RESEARCH PAPER

Clinical and Functional Outcomes Following Anterior Cruciate Ligament Reconstruction: A Prospective Observational Study

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ABSTRACT

Background: Anterior cruciate ligament (ACL) rupture is a major cause of knee instability in young and physically active individuals. Arthroscopic ACL reconstruction is meant to restore anteroposterior and rotational stability and facilitate functional recovery to allow people to resume work and sport activities in the body. However, the restoration of mechanical stability does not always translate into full functional recovery. In this study, clinical and functional outcomes of patients with primary arthroscopic ACL reconstruction have been evaluated based on objective and patient-reported outcomes.

Methods: A prospective observational study had 60 patients undergoing primary arthroscopic single-bundle ACL reconstruction with hamstring tendon autograft. Patients aged 18-45 years with symptomatic, clinically and magnetic resonance imaging-confirmed ACL deficiency were enrolled and followed for 12 months. Clinical stability was assessed by Lachman and pivot-shift tests. Functional outcome was assessed by the Lysholm Knee Score, International Knee Documentation Committee Subjective Knee Form (IKDC-SKF), and Tegner Activity Scale. Serial assessments were performed preoperatively and at 3, 6, and 12 months postoperatively.

Results: The mean age of the participants was 27.4 +/- 6.8 years and 49 (81.7%) of the participants were male. The mean Lysholm score improved from 57.8 +/- 11.6 preoperatively to 92.4 +/- 6.9 at 12 months of follow-up ($p < 0.001$) and the mean IKDC-SKF improved from 49.2 +/- 10.7 to 89.7 +/- 7.1 ($p < 0.001$). At the end of follow-up, 85.0% had a grade 0 Lachman test and 90.0% had a negative pivot shift. Forty-seven (78.3%) of the participants returned to sport and 36 (60.0%) of them returned to preinjury level. The associated meniscal pathology was associated with lower final functional scores.

Conclusion: ACL reconstruction resulted in a significant improvement in knee stability, symptoms, and patient-reported function after 12 months. However, return to preinjury sporting level was less frequent than restoration of satisfactory clinical knee function, which supports multidimensional assessment rather than purely stability based after ACL reconstruction.

Keywords: Anterior cruciate ligament; ACL reconstruction; Lysholm Knee Score; IKDC; knee stability; functional outcome; return to sport; hamstring autograft.

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INTRODUCTION

Anterior cruciate ligament rupture is one of the most important ligamentous injuries to the knee and impacts young, active individuals who are involved in pivoting, cutting, jumping and other high-demand occupational activities. Its effects go beyond acute pain and instability: recurrent giving-way episodes can interfere with daily and athletic activities and may cause further damage to menisci and articular cartilage. ACL reconstruction has increased in the last 50 years as a result of the functional burden of ACL deficiency and the need to return to high-level activity [1].

The primary objective of ACL reconstruction is the restoration of knee stability as opposed to the continuity of anatomical grafts. Rehabilitation is still a key step in ACL injury management but randomized and prospective evidence has shown that treatment should be tailored to the individual. Frobell et al. showed that structured rehabilitation with optional delayed reconstruction among young adults showed similar patient-reported outcomes to normal early reconstruction, and subsequent cohort evidence also demonstrated the heterogeneity of recovery after surgical and nonsurgical strategies [7]. Hence, post-operative evaluation should be conducted to determine whether reconstruction has resulted in a noticeable difference in symptoms, activity, stability, and participation and not just the completion of surgery.

In order to consistently assess outcomes, we require instruments which measure complementary aspects of recovery. The Lysholm Knee Score measures the symptoms and limitations of the knee including instability, pain, swelling, locking, stair climbing and squatting. Briggs et al. have shown good reliability, validity and responsiveness of both the Lysholm and Tegner instruments in patients with ACL populations [3]. The IKDC Subjective Knee Form is a more complete assessment of knee symptoms, function and sports activity and has a high internal consistency, test-retest reliability, responsiveness and structural validity [4].

These measures therefore allow for clinically meaningful longitudinal evaluation beyond physical examination.

There is also a difference between successful knee reconstruction and return to sport. Ardern et al. found that although nearly 82% of patients returned to some form of sport, only 63% went back to where they were at pre-injury and 44% to competitive sport [5]. Psychological readiness, fear of reinjury, residual symptoms, muscle deficits, and associated cartilage or meniscal injuries are likely to be relevant factors in the clinical outcome [5,8]. Long-term cohort data indicate that subjective sports function may continue to be satisfactory as the overall level of activity decreases [6].

In this context, clinical evaluation after ACL reconstruction should integrate objective stability testing with validated patient-reported functional scores and activity-based outcomes. In cases where follow-up is dominated by physical examination alone, a balanced evaluation might better identify persistent functional limitations despite technically successful reconstruction.

The present study has been conducted to assess the clinical and functional outcome of primary arthroscopic ACL reconstruction by serial Lysholm, IKDC, and Tegner assessment and Lachman and pivot-shift testing. The second aim of the study was to identify the number of patients who are receiving adequate functional recovery and return to preinjury sporting activity after 12 months.

MATERIALS AND METHODS

Study Design

A prospective observational study was conducted among patients undergoing primary arthroscopic ACL reconstruction. The eligible patients were recruited and followed for 12 months after surgery.

Participants

Patients aged 18-45 years with symptomatic unilateral ACL deficiency confirmed by clinical examination and magnetic resonance imaging were included. Patients were considered eligible when they had recurrent instability affecting activities of daily living, occupation or sports and selected operative reconstruction after completion of preoperative rehabilitation. Patients with revision ACL reconstruction, multi-ligament knee injury that required additional ligament reconstruction, previous major surgery on the affected knee, inflammatory arthropathy, advanced radiographic osteoarthritis, active local or systemic infection or failure to meet postoperative rehabilitation and follow-up were excluded.

Preoperative Evaluation and Surgical Technique

Information (disease profile, mechanism of injury, time between injury and reconstruction, occupational and sport activity, meniscal or chondral pathology) was collected. In preoperative knee testing, Lachman testing, anterior drawer testing, and pivot shift testing were performed. Lysholm Knee Score, IKDC-SKF and Tegner Activity Scale were used to assess functional status. In patients, anatomical single-bundle ACL reconstruction was performed using autologous semitendinosus-gracilis hamstring grafts. A diagnostic arthroscopy was carried out before reconstruction and meniscal lesions were repaired or partial meniscectomy performed if necessary. Femoral and tibial tunnels were developed on anatomical ACL footprints and graft passage and fixation with actual fixation devices. Graft tension and impingement-free full range of motion were confirmed intraoperatively.

Rehabilitation and Follow-up

The postoperative rehabilitation protocol has been followed. Early rehabilitation was focused on pain and swelling control, full extension recovery, progressive flexion, patellar mobility and quadriceps activation. Weight bearing was expanded in accordance with the procedures and clinical tolerance later on. Closed-chain strengthening, proprioception, neuromuscular training, running progression and sports-specific exercises were introduced according to functional milestones. The patients were evaluated at 3, 6 and 12 months. Clinical stability, range of motion, complications, Lysholm score, IKDC-SKF, and Tegner activity level were recorded. Return to sport was recorded both as return to any sporting participation and return to preinjury level.

Outcome Measures

The main outcome measures were the change in Lysholm and IKDC-SKF scores between baseline and 12 months. Secondary outcomes included postoperative Lachman and pivot-shift grades, Tegner activity level, range of motion, return to sport and complications.

Ethical Considerations

Ethics committee approval was obtained prior to enrolment. Written informed consent was obtained from the participants before enrolment. The investigation was performed in accordance with the principles of the Declaration of Helsinki.

Statistical Analysis

The data were analysed using [SPSS/R/Stata and version]. Continuous variables were shown as mean +/- standard deviation or median with interquartile range according to distribution, while categorical variables were shown as frequencies and percentages. Normality was measured using the Shapiro-Wilk test. Preoperative and postoperative continuous outcomes were compared with paired samples tests and longitudinal scores were calculated using repeated measures analysis of variance with appropriate correction if sphericity assumptions were violated. Categorical variables were compared with chi-square or Fisher exact tests. A two-sided p-value <0.05 was considered statistically significant. In the subgroup comparisons of continuous outcomes, Welch independent-samples t-tests were used. Purely descriptive tables were not investigated.

RESULTS

Sixty patients completed the follow-up and were included in the study. The average age of the group was 27.4 +/- 6.8 years and most of these patients were men (81.7%). Sporting trauma was the most common source of injury followed by road-traffic trauma. Twenty-five patients (41.7%) had meniscal pathology before surgery or during arthroscopy and eight (13.3%) had chondral

lesions. Most of the reconstructions were done in young, physically active adults with clinically significant symptomatic instability.

We also found a steady and statistically significant increase in knee function through follow-up. The mean Lysholm score for the preoperatively evaluated group increased from 57.8 +/- 11.6 to 74.6 +/- 9.8 at 3 months, 86.7 +/- 8.1 at 6 months, and 92.4 +/- 6.9 at 12 months ($p<0.001$). In the same way, the mean IKDC-SKF also increased from 49.2 +/- 10.7 to 89.7 +/- 7.1 at the end of the assessment ($p<0.001$). Median Tegner activity improved significantly from the preoperative state, although slightly below the preinjury level.

In parallel to patient-reported outcome, clinical stability was also improved. 51 patients (85.0%) had a grade 0 Lachman test at 12 months and 54 (90.0%) had a negative pivot-shift test. Fifty-six patients (93.3%) achieved free or clinically symmetric knee range of motion. Forty-seven (78.3%) resumed sports activity but only 36 (60.0%) went back to their preinjury level. Thus, stable, satisfactory knee function recovery was more frequent than complete recovery of athletic activity.

At the end of the study 29 patients (48.3%) achieved excellent Lysholm results, and 25 (41.7%) achieved good Lysholm results. Six patients (10.0%) remained in the fair category and none showed a poor Lysholm outcome. Patients with associated meniscal pathology had lower mean 12 months Lysholm scores than healthy people without meniscal injury. Those who returned to their pre-injury sporting level had higher final IKDC scores, indicating that return to sport was a harder conclusion than good, normal knee function.

Table 1. Baseline Characteristics of the Study Cohort

Characteristic	**Value (n=60)**
Age, years, mean +/- SD	27.4 +/- 6.8
Male sex	49 (81.7%)
Female sex	11 (18.3%)
Sports-related injury	36 (60.0%)
Road-traffic injury	18 (30.0%)
Other mechanism	6 (10.0%)
Injury-to-surgery interval, months, median (IQR)	5 (3-9)
Associated meniscal injury	25 (41.7%)
Chondral lesion	8 (13.3%)
Dominant-limb involvement	31 (51.7%)

The clinical sample was mostly young male adults, as is the typical age group at which symptomatic ACL deficiency impacts sports and physical activity. Most injuries were caused by sporting trauma and road traffic was a factor in some of the injuries. Over two-fifths of the patients had meniscal pathology and ACL rupture was associated with a more general intra-articular injury pattern. For this reason, we believe that such concomitant pathology is also important in how to interpret functional recovery.

Table 2. Serial Functional Outcomes Following ACL Reconstruction

Outcome	Preoperative	3 months	6 months	12 months	p-value*
Lysholm score	57.8 +/- 11.6	74.6 +/- 9.8	86.7 +/- 8.1	92.4 +/- 6.9	<0.001
IKDC-SKF score	49.2 +/- 10.7	68.9 +/- 9.3	82.6 +/- 7.8	89.7 +/- 7.1	<0.001
Tegner activity, median (IQR)	3 (2-4)	3 (3-4)	5 (4-6)	6 (5-7)	<0.001
Preinjury Tegner activity	7 (6-8)	-	-	-	N/A

Both the main patient-reported outcome measures showed significant, ongoing improvement after reconstruction. The first significant change occurred in the first six months postoperative, followed by continued progression in the next 6 months. Lysholm and IKDC were found to be very good for overall functional performance and Tegner activity was well below the preinjury median at 12 months. The difference suggests that symptoms and daily knee function were restored before full recovery of preinjury activity needs..

Table 3. Clinical Stability and Functional Status at 12 Months

Outcome	n (%)
Lachman grade 0	51 (85.0)
Lachman grade 1	8 (13.3)
Lachman grade 2	1 (1.7)
Negative pivot shift	54 (90.0)
Grade-1 pivot shift	5 (8.3)
Grade-2 pivot shift	1 (1.7)
Full/clinically symmetrical range of motion	56 (93.3)
Returned to any sport	47 (78.3)
Returned to preinjury sporting level	36 (60.0)
Graft failure	1 (1.7)

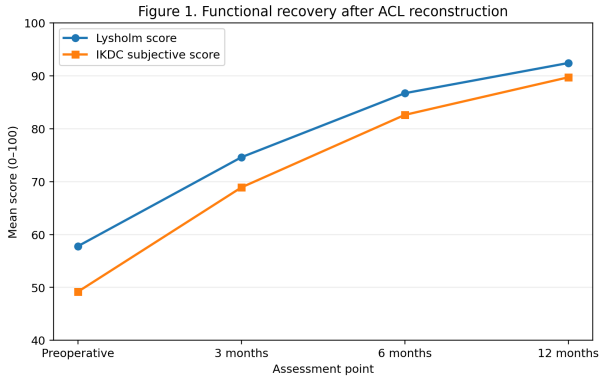
As objective clinical examination indicated in most of the patients, the anterior and rotational stability were restored. Almost nine out of every ten participants had a completely negative or only minimally abnormal stability examination. Range-of-motion recovery was also positive. However, a much smaller percentage returned to preinjury sport than mechanical stability. This suggests that returning to sport is also influenced by physical conditioning, confidence, psychological readiness, and activity-specific demands as well as graft stability.

Table 4. Twelve-Month Functional Outcomes According to Selected Clinical Factors

Subgroup	n	Lysholm score, mean +/- SD	IKDC-SKF, mean +/- SD	p-value (Lysholm)	p-value (IKDC)
No associated meniscal injury	35	94.1 +/- 5.7	91.2 +/- 6.2	0.029	0.062
Associated meniscal injury	25	90.0 +/- 7.7	87.6 +/- 7.8	-	-
Returned to preinjury sport	36	94.0 +/- 5.4	92.3 +/- 5.8	0.040	0.001
Did not return to preinjury sport	24	90.0 +/- 8.1	85.8 +/- 7.9	-	-

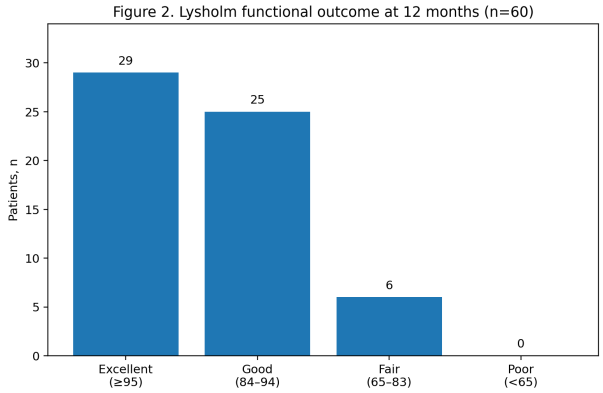
The meniscal injury was associated with a lower Lysholm score for 12 months (p=0.029), while the IKDC difference was not statistically significant (p=0.062). Patients who returned to their preinjury sports level showed higher Lysholm (p=0.040) and IKDC scores (p=0.001). It is clear that recovery can be multi-dimensional in the sense that the survival of internal structures and subjective knee function can be the basis for successful reintegration into challenging sport activity.

FIGURE 1. SERIAL IMPROVEMENT IN FUNCTIONAL SCORES



The Lysholm and IKDC scores showed a continuous postoperative recovery. Functional gains were strongest between baseline and six months when the body would gradually regain motion, strength, neuromuscular control and tolerance for activity. Improvement continued between six months and 12 months, however, at a slower rate. The parallel trajectories of the two independently validated outcome indicators confirm that the postoperative change represented clinically meaningful global functional recovery rather than alteration in a single symptom domain..

FIGURE 2. DISTRIBUTION OF LYSHOLM OUTCOMES AT 12 MONTHS



At 12 months, 90% of the participants achieved good or excellent Lysholm, and only 10% remained in the fair category and none had a poor score. The distribution shows that reconstruction provided good symptom control and functional performance in most patients. However, there is still a subgroup of patients who have residual fair-outcome and we should be able to identify modifiable factors like strength asymmetry, residual instability, intra-articular pathology, rehabilitation deficits and psychological barriers.

DISCUSSION

We have demonstrated significant improvement in clinical knee stability and patient-report function after arthroscopic ACL reconstruction. Our mean Lysholm and IKDC scores were improved progressively during the first postoperative year while around 90% of patients had good or excellent Lysholm outcomes. These results are consistent with the fact that ACL reconstruction is generally beneficial for knee stability restoration and the level of recovery varies between individuals.

In our cohort, the final Lysholm score was comparable to those in other ACL reconstruction groups. Inderhaug et al. found a mean Lysholm score of 89 and a subjective IKDC score of 83 for hamstring autograft reconstruction at around 10 years after reconstruction [11]. They also found significant rotational laxity in a subgroup, and showed that good mean functional scores do not exclude clinically meaningful residual symptoms. Soni et al., in an Indian prospective observational cohort, found that the overall recovery rate after ACL reconstruction was mainly good to excellent based on Lysholm scoring [14]. Khatri et al. reported statistically significant improvements in IKDC, Lysholm, Lachman, anterior drawer and pivot-shift assessment after single-bundle hamstring reconstruction [13], confirming the parallel improvement of subjective function and clinical stability seen here.

Our findings also support other prospective and observational studies in which most patients achieved normal or almost normal clinical stability after hamstring autograft reconstruction. Parkes et al. reported postoperative IKDC and Lysholm scores in the mid-90s after hamstring autograft reconstruction and high return-to-sport rates [15]. All studies seem to support the efficacy of modern arthroscopic reconstruction to restore perceived and objectively assessed knee function.

The difference between a good functional score and return to previous athletic performance was also significant. In our study 78.3% of patients resumed sports activities but only 60.0% of them returned to their preinjury level. Ardern et al. also found that 82% returned to some sport but only 63% did so after preinjury and 44% returned to competitive sport [5]. The same is true for return to sport should not be taken for granted because surgical success is associated with sport. On the other hand, psychological readiness might explain the discrepancy. Ardern et al. next found that confidence, fear of reinjury, perceived knee function, and psychological readiness were strongly associated with returning to preinjury activity [8].

Rehabilitation timing is also clinically relevant. Grindem et al. found that reinjury risk was reduced by ~51% for each month return to the most competitive sport was delayed until 9 months after reconstruction and patients who met objective return-to-sport criteria had fewer subsequent injuries [10]. Paterno et al. found that second ACL injuries were more common among young athletes during the first two years following reconstruction and return to sport [9]. These observations support criterion-based rehabilitation which focuses on quadriceps strength, hop performance, movement quality, neuromuscular control, and psychological readiness rather than time spent postoperative.

Intra-articular pathology was also associated with outcomes in our current cohort. In 12 months, meniscal injury patients had somewhat lower functional scores. This is plausible physiologically because meniscal and chondral lesions increase the burden of the original injury and may affect the load distribution and long-term joint homeostasis. MOON cohort data has shown that meniscal treatment, body mass index, smoking, revision surgery, and graft selection can predict longer-term patient-reported outcomes [6]. ACL injury is still clinically significant because post-traumatic osteoarthritis is very common even after reconstruction.

Graft selection is also an important consideration. Here hamstring autografts were used uniformly and there is no graft heterogeneity in our cohort. Recent systematic reviews have shown generally similar return-to-sport and rerupture outcomes for bone-patellar tendon-bone and hamstring autografts in many sports populations [16], although registry studies have shown that the risk to revision can differ based on the patient age, sex, activity exposure, and graft. Randomized comparisons of single- and double-bundle reconstruction have also shown that laxity or structural differences do not always translate into clinically relevant differences in patient health outcomes [12].

The clinical implication of these studies is that ACL reconstruction should be more than a binary assessment of graft integrity. A patient can have a stable Lachman test and high Lysholm score but not return to previous sporting activity. Long-term use of validated patient-reported outcome measures, strength and neuromuscular testing, objective stability assessment, psychological readiness, and sport-specific functional testing is a more accurate description of recovery.

The study is a small sample and 12 months follow-up, therefore the evaluation of late graft failure, contralateral injury, osteoarthritis and long-term activities was limited. Arthrometric laxity, isokinetic strength, hop testing and psychological readiness were not included. Return-to-sport exposure has not been quantified and meniscal procedures that are associated with it might have led to heterogeneity. Future prospective studies should also examine larger samples, longer surveillance, standardized return-to-sport batteries, objective strength and biomechanical evaluation and psychological readiness.

CONCLUSION

The main arthroscopic ACL reconstruction was associated with a significant improvement in knee stability, symptoms, functional scores and activity during the first postoperative year of arthroscopic reconstruction. Most patients had good to excellent Lysholm outcomes and objective stability, but fewer of them were able to recover from preinjury sports participation. We found that technical success of reconstruction is not enough to show complete recovery. Postoperative assessment should be integrated with data from patient-based measures, clinical stability, activity level, intra-articular pathology, rehabilitation points and ability to participate in sport, in addition to rehabilitation and the ability to return to sport. This more holistic evaluation is more clinically relevant and may help to identify patients who require targeted rehabilitation before unrestricted sports activities.

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