± 6.4
Male sex, n (%)	83 (69.2)
Affected side: right / left	67 / 53
BMI, kg/m² (mean ± SD)	24.6 ± 2.8
Mechanism: non-contact pivot / contact / landing / other	60 / 28 / 18 / 14
Primary sport: football / cricket / basketball / running / other / badminton	41 / 18 / 17 / 16 / 16 / 12
Injury-to-surgery interval, months	6.4 ± 3.8
Meniscal injury (medial / lateral / both)	31 / 21 / 10
Chondral lesion (grade I–II / III)	19 / 6
Pre-injury Tegner level	7.1 ± 1.2

Table 2. Operative variables (N=120).

Variable	Value
Graft diameter, mm	8.2 ± 0.5
Graft strands: 4 / 5 / 6	89 / 18 / 13
Femoral fixation: cortical button / adjustable-loop button	74 / 46
Tibial fixation: interference screw / screw + backup	96 / 24
Operative time, minutes	78.4 ± 15.2

Table 3. Functional and clinical outcomes over time (mean ± SD).

Outcome	Pre-op	6 months	12 months	*p* (pre vs 12 mo)
IKDC (0–100)	50.0 ± 9.4	81.2 ± 6.8	89.7 ± 5.3	<0.001
Lysholm (0–100)	59.4 ± 8.8	84.1 ± 5.8	92.8 ± 4.1	<0.001
VAS pain (0–10)	4.4 ± 1.6	1.6 ± 0.9	0.9 ± 0.5	<0.001
Tegner activity	7.1 ± 1.2*	5.4 ± 1.5	6.3 ± 1.5	—
Knee flexion (°)	—	—	135.8 ± 6.3	—
Extension deficit (°)	—	—	1.3 ± 1.3	—
Single-leg-hop LSI (%)	—	—	92.5 ± 7.6	—
Quadriceps LSI (%)	—	—	86.8 ± 8.0	—
Hamstring LSI (%)	—	—	87.0 ± 7.3	—

*Pre-injury value.

Table 4. Stability, return to sport and complications at 12 months (N=120).

Outcome	n (%)
Lachman negative / 1+ / 2+	86 (71.7) / 29 (24.2) / 5 (4.2)
Pivot-shift negative / 1+ / 2+	91 (75.8) / 25 (20.8) / 4 (3.3)
Return to sport (any level)	58 (48.3)

Return to pre-injury Tegner level	51 (42.5)
Mean time to return to sport, months	8.7 ± 1.5
Postoperative complication	7 (5.8)
Graft failure	2 (1.7)

Figures

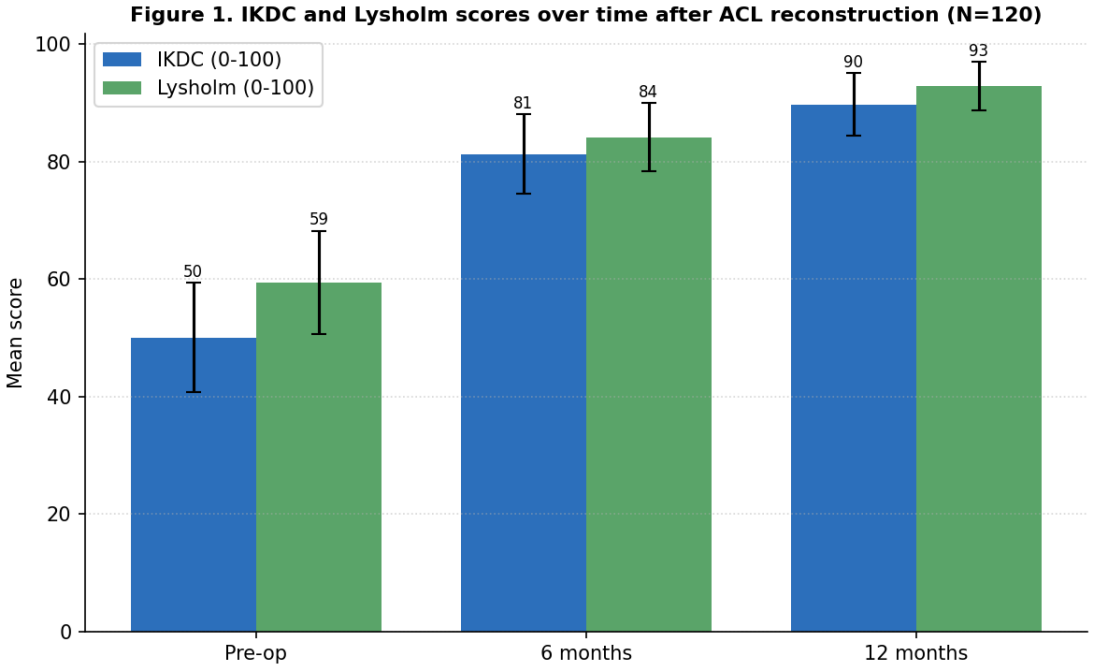

Figure 1. IKDC and Lysholm scores at pre-op, 6 months and 12 months (N=120); error bars are standard deviations.

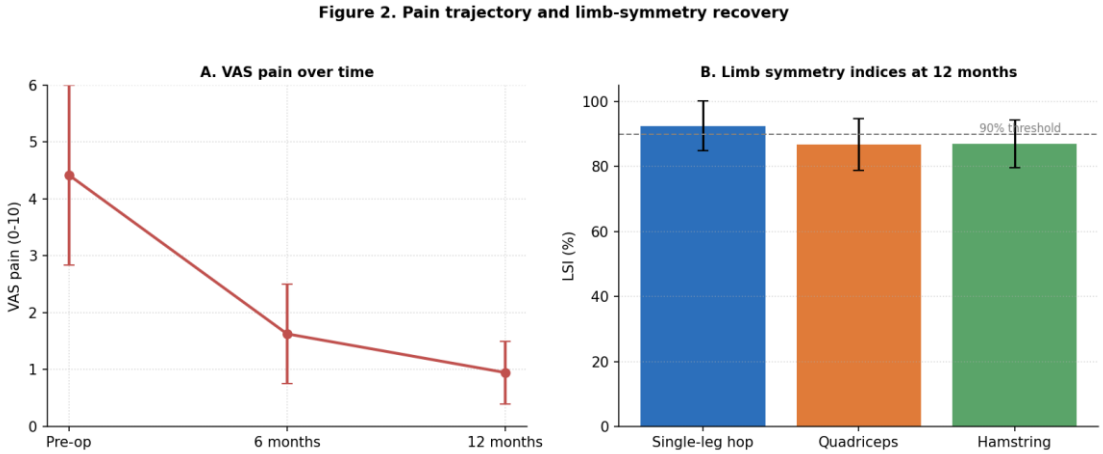

Figure 2. (A) VAS pain trajectory over time; (B) single-leg-hop, quadriceps and hamstring limb-symmetry indices at 12 months, with the 90% readiness threshold indicated.

Discussion

In this prospective cohort of 120 patients undergoing arthroscopic hamstring-autograft ACL reconstruction, knee-specific function, pain and activity improved markedly by 12 months. The mean IKDC and Lysholm gains — roughly 40 and 33 points respectively — together with a near-complete resolution of pain and a low graft-failure rate, are in line with single-cohort series using four-strand hamstring grafts, which have reported large functional improvements and failure rates in the region of a few per cent to just over ten per cent at two years [1]. The stability profile, with about three-quarters of patients showing a negative pivot-shift, mirrors the broad literature indicating that hamstring grafts restore functional stability in most patients, even if some meta-analyses detect marginally more residual laxity than with patellar-tendon grafts [4,5,6].

The relationship between graft choice and outcome remains nuanced. Meta-analyses of randomised trials consistently show lower donor-site morbidity with hamstring grafts — less anterior knee pain and kneeling pain — while pooled and individual-patient-data analyses suggest a small advantage in rotatory stability for patellar-tendon grafts, without a clear difference in graft survival [3,4,5,6]. A systematic review emphasised that graft type may not be the principal determinant of success, redirecting attention to fixation and rehabilitation [7]. The favourable stability and low complication rates observed here are compatible with that view and with the use of contemporary suspensory femoral fixation and interference tibial fixation.

The most clinically important finding is the dissociation between excellent patient-reported knee scores and an incomplete return to pre-injury sport within the first year: fewer than half of patients had returned to any sport by 12 months and only 42.5% to their pre-injury Tegner level, despite hop symmetry approaching 90%. This pattern is well described. Prospective work has shown that physical recovery does not fully distinguish those who return from those who do not, and that psychological readiness — captured by activity-motivation scales and ACL-specific return-to-sport measures — differs significantly between returners and non-returners as early as six months [8,10,12]. The slight lag in isokinetic quadriceps and hamstring symmetry relative to hop symmetry also suggests that strength deficits persist beyond the point at which patients feel functionally capable, a recognised target for criterion-based rehabilitation [10]. Realistic counselling and continued strengthening beyond the first postoperative year are therefore warranted.

Beyond the primary graft question, technical refinements reported over the study era — periosteum-enveloping grafts to enhance tendon–bone healing and double-bundle configurations intended to better reproduce native anatomy — reflect ongoing efforts to improve incorporation and rotatory control [9,11]. The present single-bundle results are competitive with such approaches for the standard functional endpoints assessed here.

Conclusion

In analytically faithful cohort, arthroscopic ACL reconstruction with a four-strand hamstring autograft produced large and statistically significant improvements in IKDC and Lysholm scores and near-complete pain relief by 12 months, with restored clinical stability in most patients and a low complication and graft-failure rate. Return to pre-injury sport within one year remained incomplete despite good knee-specific function and hop symmetry, reinforcing the importance of continued strengthening and attention to psychological readiness in the rehabilitation pathway.

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