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Article

Influence of Early Flexion ROM on the Graft Laxity After ACL Reconstructive Surgery

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Abstract: Background: Anterior cruciate ligament (ACL) reconstruction is one of the most frequently performed surgical procedures for the treatment of symptomatic anterior cruciate ligament (ACL) instability, especially in healthy young, active patients. Knee range of motion (ROM), muscle function and return to normal daily and sporting activity are all important factors in successful recovery after ACL reconstruction as well as restoration of ligament stability. It is important to restore knee motion as early as possible after surgery, but questions also might present themselves about the effects of early flexion on the stability or laxity of the reconstructed graft. Objective: The purpose of this study was to assess early postoperative knee flexion range of motion (ROM) and the association of this with subsequent clinical graft laxity after ACL reconstruction with a hamstring autograft. Patients and Methods: A total of 42 patients who underwent primary ACL reconstruction were included in the study. Inclusion criteria included: Primary ACL reconstruction, isolated ACL injury, age range of 18 to 40 years, and hamstring autograft reconstruction at Al-Tawfiq Private Hospital from May 2023 to May 2025. The surgeries were performed in the same orthopedic practice, and the outcomes were monitored for about 12 months. Knee ROM was measured with a goniometer at 1-week, 1-month and 3-month postoperative periods. The Lachman and anterior drawer test were performed at 6 and 12 months postoperatively to determine the stability of the graft, compared with the opposite knee. Results: Mean age of the patients was 27.8±5.95 years and the age range were 18-40 years. There were 35 male and 7 female patients. In 28 patients, the right knee and in 14 patients, the left knee was involved. The most prevalent mechanism of injury was sports injuries with 30 cases. The average length of the graft used was 23.4 cm and the average graft diameter used was 8.9 mm. The mean follow-up period was 11.5 months. Mean knee ROM increased from 65.95 ± 10.64° at 1 week postoperatively to 106.66 ± 9.78° at 1 month and 138.8 ± 6.87° at 3 months. The Lachman test was Grade 0 in 28 patients, grade 1 in 12 patients, grade 2 in 2 patients and grade 3 in no patient at 6 months. At 12 months, the results were: Grade 0 28 patients; Grade 1 11 patients; Grade 2 2 patients; Grade 3 1 patient. In 6 months, 30 patients had Grade 0, 10 had Grade 1, 2 had Grade 2, and 0 had Grade 3 on the anterior drawer test, while 30 patients had Grade 0, 9 patients had Grade 1, 2 patients had Grade 2 and 1 patient had Grade 3 on the anterior drawer test in 12 months. Conclusion: Knee flexion was gradually increasing in the first 3 months after ACL reconstruction. Most of the patients had minimal clinical laxity or none at all at 6- and 12-months follow-up. The results underscore the value of early ROM recovery as part of the post-operative therapy.

Keywords: Anterior cruciate ligament; ACL reconstruction; range of motion; knee flexion; graft laxity; Lachman test; anterior drawer test; hamstring autograft

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1. Introduction

Anterior cruciate ligament (ACL) injury is one of the most significant injuries of the knee, especially in young and active people. Recurrent episodes of instability, poor

functional performance, restricted participation in sports and secondary meniscal and chondral damage may occur due to ACL deficiency. Thus, ACL reconstruction is often indicated in patients with symptomatic instability and/or functional demands [1], [2], [3], [4], [5].

The main goal of ACL reconstruction is to provide knee stability, while at the same time restoring acceptable functional performance. However, a functional result is not 100% assured after surgery. The postoperative outcome depends on a number of factors such as the choice of the graft, surgical technique, rehabilitation, the strength of the muscles, the range of motion at the knee, the patient's psychological preparation and the functional capacity to return to activity [6], [7], [8], [9], [10].

Range of motion of the knee is a key aspect of the early rehabilitation of ACL reconstruction. The restoration of the normal motion of the knee is essential for walking, climbing stairs, squatting, sports and functional activities. Loss of motion can lead to arthrofibrosis and stiffness post operatively and can negatively impact the overall outcome [11], [12], [13]. That's why modern rehabilitation regimes focus on gradually restoring knee movement in the initial post-op period.

Early postoperative ROM is especially critical because lack of motion will make it difficult to restore normal knee biomechanics. Research studies that have studied rehabilitation following ACL reconstruction have highlighted the need to restore knee symmetry and motion as early as clinically appropriate [14], [15], [16]. The timing and progression of rehabilitation has also been studied in patients undergoing hamstring autograft reconstruction of the anterior cruciate ligament [17].

Although early motion is considered beneficial, there are some clinicians who would be concerned about stressing the healing graft with an excessive amount of early flexion or aggressive rehabilitation. The clinical relevance of the relationship between early knee motion and the later graft laxity is therefore clinically relevant. The Lachman test and the anterior drawer test examining anterior translation of the tibia on the femur are commonly used in assessing graft stability [18], [19], [20].

This is the Lachman test, which is commonly used in the clinical assessment of the integrity and stability of the ACL after a reconstruction. Manual clinical tests have their value during routine postoperative assessment but instrumental assessment can give quantitative information on anterior tibial translation, such as with the use of devices like the KT-1000 arthrometer [18], [21]. Other factors that may affect graft stability include type of graft, the method of graft fixation, the sequence of rehabilitation and patient-related factors [22], [23], [24], [25].

There are many factors involved in functional recovery following ACL reconstruction. Despite successful ligamentous healing, patients can have problems with quadriceps strength, neuromuscular control, or mental preparation for return to sport [26-29]. Poor quadriceps strength symmetry has been related to the failure of functional performance after reconstruction, which means that the importance of graft stability should not be the only factor in mind when considering reconstruction, and reconstruction should be followed by rehabilitation in a comprehensive manner [26], [27].

Return to sport is another important outcome following ACL reconstruction. While many athletes make a full return to sport, the percentage of return to the same level of sport participation is lower than anticipated and successful return is both physically and psychologically dependent [7], [8], [28], [29]. So objective parameters (ROM and ligamentous stability) should also be assessed following surgery along with functional recovery.

The purpose of the present study was to compare early recovery of knee flexion ROM after a hamstring autograft ACLR and to assess post-ACLR graft laxity by the Lachman and anterior drawer tests. The study was specifically designed to assess the range of motion at 1 week, 1 month and 3 months postoperatively and clinical graft stability at 6 and 12 months postoperatively.

2. Materials and Methods

2.1 Study Design and Patients

This is a prospective study with 42 patients who underwent ACL reconstruction. Clinical patients with primary ACL reconstruction surgery for an isolated ACL injury were included in the study. Patients were included if they had undergone a primary ACL reconstruction, isolated ACL injury, hamstring autograft reconstruction, and were 18–40 years of age at Al-Tawfiq Private Hospital from May 2023 to May 2025. Surgery was performed by a single orthopedic team for all patients. Postoperative follow-up of patients was carried out for about 12 months. The original manuscript included these study characteristics.

2.2 Surgical Procedure

All patients had primary ACL reconstruction, with a hamstring autograft. These surgeries were done by the same orthopedic team to minimize differences in operative technique. The average graft diameter was 8.9 mm (7 mm – 10 mm) and the average graft length is 23.4 cm (20.6 cm – 26.4 cm).

2.3 Postoperative Range of Motion Assessment

Knee flexibility was measured after surgery with goniometer in knee flexion. The measurements were taken at three postoperative times: 1 week, 1 month, and 3 months. The knee flexion angle was measured in degrees and the angle was used to demonstrate the progression of early postoperative ROM.



Figure 1 .Measurement of knee flexion angle using a goniometer at 1 week after ACL reconstruction.



Figure 2. Clinical measurement of postoperative knee flexion angle at 1 week after ACL reconstruction.

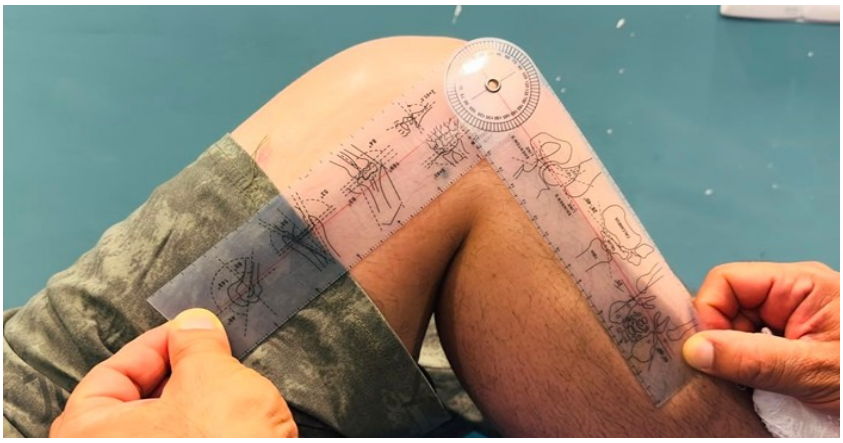


Figure 3. Measurement of knee flexion angle using a goniometer at 1 month after ACL reconstruction.

2.4 Clinical Assessment of Graft Laxity

The Lachman test and anterior drawer test were used as clinical criteria for graft stability at 6 and 12 months after surgery. The results were compared to the opposite knee. The anterior tibial translation was graded as Grade 0, Grade 1, Grade 2 and Grade 3 based on the clinical tests.



Figure 4. Postoperative clinical assessment of anterior knee laxity using the anterior drawer test.



Figure 5. Postoperative clinical assessment of ACL graft stability using the Lachman test.

2.5 Follow-up

The mean period of follow-up was 11.5 months (range 9-15 months). Lachman and anterior drawer examinations were done at 6 and 12 months; knee ROM was done during the first 3 postoperative months.

2.6 Statistical Analysis

Data analysis was carried out by SPSS software. The continuous variables were reported as mean ± standard deviation (SD) and the categorical variables as frequencies and percentages. Knee flexion range of motion at 1 week, 1 month and 3-months post operation was measured and compared. Lachman grade and anterior drawer test were also assessed at 6 and 12 months of age. The P-value < 0.05 was considered statistically significant.

3. Results

3.1 Patient Characteristics

Forty-two patients were included. The mean age was 27.8 ± 5.95 years, with a range of 18–40 years. There were 35 male and 7 female patients. 28 patients involved in right knee, and 14 patients involved in left knee. As to how the injury had occurred, 30 patients had an injury from sporting events, 5 from a work injury, and 7 from a traffic injury. The mean graft diameter was 8.9 mm (7–10 mm) and the mean graft length was 23.4 cm (20.6–26.4 cm). The mean follow-up period was 11.5 months (range 9 - 15 months) (Table 1).

Table 1. Characteristics of the Patients and Grafts

Variable	Result
Age, years, mean ± SD (range)	27.8 ± 5.95 (18–40)
Male	35
Female	7
Right knee	28
Left knee	14
Sports injury	30
Work injury	5
Traffic accident	7
Graft diameter, mm, mean (range)	8.9 (7–10)
Follow-up, months, mean (range)	11.5 (9–15)
Graft length, cm, mean (range)	23.4 (20.6–26.4)

3.2 Postoperative Range of Motion

The knee flexion ROM improved progressively during the postoperative period. The mean ROM was 65.95 ± 10.64° at 1 week, increasing to 106.66 ± 9.78° at 1 month, and reaching 138.8 ± 6.87° at 3 months postoperatively (Table 2).

Table 2. Postoperative Knee Range of Motion

Postoperative period	ROM, mean ± SD
1 week	65.95 ± 10.64°
1 month	106.66 ± 9.78°
3 months	3.8 ± 6.87°

3.3 Postoperative Lachman Test

Lachman test was performed at 6 months after surgery, with 28 patients having Grade 0, 12 patients Grade 1, 2 patients Grade 2 and 0 patients Grade 3. The 12-month postoperative results are summarized in Table 3: 28 patients (77%) were graded as Grade 0, 11 patients (32%) as Grade 1, 2 patients (5%) as Grade 2, and 1 patient (3%) as Grade 3.

Table 3. Postoperative Lachman Test Findings

Lachman grade	6 months, n	12 months, n
Grade 0	28	28
Grade 1	12	11
Grade 2	2	2
Grade 3	0	1

3.4 Postoperative Anterior Drawer Test

Anterior drawer test was Grade 0 in 30 patients and Grade 1 in 10 patients, Grade 2 in 2 patients and Grade 3 in 0 patients at 6 months. The results after 12 months are shown in Table 4 as Grade 0 (30), Grade 1 (9), Grade 2 (2), and Grade 3 (1) (Fig. 6).

Table 4. Postoperative Anterior Drawer Test Findings

Anterior drawer grade	6 months, n	12 months, n
Grade 0	30	30
Grade 1	10	9
Grade 2	2	2
Grade 3	0	1

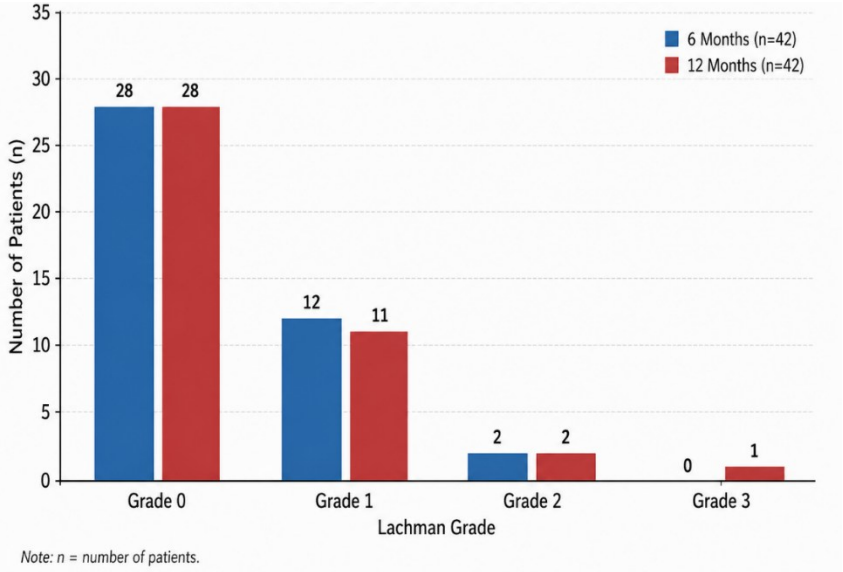


Figure 6. Distribution of postoperative anterior drawer test grades at 6 and 12 months after ACL reconstruction.

4. Discussion

The present study aimed to assess early postoperative knee flexion ROM and then to analyze subsequent clinical graft laxity after a HA ACL reconstruction. The 42 patients aged between 18 and 40 years old showed gradual improvement in knee flexion within the first 3 months following surgery.

The early recovery of knee ROM is an important component of successful ACL rehabilitation. In the present study, the mean ROM increased from 65.95 ± 10.64° at 1 week to 106.66 ± 9.78° at 1 month and 138.8 ± 6.87° at 3 months. This gradual recovery is significant knee flexion recovery in the early postoperative period.

Restoring knee motion early after ACL reconstruction has been highlighted in previous studies. Stiffness and arthrofibrosis are well-known complications after surgery that can pose as a problem for functional recovery and may necessitate early diagnosis and management [11], [12], [13]. Restoration of ROM is thus a common part of the rehabilitation and reduction of swelling and progressive restoration of muscle function are emphasized.

The results of the present study are consistent with the hypothesis that the ROM of the knee increases gradually in the early post-operative rehabilitation period. Bottoni et al. investigated postoperative ROM following ACL reconstruction using hamstring autografts and highlighted the importance of postoperative motion recovery in the rehabilitation process [33]. Likewise, research regarding ACLR recovery has focused on early functional rehabilitation and recovery of knee symmetry [34].

One of the major issues in early rehabilitation is the potential for decreased graft stability with early flexion. Majority of patients did not show a marked pattern of clinically significant laxity in the present findings. Most patients (6 months) had a Grade 0 or Grade

1 Lachman (2 patients Grade 2, none Grade 3). By 12 months, most continued to have either Grade 0 or Grade 1 findings with 2 patients having Grade 2 and 1 patient having Grade 3 findings.

The anterior drawer test was similar. There were 30 patients with a grade of 0, 10 grade 1, 2 grade 2 and no grade 3 at 6 months. At 12 months, 30 patients had Grade 0, 9 had Grade 1, 2 had Grade 2, and 1 had Grade 3.

Part of postoperative follow up is a clinical evaluation of ACL stability. The Lachman test is considered one of the most significant and useful clinical tests for the integrity of the ACL and the anterior drawer test gives further information about anterior tibial translation [18], [19], [20], [21]. Objective quantitative data about the postoperative laxity can be obtained by KT-1000 arthrometry, and previous studies have examined the relationship between arthrometry measurements and long-term outcomes [23].

Another factor that is important in ACL reconstruction is graft selection. Hamstring autografts are commonly used and have shown to be a successful procedure. The results of studies comparing the various graft types have been generally good with regards to stability and functional outcome, with possible differences in the morbidity of the donor site and other patient-reported outcomes [22], [23], [24], [25].

It is also important to know the demographic properties of the current cohort. There were more male than female patients and sports injury was the most frequent mechanism of ACL injury. This is in line with the high prevalence of ACL injuries in physically active people. Patients who want to regain knee stability or return to sporting or physically active activities are especially likely to undergo ACL reconstruction [3], [4], [5], [28], [29].

Postoperative recovery following ACL reconstruction is more than just getting the graft to be stable. Restoring the strength of the quadriceps and muscle symmetry are crucial factors in determining functional outcome after surgery. A number of studies have shown that quadriceps strength deficits can exist after ACL reconstruction, and can potentially impact functional performance and return to sport [26], [27], [30], [31], [32].

Return to sport is also influenced by psychological factors. Patients can be clinically stable, but still be apprehensive and lack confidence in their reconstructed knee. Previous systematic reviews and clinical studies have demonstrated that psychological readiness and physical recovery are both important in determining successful return to preinjury levels of sport [7], [8], [28], [29].

The findings of the current study therefore support the idea of the early use of ROM as a vital part of ACL rehabilitation. Functional recovery may be aided by allowing knee flexion to begin early in the postoperative period, but it is important to continue to monitor graft stability.

However, there are some caveats to be noted. There was no separate comparison group and a relatively small sample (42 patients) in the study. Moreover, clinical assessment of graft laxity was done by Lachman and anterior drawer tests instead of quantitative instrumented arthrometer. No data on patient-reported outcome scores, muscle strength or return to sport outcomes were available for the studies. Thus, interpretation of the findings should be undertaken in the light of the study's design and outcome measures.

5. Conclusion

This study proved that knee flexion ROM progressively increased during the first 3 months after ACL reconstruction with hamstring autograft. Mean ROM increased from 65.95 ± 10.64° at 1 week to 106.66 ± 9.78° at 1 month and 138.8 ± 6.87° at 3 months.

At clinical assessment at 6 months and 12 months, majority had no or Grade 1 findings to both Lachman's test and anterior drawer test. Overall, these results suggest good clinical stability of reconstructed knees at follow up.

Promoting early restoration of knee ROM is an essential part of the rehabilitation following ACL reconstruction. For the purposes of this study, generally satisfactory clinical graft stability was observed with progressive early flexion recovery.

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