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# Comparative Study of Functional Recovery after Anterior Cruciate Ligament Reconstruction Using Patellar Tendon versus Hamstring Tendon Grafts.

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## Abstract

***Background:*** Anterior cruciate ligament (ACL) reconstruction is one of the most commonly performed orthopedic procedures for restoring knee stability and functional activity after ACL injury. Bone-patellar tendon-bone grafts and hamstring tendon grafts are the two most frequently used autografts for ACL reconstruction. However, controversy still exists regarding the superiority of one graft over the other in terms of functional recovery and postoperative complications. ***Aim:*** To compare the functional recovery after anterior cruciate ligament reconstruction using patellar tendon grafts versus hamstring tendon grafts. ***Objectives:*** To evaluate postoperative functional outcomes in patients undergoing ACL reconstruction using patellar tendon grafts and hamstring tendon grafts. To compare knee stability, complications, and return to functional activity between the two graft groups. ***Materials and Methods:*** A hospital-based comparative observational study was conducted in the Department of Orthopedics at a tertiary care teaching hospital over a period of 24 months. A total of 200 patients with ACL injury undergoing arthroscopic ACL reconstruction were included in the study. Among them, 101 patients underwent reconstruction using patellar tendon grafts and 99 patients underwent reconstruction using hamstring tendon grafts. Baseline demographic and clinical characteristics were recorded. Functional outcomes were assessed using IKDC score, Lysholm score, Tegner activity score, range of motion assessment, and knee stability tests including Lachman and Pivot shift tests. Postoperative complications and return to daily and sports activities were also evaluated. Statistical analysis was performed using Student's t-test and Chi-square test, with p-value <0.05 considered statistically significant. ***Results:*** Baseline demographic characteristics and preoperative functional scores were comparable between the two groups. Patients in the hamstring tendon graft group demonstrated significantly better postoperative IKDC scores, Lysholm scores, Tegner activity scores, and achievement of full range of motion compared to the patellar tendon graft group. Knee stability outcomes were comparable between both groups. Anterior knee pain and donor site morbidity were significantly higher in the patellar tendon graft group, whereas hamstring weakness was more common in the hamstring tendon graft group. Patients receiving hamstring tendon grafts returned earlier to routine activities and sports participation. ***Conclusion:*** Both patellar tendon and hamstring tendon grafts provided satisfactory knee stability and functional recovery after ACL reconstruction. However, hamstring tendon grafts demonstrated superior short-term functional outcomes, earlier return to activity, and lower anterior knee morbidity. Graft selection should be individualized according to patient requirements and surgeon expertise.

**Keywords:** Anterior Cruciate Ligament Reconstruction. Patellar Tendon Graft. Hamstring Tendon. Graft.



## INTRODUCTION

Anterior cruciate ligament (ACL) injury is one of the most common ligamentous injuries of the knee joint, especially among young adults and athletes involved in pivoting sports such as football, basketball, kabaddi, and cricket. The ACL plays a crucial role in maintaining rotational stability and preventing anterior translation of the tibia relative to the femur.

ACL rupture often results in knee instability, pain, swelling, restricted activity, and long-term complications such as meniscal injury and osteoarthritis if left untreated. Surgical reconstruction of the ACL has become the standard treatment for symptomatic patients aiming to restore knee stability and return to pre-injury functional levels.[1]

Various graft options have been used for ACL reconstruction, among which Bone-Patellar Tendon-Bone (BPTB) grafts and Hamstring Tendon (HT) grafts are the most commonly preferred autografts. Patellar tendon grafts have traditionally been considered the gold standard because of their excellent fixation strength, rapid graft incorporation, and favorable biomechanical properties.

However, complications such as anterior knee pain, kneeling discomfort, patellar fracture, and extensor mechanism morbidity have been associated with BPTB grafts. In contrast, hamstring tendon grafts gained popularity because of reduced donor site morbidity, smaller incision, and less postoperative anterior knee pain. Nevertheless, concerns regarding hamstring weakness, graft fixation, and slower graft integration have been reported.[2]

Functional recovery after ACL reconstruction depends on multiple factors including graft selection, surgical technique, rehabilitation protocol, patient compliance, and associated injuries. Several comparative studies have evaluated the outcomes of patellar tendon and hamstring tendon grafts with respect to knee stability, range of motion, return to sports activity, pain, and patient satisfaction.

While some studies reported superior stability with patellar tendon grafts, others demonstrated comparable functional outcomes with fewer complications in hamstring tendon grafts. Hence, controversy still exists regarding the ideal graft choice for ACL reconstruction.[3]

Assessment of postoperative functional recovery is commonly performed using validated scoring systems such as the Lysholm Knee Score, International Knee Documentation Committee (IKDC) score, Tegner Activity Scale, and clinical stability tests. Comparative evaluation of these grafts is important for guiding orthopedic surgeons in selecting the most suitable graft based on patient characteristics and functional demands.[4]

**AIM**

To compare the functional recovery after anterior cruciate ligament reconstruction using patellar tendon grafts versus hamstring tendon grafts.

**OBJECTIVES**

1. To evaluate postoperative functional outcomes in patients undergoing ACL reconstruction using patellar tendon grafts and hamstring tendon grafts.
2. To compare knee stability, complications, and return to functional activity between the two graft groups.

## MATERIALS AND METHODS

**Source of Data**

The data were collected from patients diagnosed with anterior cruciate ligament injury who underwent ACL reconstruction surgery at the Department of Orthopedics of the tertiary care teaching hospital.

Clinical details, operative findings, postoperative follow-up records, and rehabilitation outcomes were obtained from hospital records and direct patient evaluation during follow-up visits.

**Study Design**

The study was conducted as a hospital-based comparative observational study.

**Study Location**

The study was conducted in the Department of Orthopedics at a tertiary care teaching hospital and associated rehabilitation center.

**Study Duration**

The study was carried out over a period of 24 months, including patient recruitment, surgical intervention, follow-up, data collection, and statistical analysis.

**Sample Size**

A total sample size of 200 patients was included in the study.

- Group A: 100 patients underwent ACL reconstruction using Bone-Patellar Tendon-Bone grafts.

- Group B: 100 patients underwent ACL reconstruction using Hamstring Tendon grafts.

**Inclusion Criteria**

1. Patients aged between 18 and 50 years.
2. Patients diagnosed with complete ACL tear confirmed clinically and radiologically by MRI.
3. Patients willing to undergo ACL reconstruction surgery and participate in follow-up.
4. Patients with unilateral ACL injury.
5. Patients medically fit for surgery and anesthesia.

**Exclusion Criteria**

1. Patients with previous surgery on the affected knee joint.
2. Patients with multi-ligament knee injuries.
3. Patients with severe osteoarthritis or inflammatory arthritis of the knee.
4. Patients with associated fractures around the knee joint.
5. Patients unwilling for surgery or follow-up.
6. Patients with neuromuscular disorders affecting lower limb function.

**Procedure and Methodology**

After obtaining approval from the Institutional Ethics Committee and informed written consent from all participants, eligible patients were enrolled in the study. Detailed clinical history including mode of injury, duration of symptoms, instability episodes, and activity level was recorded.

General and local examination of the affected knee was performed. Clinical tests such as Lachman test, Anterior Drawer test, and Pivot Shift test were carried out to assess ACL deficiency.
Radiological evaluation included plain X-ray of the knee joint and MRI for confirmation of ACL tear and associated injuries. Patients were allocated into two groups based on the graft used for reconstruction.

All surgeries were performed under spinal or general anesthesia using standard arthroscopic ACL reconstruction techniques. In Group A, Bone-Patellar Tendon-Bone graft was harvested from the central third of the patellar tendon with bone plugs from the patella and tibial tuberosity. In Group B, semitendinosus with or without gracilis tendon grafts were harvested and prepared as quadrupled hamstring grafts.

Femoral and tibial tunnels were created arthroscopically and graft fixation was performed using interference screws or appropriate fixation devices. Postoperative rehabilitation protocol including range of motion exercises, quadriceps strengthening, progressive weight bearing, and physiotherapy was standardized for both groups.

Patients were followed up at regular intervals of 6 weeks, 3 months, 6 months, and 12 months postoperatively. Functional recovery was assessed using Lysholm Knee Score, IKDC score, range of motion, knee stability tests, and return to daily activities or sports participation.

**Sample Processing**

All collected clinical and functional assessment data were entered into a predesigned proforma. Data were checked for completeness, accuracy, and consistency before analysis. Functional scores and clinical findings were categorized according to standard scoring criteria.

**Statistical Methods**

The collected data were compiled and analyzed using appropriate statistical software. Quantitative variables such as age and functional scores were expressed as mean ± standard deviation, while qualitative variables were expressed as frequencies and percentages. Independent Student's t-test was used for comparison of continuous variables between the two groups. Chi-square test or Fisher's exact test was applied for categorical variables. A p-value of less than 0.05 was considered statistically significant.

**Data Collection**

Data collection was performed using a structured case record form containing demographic details, clinical findings, MRI findings, operative details, graft type, postoperative complications, rehabilitation progress, and functional outcome scores. Follow-up assessments were conducted during outpatient visits and documented systematically for comparative analysis between both graft groups.

## RESULTS

**Table 1: Baseline Characteristics and Overall Functional Recovery Comparison among Study Participants (n=200)**

| Variable | Patellar Tendon Graft n=101 | Hamstring Tendon Graft n=99 | Test value | 95% CI | p-value |
|---|---|---|---|---|---|
| Age, years | 29.84 ± 6.71 | 30.92 ± 7.13 | t=1.10 | -3.02 to 0.86 | 0.273 |
| Male | 73 (72.3%) | 68 (68.7%) | $\chi^2$=0.31 | -9.1% to 16.3% | 0.579 |
| Female | 28 (27.7%) | 31 (31.3%) | $\chi^2$=0.31 | -16.3% to 9.1% | 0.579 |
| Injury duration, months | 7.42 ± 2.96 | 7.91 ± 3.14 | t=1.13 | -1.34 to 0.36 | 0.259 |
| Preoperative Lysholm score | 54.63 ± 8.42 | 55.71 ± 8.19 | t=0.92 | -3.39 to 1.23 | 0.360 |
| Postoperative Lysholm score at 12 months | 88.76 ± 6.31 | 91.24 ± 5.84 | t=2.89 | -4.17 to -0.79 | 0.004 |
| Functional recovery achieved | 82 (81.2%) | 89 (89.9%) | $\chi^2$=3.02 | -18.1% to 0.7% | 0.082 |

Table 1 shows the baseline characteristics and overall functional recovery comparison between patients who underwent anterior cruciate ligament reconstruction using patellar tendon grafts and hamstring tendon grafts. The mean age of patients in the patellar tendon graft group was 29.84 ± 6.71 years, while in the hamstring tendon graft group it was 30.92 ± 7.13 years. The difference between the two groups was not statistically significant (t=1.10, p=0.273), indicating that both groups were comparable with respect to age distribution. Male participants constituted the majority in both groups, accounting for 72.3% in the patellar tendon group and 68.7% in the hamstring tendon group, whereas females comprised 27.7% and 31.3% respectively.

The gender distribution did not differ significantly between groups ($\chi^2$=0.31, p=0.579). The mean duration of injury before surgery was 7.42 ± 2.96 months in the patellar tendon group and 7.91 ± 3.14 months in the hamstring tendon group, with no statistically significant difference observed (t=1.13, p=0.259). Similarly, the preoperative Lysholm knee score was comparable between both groups, measuring 54.63 ± 8.42 in the patellar tendon group and 55.71 ± 8.19 in the hamstring tendon group (t=0.92, p=0.360). However, postoperative Lysholm score at 12 months showed a statistically significant improvement in the hamstring tendon graft group (91.24 ± 5.84) compared to the patellar tendon graft group (88.76 ± 6.31) with a p-value of 0.004. Functional recovery was achieved in 81.2% of patients in the patellar tendon group and 89.9% of patients in the hamstring tendon group. Although the hamstring tendon group demonstrated a higher recovery rate, the difference did not reach statistical significance ($\chi^2$=3.02, p=0.082).

**Table 2: Postoperative Functional Outcomes after ACL Reconstruction (n=200)**

| Functional Outcome | Patellar Tendon Graft n=101 | Hamstring Tendon Graft n=99 | Test value | 95% CI | p-value |
|---|---|---|---|---|---|
| IKDC score at 6 months | 76.84 ± 7.93 | 79.62 ± 7.41 | t=2.56 | -4.92 to -0.64 | 0.011 |
| IKDC score at 12 months | 84.91 ± 6.86 | 87.38 ± 6.29 | t=2.65 | -4.30 to -0.64 | 0.009 |
| Lysholm score at 6 months | 80.73 ± 7.24 | 83.18 ± 6.82 | t=2.46 | -4.41 to -0.49 | 0.015 |
| Lysholm score at 12 months | 88.76 ± 6.31 | 91.24 ± 5.84 | t=2.89 | -4.17 to -0.79 | 0.004 |
| Tegner activity score at 12 months | 6.24 ± 1.18 | 6.67 ± 1.09 | t=2.67 | -0.75 to -0.11 | 0.008 |
| Full range of motion achieved | 86 (85.1%) | 93 (93.9%) | $\chi^2$=4.03 | -17.1% to -0.5% | 0.045 |
| Excellent functional outcome | 59 (58.4%) | 71 (71.7%) | $\chi^2$=3.89 | -26.2% to -0.4% | 0.049 |

Table 2 presents the postoperative functional outcomes following ACL reconstruction in both graft groups. The mean IKDC score at 6 months was significantly higher in the hamstring tendon graft group (79.62 ± 7.41) compared to the patellar tendon graft group (76.84 ± 7.93), indicating better early postoperative knee function in the hamstring graft group (t=2.56, p=0.011). Similarly, at 12 months follow-up, the hamstring tendon group continued to demonstrate significantly superior IKDC scores (87.38 ± 6.29) compared to the patellar tendon group (84.91 ± 6.86) with a p-value of 0.009.

The Lysholm knee score at 6 months was also significantly higher among patients receiving hamstring tendon grafts (83.18 ± 6.82) than those receiving patellar tendon grafts (80.73 ± 7.24) (t=2.46, p=0.015). At 12 months, the Lysholm score remained significantly better in the hamstring tendon group (91.24 ± 5.84) as compared to the patellar tendon group (88.76 ± 6.31), with statistical significance observed (p=0.004).

The Tegner activity score at 12 months was significantly greater in the hamstring tendon group (6.67 ± 1.09) than in the patellar tendon group (6.24 ± 1.18), indicating improved return to activity levels (t=2.67, p=0.008). Full range of motion was achieved in 93.9% of patients in the hamstring tendon graft group compared to 85.1% in the patellar tendon graft group, and this difference was statistically significant ($\chi^2$=4.03, p=0.045). Furthermore, excellent functional outcomes were noted in 71.7% of patients in the hamstring tendon group as compared to 58.4% in the patellar tendon group, showing a statistically significant advantage for hamstring tendon grafts ($\chi^2$=3.89, p=0.049).

**Table 3: Knee Stability, Complications, and Return to Functional Activity between Graft Groups (n=200)**

| Variable | Patellar Tendon Graft n=101 | Hamstring Tendon Graft n=99 | Test value | 95% CI | p-value |
|---|---|---|---|---|---|
| Negative Lachman test at 12 months | 91 (90.1%) | 88 (88.9%) | $\chi^2$=0.08 | -7.5% to 9.9% | 0.774 |
| Grade I anterior laxity | 8 (7.9%) | 9 (9.1%) | $\chi^2$=0.09 | -9.0% to 6.6% | 0.764 |
| Pivot shift negative | 94 (93.1%) | 92 (92.9%) | $\chi^2$=0.00 | -7.0% to 7.4% | 0.961 |
| Anterior knee pain | 27 (26.7%) | 13 (13.1%) | $\chi^2$=5.76 | 3.2% to 24.0% | 0.016 |
| Donor site morbidity | 24 (23.8%) | 11 (11.1%) | $\chi^2$=5.53 | 2.6% to 22.8% | 0.019 |
| Hamstring weakness | 7 (6.9%) | 18 (18.2%) | $\chi^2$=5.89 | -20.1% to -2.5% | 0.015 |
| Superficial infection | 4 (4.0%) | 3 (3.0%) | $\chi^2$=0.13 | -4.6% to 6.6% | 0.711 |
| Return to routine daily activity, weeks | 9.84 ± 2.17 | 8.92 ± 1.86 | t=3.21 | 0.35 to 1.49 | 0.002 |
| Return to sports activity, months | 8.41 ± 1.62 | 7.86 ± 1.48 | t=2.50 | 0.12 to 0.98 | 0.013 |

Table 3 compares knee stability, postoperative complications, and return to functional activity between the two graft groups. Assessment of knee stability showed comparable results in both groups. Negative Lachman test at 12 months was observed in 90.1% of patients in the patellar tendon graft group and 88.9% in the hamstring tendon graft group, with no statistically significant difference ($\chi^2$=0.08, p=0.774). Grade I anterior laxity was found in 7.9% and 9.1% of patients in the patellar and hamstring tendon groups respectively, which was also statistically insignificant (p=0.764). Similarly, negative pivot shift test was demonstrated in 93.1% of patients in the patellar tendon group and 92.9% in the hamstring tendon group, indicating comparable rotational stability between both grafts (p=0.961). However, postoperative complications differed significantly between groups.

Anterior knee pain was significantly more common in the patellar tendon graft group (26.7%) compared to the hamstring tendon graft group (13.1%) ($\chi^2$=5.76, p=0.016). Donor site morbidity was also significantly higher in the patellar tendon group, affecting 23.8% of patients versus 11.1% in the hamstring tendon group ($\chi^2$=5.53, p=0.019). Conversely, hamstring weakness was significantly more frequent in the hamstring tendon graft group (18.2%) than in the patellar tendon graft group (6.9%) ($\chi^2$=5.89, p=0.015). Superficial infection rates were low and comparable between groups, with no significant difference observed (p=0.711). Patients in the hamstring tendon graft group returned to routine daily activities significantly earlier, at a mean duration of 8.92 ± 1.86 weeks compared to 9.84 ± 2.17 weeks in the patellar tendon graft group (t=3.21, p=0.002). Likewise, return to sports activity occurred significantly earlier in the hamstring tendon group (7.86 ± 1.48 months) than in the patellar tendon group (8.41 ± 1.62 months) with a statistically significant p-value of 0.013.

## DISCUSSION

In the present study, baseline parameters were comparable between the patellar tendon graft and hamstring tendon graft groups. The mean age was 29.84 ± 6.71 years in the patellar tendon group and 30.92 ± 7.13 years in the hamstring tendon group, with no statistically significant difference. Gender distribution, injury duration, and preoperative Lysholm scores were also comparable, indicating that both groups were similar before surgery. This finding is consistent with Mohtadi et al. (2019)[1], who reported comparable baseline characteristics among patients undergoing ACL reconstruction with patellar tendon and hamstring tendon grafts. Similarly, Pinczewski et al. (2007)[2] observed that patients in both graft groups were comparable at baseline in their long-term prospective study.

In the present study, postoperative Lysholm score at 12 months was significantly higher in the hamstring tendon graft group compared to the patellar tendon graft group. The hamstring group also showed better IKDC scores at 6 and 12 months, better Lysholm scores at 6 and 12 months, higher Tegner activity score, greater achievement of full range of motion, and higher proportion of excellent functional outcomes. These findings suggest that hamstring tendon grafts provided slightly

better short-term functional recovery. Similar observations were reported by Zhao et al. (2020)[3], who found that hamstring tendon grafts were associated with fewer complications such as anterior knee pain, kneeling pain, and extension loss, which may contribute to better functional recovery. Lubis et al. (2021)[4] also reported good functional improvement after ACL reconstruction using both grafts, with hamstring grafts showing favorable postoperative recovery in selected patients.

Regarding knee stability, the present study found no significant difference between the two groups in negative Lachman test, Grade I anterior laxity, and negative pivot shift test at 12 months. This indicates that both patellar tendon and hamstring tendon grafts provided satisfactory postoperative knee stability. This finding is supported by Pinczewski et al. (2007)[2], who reported no significant difference in graft rupture rates and normal or near-normal knee function in 97% of patients in both groups at 10 years. Similarly, Mohtadi et al. (2019)[1] found no significant difference in quality-of-life outcomes between graft groups at 5 years.

In the present study, anterior knee pain and donor site morbidity were significantly higher in the patellar tendon graft group. Anterior knee pain was observed in 26.7% of patellar tendon patients compared to 13.1% of hamstring tendon patients, while donor site morbidity was 23.8% versus 11.1%, respectively. These results are in agreement with Yunes et al. (2001)[5], who reported higher anterior knee pain and donor site complications with patellar tendon grafts. Zhao et al. (2020)[3] also concluded that hamstring tendon autografts had lower risk of anterior knee pain and kneeling pain compared with bone-patellar tendon-bone grafts.

However, hamstring weakness was significantly more common in the hamstring tendon graft group in the present study. This is expected because harvesting semitendinosus and gracilis tendons may affect knee flexion strength. Similar findings were noted by Mohtadi et al. (2011)[6], who reported that graft selection influences donor-site symptoms and functional morbidity. Samuelsen et al. (2017)[7] also noted that although hamstring grafts reduce anterior knee symptoms, graft selection must consider functional demand and possible differences in failure risk.

The present study also showed that patients in the hamstring tendon group returned earlier to routine daily activity and sports activity compared to the patellar tendon group. This may be attributed to lower anterior knee pain and less donor-site discomfort in the hamstring group. Migliorini et al. (2023)[8] reported that graft choice affects anterior knee pain, joint laxity, return to sport, and functional outcomes after ACL reconstruction. Overall, the findings of the present study suggest that both grafts are effective for ACL reconstruction, but hamstring tendon grafts may offer better short-term functional recovery and lower anterior knee morbidity, while patellar tendon grafts provide comparable stability but with higher donor-site symptoms.

## CONCLUSION

The present study concluded that both patellar tendon grafts and hamstring tendon grafts provided satisfactory functional recovery and knee stability following anterior cruciate ligament reconstruction. Baseline demographic and preoperative clinical characteristics were comparable between both groups, ensuring appropriate comparison of postoperative outcomes. Patients reconstructed with hamstring tendon grafts demonstrated significantly better postoperative functional outcomes in terms of IKDC score, Lysholm score, Tegner activity score, achievement of full range of motion, and earlier return to routine and sports activities. Knee stability parameters including Lachman test and pivot shift test were comparable between the two graft groups, indicating that both grafts were effective in restoring mechanical stability of the knee joint.

However, the patellar tendon graft group showed a significantly higher incidence of anterior knee pain and donor site morbidity, whereas hamstring weakness was more common among patients reconstructed with hamstring tendon grafts. Despite these graft-specific complications, both techniques achieved good overall functional recovery. Based on the findings of the present study, hamstring tendon grafts may offer superior short-term functional recovery with lower anterior knee morbidity, while patellar tendon grafts continue to provide reliable knee stability. Therefore, graft selection should be individualized according to patient characteristics, activity demands, occupation, and surgeon preference.

### LIMITATIONS OF THE STUDY

1) The study was conducted at a single tertiary care center, which may limit generalizability of the results to the broader population.
2) The duration of follow-up was limited to 12 months, which may not reflect long-term graft survival and functional outcomes.
3) Randomization of patients into graft groups was not performed, introducing the possibility of selection bias.
4) Rehabilitation compliance among patients could not be completely standardized and may have influenced postoperative outcomes.
5) Objective biomechanical assessment tools such as instrumented laxity testing were not used in all patients.
6) The study did not evaluate long-term osteoarthritic changes or graft re-rupture rates.

7) Functional outcomes were primarily assessed using subjective scoring systems, which may be influenced by patient perception.
8) Occupational and sports-specific functional demands of patients were not analyzed separately.

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