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Functional outcomes of anterior cruciate ligament reconstruction using quadriceps tendon autograft

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Abstract
Background: Anterior cruciate ligament (ACL) injuries are common among physically active individuals, often resulting in knee instability, functional limitation, and reduced quality of life. Quadriceps tendon autograft has emerged as a reliable option for ACL reconstruction, offering favorable biomechanical strength and low donor-site morbidity.
Aim of the study: To evaluate the functional outcomes, clinical stability, and postoperative complications following ACL reconstruction using quadriceps tendon autograft in patients with isolated ACL tears.
Methods: A quasi-experimental study was conducted from September 2022 to September 2024 at the Department of Orthopaedic Surgery, BSMMU, Dhaka. Eighteen patients (17 males, 1 female; mean age 29.5 ± 6.2 years) with isolated ACL tears underwent ACL reconstruction using quadriceps tendon autograft. Purposive non-randomized sampling was employed. Clinical knee stability was assessed using the Anterior Drawer and Lachman tests. Functional outcomes were evaluated using Lysholm and IKDC scores preoperatively and at final follow-up. Knee range of motion (ROM) was recorded postoperatively. Postoperative complications were documented. Statistical analysis included paired t-tests and chi-square tests, with significance set at $p < 0.05$.
Result: Postoperatively, clinical stability improved significantly: negative Anterior Drawer tests in 88.9% and negative Lachman tests in 83.3% of patients ($p < 0.001$). Functional scores increased markedly, with mean Lysholm and IKDC scores improving to 90.1 ± 3.7 and 89.2 ± 4.3, respectively (both $p < 0.001$). Knee ROM was preserved postoperatively (132.5° ± 5.8°), indicating maintained mobility. Complications were minimal, including anterior knee pain (16.7%), superficial infection (5.6%), and knee stiffness (5.6%). At final follow-up, 77.8% of patients achieved excellent Lysholm scores, 16.7% good, and 5.6% fair.
Conclusion: Quadriceps tendon autograft ACL reconstruction provides excellent clinical stability and significant functional improvement while preserving knee range of motion. Complications are minimal, making this technique a safe and effective option for young, active individuals.

Keywords: Anterior cruciate ligament, quadriceps tendon autograft, ACL reconstruction, functional outcome, knee stability, lysholm score, IKDC score

Introduction

The anterior cruciate ligament (ACL) is one of the primary stabilizing structures of the knee joint, preventing anterior translation of the tibia relative to the femur and maintaining rotational stability during dynamic activities [1]. Anterior cruciate ligament injury is defined as a partial or complete tear of this ligament, resulting in knee instability, pain, and functional limitation, most frequently observed in athletes and physically active individuals [2]. Globally, ACL injuries represent one of the most common sports-related knee pathologies, with an estimated 200,000-250,000 new cases diagnosed annually [3]. In Bangladesh, hospital-based studies indicate that ACL injuries constitute nearly 35-40% of all knee ligament disorders, predominantly affecting young males engaged in football, cricket, and occupations requiring frequent pivoting and sudden directional changes [4]. ACL injuries not only impair sports participation but also adversely affect daily activities, work productivity, and overall quality of life. If left untreated or inadequately managed, these injuries predispose patients to recurrent

episodes of instability, secondary meniscal tears, and the early development of osteoarthritis, ultimately leading to chronic pain and disability [5]. Although conservative management may be suitable for selected low-demand individuals, surgical reconstruction is considered the gold standard approach for restoring stability and enabling return to pre-injury activity levels in young and active populations [6]. Over the past decades, advancements in surgical techniques and graft selection have aimed to optimize functional outcomes, reduce complications, and improve long-term graft survival [7]. Autografts are widely favored in ACL reconstruction due to their superior biological incorporation and reduced immune risks compared with allografts. Traditionally, bone-patellar tendon-bone (BPTB) and hamstring tendon autografts have been the primary choices [8]. However, BPTB grafts often cause anterior knee pain and kneeling discomfort, whereas hamstring grafts may lead to postoperative weakness. These limitations have encouraged interest in the quadriceps tendon (QT) autograft as an alternative [9]. The QT autograft offers a large graft size, strong tensile properties, and lower donor site morbidity. Biomechanical studies indicate comparable or superior stability to traditional grafts, while clinical research highlights reduced postoperative pain, faster recovery, and reliable return to sports [10]. Its versatility—being harvestable with or without a bone plug provides surgeons flexibility to adapt to patient-specific needs. Furthermore, minimally invasive harvesting techniques have improved cosmetic results and further lowered donor site complications [11]. Despite these advantages, QT autograft use remains less common in South Asia, largely due to limited familiarity and a lack of region-specific outcome data. However, with growing evidence of its clinical efficacy, the technique is gaining wider acceptance worldwide [12]. Considering the increasing incidence of ACL injuries globally and in Bangladesh, evaluating the functional outcomes of quadriceps tendon autografts is crucial to guide surgical decision-making in diverse healthcare settings [13]. The present study aims to evaluate the functional outcomes of anterior cruciate ligament reconstruction using quadriceps tendon autograft.

Methodology and Materials

This prospective quasi-experimental study was conducted between September 2022 and September 2024 in the Department of Orthopaedic Surgery, Bangabandhu Sheikh Mujib Medical University (BSMMU), Shahbagh, Dhaka, Bangladesh. Ethical approval was obtained from the institutional review board, and written informed consent was obtained from all participants prior to enrollment. A total of 18 patients with clinically and radiologically confirmed ACL injuries were enrolled using purposive non-randomized sampling.

Inclusion and Exclusion criteria

Inclusion criteria

- Age between 20 and 45 years.
- Both genders.
- Body mass index (BMI) < 40 kg/m².
- Symptomatic, isolated ACL tear diagnosed by clinical examination and magnetic resonance imaging (MRI).

Exclusion criteria

- Associated meniscus, cartilage, or posterior cruciate ligament injury.
- Bilateral ACL deficiency or multiple ligament injuries of the knee.
- Ipsilateral ankle injuries.
- Previous knee or ankle surgery.
- Fractures around the knee (femoral condyle, tibial plateau, patella).
- Osteoarthritis of the knee.
- Active knee sepsis or loss of knee motion due to acute injury.
- Patients unable or unwilling to provide informed consent.

Surgical Procedure

All ACL reconstructions were performed arthroscopically by experienced orthopaedic surgeons using a standardized technique. The quadriceps tendon autograft was harvested from the ipsilateral knee through a minimally invasive approach, ensuring adequate graft length and thickness for optimal fixation. After graft preparation, anatomical tunnels were created in the femur and tibia under arthroscopic guidance. The graft was then secured using Endo-button & interference screws, and final tensioning was performed to restore knee stability. The diameter of the graft was measured intraoperatively and documented for each patient.

Postoperative Rehabilitation

Postoperative rehabilitation followed a structured, progressive protocol aimed at restoring knee function and stability. Patients were encouraged to perform passive and active-assisted range-of-motion exercises after 14 days. Partial weight-bearing was allowed initially and progressed to full weight-bearing as tolerated. Strengthening exercises for quadriceps and hamstrings, as well as proprioceptive and balance training, were introduced gradually. Return to sports and high-impact activities was typically permitted after 6 to 9 months, contingent upon achieving adequate functional recovery and knee stability.

Outcome Measures

Functional outcomes were assessed preoperatively and at the final follow-up using validated scoring systems and clinical tests. The Lysholm Knee Score evaluated pain, instability, locking, swelling, and functional limitation, while the International Knee Documentation Committee (IKDC) subjective score assessed symptoms, sports activity, and overall knee function. Knee range of motion (ROM) was measured using a goniometer, and clinical stability was evaluated through the Anterior Drawer and Lachman tests, graded from 0 to III. Postoperative complications, including infection, anterior knee pain, stiffness, paresthesia, or graft re-rupture, were systematically recorded.

Statistical Analysis

Data were analyzed using SPSS version 26 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequency and percentage. Paired ordinal variables, including Anterior Drawer Test and Lachman Test grades. Paired continuous variables, such as Lysholm and IKDC scores and knee range of motion, were compared using the paired-sample t-test for parametric data or Wilcoxon signed-rank test for non-parametric data. A p-values < 0.05 were considered statistically significant for all analyses.

Results

The study enrolled 18 patients with anterior cruciate ligament (ACL) injury. The mean age was 29.5±6.16 years, with the majority of patients (66.7%) aged 20-30 years. Male patients

predominated (94.4%), and the mean body mass index (BMI) was 24.48 ±3.03 kg/m². Regarding occupation, most participants were students (44.4%), followed by business personnel (22.2%) and athletes (16.7%). The mean duration from injury to surgery was 5.39±3.60 months, and the mean graft diameter used for reconstruction was 8.53±0.56 mm (Table 1). Figure 1 illustrated the distribution of patients according to the side of knee injury. The majority of injuries occurred on the right knee (72.2%), while 27.8% of patients had left knee involvement. Road traffic accidents were the most common cause, accounting for 50.00% of cases, followed by sports-related activities at 33.33%. Domestic accidents contributed to 16.67% of the injuries (Figure 2). Preoperative anterior drawer and Lachman tests revealed that 77.8% and 72.3% of patients, respectively, had Grade II laxity, while 22.22% and 27.8% had Grade III laxity. Postoperatively, significant improvements were observed, with 88.9% achieving Grade 0 and 11.1% Grade I on anterior drawer test ($p<0.001$). Similarly, 83.3% achieved Grade 0 and 16.7% Grade I on Lachman test postoperatively ($p<0.001$) (Table 2). Functional assessment showed significant improvement after ACL reconstruction in Table 3. The mean Lysholm score increased from 55.5±6.9 preoperatively to 90.1±3.7 postoperatively (mean difference +34.6, 95% CI 30.9-38.3; $p<0.001$). The mean IKDC score improved from 55.0±5.0 to 89.2±4.3 (mean difference +34.2, 95% CI 30.8-37.6; $p<0.001$). Knee ROM was preserved postoperatively, with a mean of 132.5° ± 5.8° (range 120-140°), demonstrating that mobility was maintained after surgery. Postoperative complications were minimal. Anterior knee pain was the most common complication (16.7%), followed by superficial infection and knee stiffness (each 5.6%). No cases of paresthesia or graft re-rupture were reported, and 72.2% of patients experienced no complications (Table 4). At the last follow-up, the majority of patients achieved excellent functional outcomes based on Lysholm score (77.8%), with 16.7% categorized as good and 5.6% as fair. No patient was classified as poor (Table 5).

Table 1: Baseline characteristics of the study population (n = 18).

Variable	Frequency (n)	Percentage (%)
Age (years)		
20-30	12	66.67
31-40	4	22.22
41-45	2	11.11
Mean± SD	29.50 ±6.16	
Gender		
Male	17	94.44
Female	1	5.56
BMI (kg/m²)		
Mean± SD	24.48 ±3.03	
Occupation		
Student	8	44.44
Service Holder	2	11.11
Athlete	3	16.67
Business	4	22.22
Homemaker	1	5.56
Duration from Injury to Surgery (months)		
Mean± SD	5.39 ±3.60	
Graft Diameter (mm)		
Mean± SD	8.53 ±0.56	

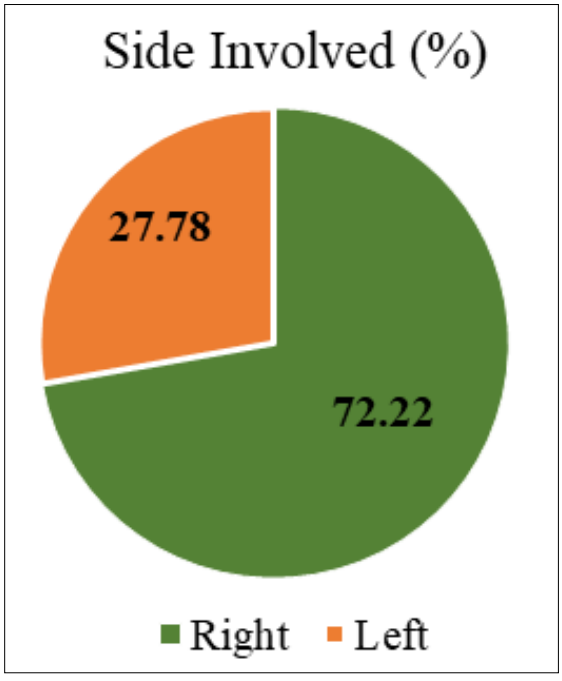

Fig 1: Distribution of patients according to side of knee injury

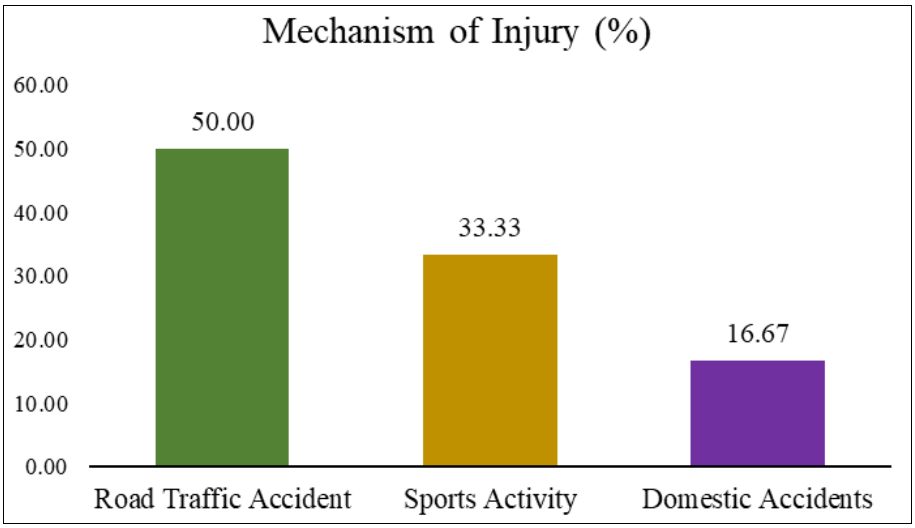

Fig 2: Distribution of patients according to mechanism of injury

Table 2: Comparison of clinical knee stability tests before and after ACL reconstruction

Test	Preoperative, n (%)	Postoperative, n (%)	p-value
Anterior Drawer Test			
Grade 0	0 (0.00)	16 (88.89)	<0.001
Grade I	0 (0.00)	2 (11.11)	
Grade II	14 (77.78)	0 (0.00)	
Grade III	4 (22.22)	0 (0.00)	
Lachman Test			
Grade 0	0 (0.00)	15 (83.33)	<0.001
Grade I	0 (0.00)	3 (16.67)	
Grade II	13 (72.32)	0 (0.00)	
Grade III	5 (27.78)	0 (0.00)	

Table 3: Functional outcome scores before and after ACL reconstruction

Outcome Measure	Pre-op Mean ± SD (range)	Post-op Mean ± SD (range)	Mean Difference (95% CI)	p-value*
Lysholm Score	55.5 ± 6.9 (44-67)	90.1 ± 3.7 (80-95)	+34.6 (30.9 - 38.3)	<0.001
IKDC Score	55.0 ± 5.0 (45-65)	89.2 ± 4.3 (80-94)	+34.2 (30.8 - 37.6)	<0.001

Table 4: Postoperative complications following ACL reconstruction with quadriceps tendon autograft

Complication	Frequency (n)	Percentage (%)
Superficial Infection	1	5.56
Anterior Knee Pain	3	16.67
Knee Stiffness	1	5.56
Paresthesia	0	0.00
Re-rupture	0	0.00
No Complications	13	72.22

Table 5: Final functional outcome categories at last follow-up based on Lysholm score

Outcome Category	Frequency (n)	Percentage (%)
Excellent (91-100)	14	77.78
Good (84-90)	3	16.67
Fair (65-83)	1	5.56
Poor (<65)	0	0.00

Discussion

Anterior cruciate ligament (ACL) reconstruction using quadriceps tendon (QT) autografts has emerged as a reliable technique for restoring knee stability and function [14]. In the present study, the mean age of patients was 29.50 ± 6.16 years, with the majority (66.7%) between 20-30 years, reflecting the higher risk of ACL injury in young, active populations. This finding is consistent with prior studies reporting peak incidence of ACL injuries in the second and third decades of life [15]. Furthermore, a predominance of male patients (94.4%) was observed, which aligns with the literature suggesting greater ACL injury prevalence among men due to participation in high-intensity sports and higher quadriceps muscle mass, both of which increase stress on the knee [16]. The mean BMI in our study was 24.48 ±3.03 kg/m², indicating a generally healthy weight range. Previous studies have suggested that BMI is a significant factor influencing both the risk of ACL injury and postoperative recovery [17]. Elevated BMI increases the mechanical load on the knee joint during dynamic activities such as running or jumping, potentially exacerbating injury severity [18]. Regarding the mechanism of injury, road traffic accidents accounted for 50% of cases, followed by sports activities (33.3%) and domestic accidents (16.7%). This distribution reflects regional variations in injury mechanisms, as road traffic accidents are a major contributor to ACL injuries in developing countries, often involving high-energy trauma to the knee [19]. The predominance of right knee involvement (72.2%) observed in our study may be related to leg dominance, with individuals placing greater mechanical demand on their dominant limb during daily and athletic activities [20]. The mean duration from injury to surgery was 5.39 ± 3.60 months. Although longer than the optimal window reported in some studies (30-45 days) [21], the delay in our context likely reflects late patient presentation, missed diagnosis, limited access to advanced imaging, and economic constraints. Graft characteristics are critical for successful ACL reconstruction. In our study, the mean quadriceps tendon graft diameter was

8.53 ± 0.56 mm, which is comparable with previous studies reporting a larger graft diameter in QT autografts than hamstring or patellar tendon grafts [22]. Clinical knee stability tests demonstrated significant improvement postoperatively. Negative anterior drawer tests were observed in 88.9% of patients, and negative Lachman tests in 83.3% (Table 2), indicating effective restoration of anterior-posterior stability. These results are consistent with previous studies reporting 74-96% negative postoperative stability tests with QT grafts [23]. Functional outcomes in the present study also improved significantly. The Lysholm score increased from 55.5 ± 6.9 preoperatively to 90.1 ± 3.7 postoperatively, while the IKDC subjective score improved from 55.0 ± 5.0 to 89.2 ± 4.3 (Table 3). This substantial improvement reflects successful restoration of knee function and reduction of symptoms such as instability and pain. These findings are consistent with the literature, where QT autografts have demonstrated Lysholm scores ranging from 89 to 92 points and IKDC scores from 88 to 94 points postoperatively [17]. In this study, anterior cruciate ligament (ACL) reconstruction using quadriceps tendon (QT) autografts resulted in significant improvement in knee function and stability. Postoperative assessment demonstrated restoration of ligamentous integrity, enabling patients to resume pre-injury activity levels efficiently. The QT autograft provided a structurally robust graft with minimal donor-site morbidity, which translated into enhanced patient-reported functional outcomes. Importantly, the procedure preserved full knee range of motion, with no significant deficits observed during rehabilitation. These findings are consistent with previously published reports indicating that QT autografts offer reliable mechanical strength and favorable postoperative recovery profiles, supporting their use as a viable alternative to traditional grafts for both primary and revision ACL reconstruction [24]. Postoperative complications in our study were minimal. Anterior knee pain was observed in 16.7% of patients, and superficial infection in 5.6%, while knee stiffness was noted in only one case (5.56%) (Table 4). No re-ruptures or permanent neurological deficits were reported. These low complication rates are comparable with prior studies, highlighting the safety and reliability of QT autografts. Anterior knee pain remains the most commonly reported donor site morbidity, which may be related to disruption of the extensor mechanism and postoperative rehabilitation challenges [25]. Final functional outcomes based on Lysholm scores demonstrated that 77.8% of patients achieved excellent outcomes, 16.7% good outcomes, and 5.6% fair outcomes, with no poor outcomes (Table 5). This high proportion of favorable outcomes is consistent with previous studies reporting 75-90% excellent to good results following QT ACL reconstruction [26].

Limitations of the study: The non-randomized design may introduce inherent selection bias, limiting definitive causal conclusions. Short-term follow-up precluded assessment of long-term graft integrity and delayed complications. Functional outcomes were evaluated primarily through clinical and patient-reported measures without routine imaging confirmation, and variability in rehabilitation adherence may have influenced results. Single-center conduct may restrict extrapolation to broader populations.

Conclusion and Recommendations

Anterior cruciate ligament reconstruction using quadriceps tendon autograft demonstrated excellent outcomes in terms of knee stability and functional recovery. Significant improvements were observed in Lysholm and IKDC scores, while knee range of motion was well preserved, indicating that mobility was not compromised by the procedure. Postoperative complications were minimal, and the majority of patients achieved excellent or good results. These findings support quadriceps tendon autograft as a safe, effective, and reliable option for restoring knee function in young and active individuals.

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Ethical approval: The study was approved by the Institutional Ethics Committee.

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