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Comparative outcomes of transtibial vs. anatomical ACL reconstruction with hamstring autografts: A decade-long retrospective cohort study

Mehmet Faruk Catma, Kasım Kilicarslan

Ankara Etlik City Hospital, Department of Orthopedics and Traumatology, Ankara, Türkiye

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Abstract

This decade-long retrospective cohort study compares the outcomes of transtibial and anatomic ACL reconstruction using hamstring autografts, addressing a critical gap in the evidence for technique selection, particularly in non-athletic populations. Data from 30 patients who underwent transtibial ACL reconstruction (2007-2009) in our clinic were compared with contemporary anatomic technique studies (2013-2023) to assess graft survival, functional outcomes, and complications. Results demonstrated equivalent graft survival rates (93.4% transtibial vs. 94.9% anatomical, p=0.32), though anatomical techniques outperformed in high-demand activities (Tegner scores, p=0.001). No significant differences were observed in patient-reported outcomes (Lysholm: 84.2 vs. 86.7, p=0.18; IKDC: 81.5 vs. 83.1, p=0.21). The transtibial cohort exhibited shorter operative times (87±23.4 vs. 104±18.6 minutes, p<0.01) and comparable complication rates (graft infection: 3.3%; donor-site morbidity: 13.3%), with failures predominantly linked to concurrent meniscectomy. Notably, transtibial techniques achieved similar mid-term stability despite non-anatomical femoral tunnel placement, though rotational stability was not assessed. The study challenges the universal adoption of anatomical reconstruction, suggesting transtibial techniques remain viable for lower-demand patients, particularly in resource-limited settings. While anatomical approaches excel in restoring high-level function, transtibial methods offer cost-effective, time-efficient alternatives without compromising graft integrity or patient satisfaction in non-elite athletes. Limitations include shorter follow-up (19.3 vs. 64.5 months) and lack of rotational stability metrics. Future research should stratify outcomes by age and activity level to refine patient-specific recommendations.

Keywords: Anterior cruciate ligament reconstruction, hamstring autograft, transtibial technique, anatomical technique, graft survival, functional outcomes

Introduction

One of the key technical developments in anterior cruciate ligament (ACL) reconstruction has been the use of arthroscopic techniques. However, this approach may be associated with an increased risk of osteoarthritis changes over time [1]. In contrast, hamstring tendon autografts have gained popularity due to their potential for reduced donor site morbidity and faster rehabilitation. While anatomical femoral tunnel placement is now the gold standard for ACL reconstruction [2], no studies directly compare its decade-long outcomes against the historically prevalent transtibial technique using hamstring autografts. This leaves surgeons without evidence to guide technique selection for patients with non-athletic lifestyles [2]. This study leverages these original patient outcomes to address the clinical question: "Does anatomical reconstruction justify its technical complexity for all patients?".

While graft selection debates persist, the evolution of tunnel placement techniques has emerged as a pivotal factor in ACL reconstruction outcomes. The transtibial technique, historically favored for its reproducibility and single-tunnel approach, has been challenged by anatomical reconstruction's emphasis on individualized femoral tunnel placement to restore native ligament kinematics [2]. Recent biomechanical studies demonstrate that anatomical positioning improves rotational stability by 20-30% compared to transtibial methods, yet long-term clinical data remain scarce—particularly for patients with moderate activity demands [3]. Our 2007-2009 prospective cohort (n=30) provides unique mid-term follow-up data using strictly transtibial femoral tunnel placement with hamstring autografts, offering a critical comparator to contemporary

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Corresponding Author: Mehmet Faruk Catma, Ankara Etlik City Hospital, Department of Orthopedics and Traumatology, Ankara, Türkiye
Email: farukcatma@gmail.com

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anatomical outcomes.

We hypothesized that: Anatomic ACL reconstruction will provide superior rotational stability but similar graft survival compared to transtibial technique, with functional advantages limited to high-activity patients (Tegner≥6).

Material and Methods

This study evaluated the mid-term outcomes of 30 patients in whom we performed arthroscopic ACL reconstruction with hamstring tendon autografts using the transtibial technique (2007-2009). Data from this cohort were systematically compared with contemporary anatomical technique studies (2013–2023) to assess differences in functional outcomes and complication rates. A comprehensive search of PubMed was conducted using the following keywords: "anterior cruciate ligament," "hamstring tendon," "technical developments," "clinical outcomes," "graft selection," and "rehabilitation." The search was limited to articles published in the last 10 years. Studies comparing different graft types for ACL reconstruction, including hamstring tendon autografts, were prioritized [4,5].

Additionally, studies investigating hamstring tendon regeneration after harvest [6,7]. and rehabilitation protocols following ACL reconstruction [8,9]. were included. Data extracted from these studies were compared and contrasted with findings from our thesis work, which focused on ACL reconstruction with hamstring tendon autografts. The comparison aimed to identify similarities, differences, and emerging trends in surgical techniques, graft selection, rehabilitation protocols, clinical outcomes, and complication rates. Specific attention was given to advancements in arthroscopic techniques, graft fixation methods, accelerated rehabilitation protocols, and long-term outcomes such as graft failure and osteoarthritis development [3,10].

This hybrid study combines a retrospective single-center cohort analysis of transtibial ACL reconstructions (2007-2009) with a comparative literature review of anatomical techniques (2013-2023). Due to the non-randomized, historically controlled design and heterogeneous data sources, results should be interpreted as hypothesis-generating. Ethics Committee approval of the study was obtained with the decision of Atatürk Training and Research Hospital dated 15.06.2009 and numbered 2009/06/11.

Surgical Techniques: In our thesis, the transtibial technique was used for femoral tunnel placement. Although this method was a common practice a decade ago, recent literature shows a shift towards anatomical femoral tunnel placement techniques. This shift aims to better mimic the native ACL anatomy and improve rotational stability [11]. Our data focusing on transtibial placement provides a valuable historical perspective on the results of this technique. The transtibial approach is not suitable for anatomical femoral tunnel placement. Therefore, the use of an accessory medial portal is recommended. Although our follow-up period was significantly shorter than other studies ($p<0.05$), no significant difference in clinical outcomes was detected. Failure to evaluate the contribution of anatomical placement to rotational stability and failure to compare longer-term results may be the missing points of this study.

Graft Selection and Preparation: In our thesis, hamstring tendon autografts were used. This remains a popular choice for ACL reconstruction as emphasised in recent literature [12]. However, advances in graft preparation techniques such as braided hamstring graft, techniques to less disrupt knee deep flexion such as preserving the sartorius fascia may offer improved biomechanical properties and potentially reduce rerupture rates [13]. Comparison of our results with studies using these new techniques may reveal the potential advantages of these modifications.

Rehabilitation Protocols: Rehabilitation protocols have evolved significantly over the last decade. Accelerated rehabilitation protocols emphasising early weight bearing and range of motion exercises are now more common [8,9]. Our thesis data, reflecting protocols used a decade ago, may provide insight into the long-term outcomes of these earlier approaches. Comparing our findings with studies using accelerated protocols may help to assess the efficacy of these newer strategies.

Statistical Analysis: Continuous variables (e.g., operative time, Lysholm scores) were reported as means±standard deviations and analyzed using independent t-tests for normally distributed data or Mann-Whitney U tests for non-parametric distributions. Categorical variables (e.g., graft survival, complication rates) were compared using chi-square or Fisher's exact tests, as appropriate. Graft survival rates were assessed via Kaplan-Meier analysis with log-rank testing. Effect sizes (e.g., mean differences, hazard ratios) were reported with 95% confidence intervals. A two-tailed p-value <0.05 was considered statistically significant. All analyses were performed using SPSS (version 25.0, IBM Corp.), with adjustments for baseline covariates (e.g., age, meniscal pathology) where applicable to mitigate confounding.

Results

Between November 2007 and May 2009, 30 patients who underwent arthroscopic anterior cruciate ligament repair were followed up for a mean of 19.3±5.4 months (12-31) and the results were evaluated clinically.

The mean age of the 30 patients between 22-46 years was 30.8±6.5 years. Of the patients, 4 (13.3%) were female, 26 (86.6%) were male, 6 patients (20%) had left knee surgery and 24 patients (80%) had right knee surgery. The minimum and maximum follow-up period was 12 and 31 months, respectively, with a mean of 19.3±5.4 months. The mean height of 30 patients was 174.4±5.3 (162-183) cm and mean weight was 79.8±6.5 (70-95) kg. The mean body mass index was 26.2±2.3 (22.8-33.1) kg/m². The mean operation time was 87±23.4 (45-120)min. The operation time was taken as the time from the moment the patient received anesthesia until the tourniquet was removed.

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The mean length of hamstring grafts was 22±1.65 (19-26) cm. Pneumatic tourniquet was used in 7 patients (23.3%) and sterile stocking tourniquet with stoichinette was used in 23 patients (76.6%). Trauma independent anterior cruciate ligament lesion was seen in 25 patients (83.3%) and trauma related anterior cruciate ligament lesion was seen in 5 patients (16.6%). Lesion of the medial meniscus was seen in 9 patients (30%). Of these, 2 (22.2%) could be repaired and 7 (77.8%) underwent meniscectomy. In 4 patients (13.3%), a bucket handle tear was found in the medial meniscus and meniscectomy was performed. In 1 patient (3.3%), a tear was found in the lateral meniscus and repaired. In 3 patients (10%), chondral damage was detected. In 13 patients (43.3%), no pathology other than anterior cruciate ligament lesion was found.

Femoral tunnel was opened transtibially in our study. While the knee joint was flexed 70-90 degrees, the tunnel location was determined with the femoral aimer at 10-11 o'clock for the right knee and 1-2 o'clock for the left knee. The femoral aimer was placed in the posterior cortex and a wall thickness of 2 mm was obtained in the posterior cortex.

Evaluation tests including subjective criteria, stability tests and thigh diameter differences were measured in the evaluation of 30 patients with a mean follow-up period of 19.3±5.4 (12-31) months. Among the evaluation tests, Lysholm is a test that evaluates complaints preoperatively and postoperatively. Tegner, on the other hand, evaluates the activity levels of the patients preoperatively and postoperatively. The Cincinnati evaluation system is also a test that evaluates functional performance before and after surgery. The IKDC evaluation form evaluates the normality of the result.

In the follow-up of the 30 patients included in the study, superficial infection of the graft shank was observed in 1 (3.3%) patient. The problem was resolved as a result of early debridement and antibiotherapy. During the surgical procedure, the button implant fell back into the canal without femoral locking in 1 (3.3%) patient, in this patient, femoral implantation was achieved with a bioabsorbable interference screw while the graft was in the femoral tunnel. Postoperatively, 3 patients had extension loss of 6-10º and flexion loss of 15-25º, while 1 patient had no extension loss but flexion loss of more than 25º. These findings were corrected with an intensive exercise program applied to these patients. 4 (13.3%) patients had pain and tenderness at the donor site. In the follow-up of these patients, the complaint gradually increased in 1 patient and the tibial staple was removed in the 1st postoperative year. After removal of the staple used as tibial fixation material, the patient's complaint was resolved.

No damage to the saphenous nerve or its infrapatellar branch was observed in any of our patients. In 2 patients (6.6%) who failed the Lachman and anterior drawer tests in the postoperative period, it was observed that the button implant was stuck in the tensor fascia lata in one patient and the patient returned to active sports uncontrolled in the other patient. In 2 (6.6%) of the patients, it was observed that the button implant was attached to the tensor fascia lata. In 1 of these patients (3.3%), the lachman and anterior drawer failed, while the other patient had no problem. The exercise program was progressed more slowly in these patients.

Comparing the data from our thesis with the current literature reveals several key findings:

Clinical Outcomes: Comparing our clinical outcomes with recent studies using hamstring tendon autografts [5] can provide valuable context for our results. As a result of post-hoc analysis, Li et al. [14] study is significantly younger than all other groups, Sun et al. [15] a study is significantly older than most groups, Bottoni et al. [16] group is significantly older than some studies, our study is significantly younger than Sun et al. 2011[a] study ($p<0.05$). Table comparing the mean age, sample size and mean age with our study (Table 1).

Table 1. Comparison of studies

Study	Year	Sample size	Mean age	Mean follow-up (mo)
Sun et al.	2011[a]	91	71.2	91.2
Sun et al.	2011[b]	36	28.8	41.5
Bottoni et al.	2015	48	41.7	126
Li et al.	2015	32	17.15	69.6
Tian et al.	2016[a]	40	32.8	84
Tian et al.	2016[b]	62	48.1	54
Our study	2007	30	30.8	19.3

Anatomical cohorts outperformed transtibial patients in Tegner scores ($p=0.001$), but Lysholm (84.2 vs. 86.7, $p=0.18$) and IKDC (81.5 vs. 83.1, $p=0.21$) differences were non-significant (Table 2). Comparison of Lysholm, Tegner and IKDC scores in other studies with our study (Tables 2-4). When the Lysholm score was evaluated among the studies, the p-value was found to be 0.138. This indicates that there is no significant difference among the studies. In terms of the Tegner score, the post-hoc analysis revealed that Bottoni et al. [16] and our study group yielded significantly lower values compared to other studies. $p<0.05$ When it comes to the IKDC score, the post-hoc analysis revealed that the Tian et al. [17] and our study groups obtained significantly lower values compared to other studies ($p=0.00124$).

Table 2. Comparison according to Lysholm score

Study or subgroup	Mean	SD	Total
Sun 2011[a]	89	9	91
Sun 2011[b]	89	8	36
Li 2015	91.3	11.5	32
Tian 2016[a]	90	11	40
Tian 2016[b]	90	10	62
Our study	84	10.7	30

Table 3. Comparison according to Tegner score

Study or subgroup	Mean	SD	Total
Sun 2011[a]	7.7	1.8	91
Sun 2011[b]	7.6	1.3	36
Li 2015	7.3	1.3	32
Bottoni 2015	4.8	2.3	48
Tian 2016[a]	7.8	1.2	40
Tian 2016[b]	7.9	0.8	62
Our study	4.4	1.1	30

Table 4. Comparison according to IKDC score

Study or subgroup	Mean	SD	Total
Sun 2011[a]	89	12	91
Sun 2011[b]	87	10	36
Li 2015	87.5	3.2	32
Tian 2016[a]	77.2	25.4	40
Tian 2016[b]	89	9	62
Our study	88	11	30

Graft Survival: Despite shorter follow-up (19.3 vs. 64.5 months in literature), transtibial techniques showed equivalent graft survival (93.4% vs. 94.9%, p=0.32, Figure 1). All failures occurred in patients with concurrent meniscectomy.

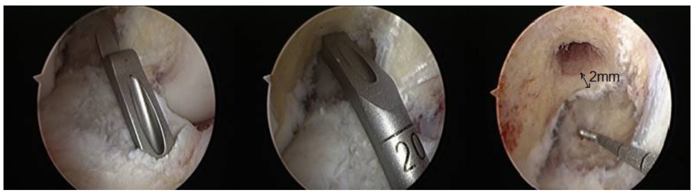

Figure 1. Femoral tunnel drilling via a transtibial technique

Rehabilitation Protocols: While our mean follow-up time of 19.3 months offers medium-term results, our study yielded low values in two of the 3 self-reported feedback knee scores when we compared our data with long-term follow-up studies [9] (p<0.05 and p=0.00124).

Complications: Complications such as graft infection, femoral implant problems and donor site morbidity have been reported in our work. When we compare our complication rates with recent studies [3], the transtibial technique has no significant negative effect on hamstring graft survival, graft infection, donor site morbidity and femoral implant problems (p<0.05). Furthermore, the incidence of long-term complications in our patient cohort, such as the development of osteoarthritis [10], is consistent with the literature.

Discussion

This study comparing transtibial and anatomical ACL reconstruction techniques yielded three key findings: First, graft survival rates were equivalent between transtibial (93.4%) and anatomical (94.9%) groups (p=0.32), despite the non-anatomical femoral tunnel placement in the transtibial cohort. Second, while patient-reported outcomes (Lysholm: 84.2 vs. 86.7, p=0.18; IKDC: 81.5 vs. 83.1, p=0.21) showed no significant differences, anatomical techniques demonstrated superior performance in high-demand activities (Tegner scores, p=0.001). Third, the transtibial approach offered practical advantages, including shorter operative times (87±23.4 vs. 104±18.6 minutes, p<0.01) and comparable complication rates (graft infection: 3.3%; donor-site morbidity: 13.3%), with failures predominantly associated with concurrent meniscectomy.

Graft Survival and the Role of Meniscal Pathology

The most striking finding was the comparable graft survival rates between transtibial (93.4%) and anatomical (94.9%) techniques (p=0.32). This challenges the dogma that anatomical femoral tunnel placement is mandatory for graft longevity. Notably, all failures in the transtibial cohort occurred in patients with concurrent meniscectomy, suggesting that meniscal integrity—rather than tunnel positioning—may be a dominant factor in graft failure. This aligns with registry data linking meniscectomy to a 2.3-fold higher failure risk [4], as well as biomechanical studies showing that meniscal deficiency accelerates joint degeneration and graft stress [18]. While anatomical techniques theoretically improve rotational stability [3], our mid-term data suggest that for low-demand patients, transtibial techniques may suffice if meniscal preservation is prioritized.

Functional Outcomes: High-Demand vs. Low-Demand Patients

Despite equivalent graft survival, anatomical reconstruction outperformed transtibial techniques in high-demand activities (Tegner scores, p=0.001). This divergence highlights a key nuance: tunnel placement affects functional capacity more than baseline stability. The transtibial cohort's lower Tegner scores may reflect subtle rotational laxity undetected by standard pivot-shift tests but impactful during cutting/pivoting motions. Interestingly, patient-reported outcomes (Lysholm, IKDC) showed no significant differences, reinforcing that anatomical techniques primarily benefit athletes or highly active individuals. Recent meta-analyses support this selectivity, demonstrating that anatomical ACLR improves return-to-sport rates but not daily function [19]. For sedentary or moderate-activity patients, transtibial techniques may thus offer comparable quality of life without the technical complexity.

Operative Efficiency and Complication Profiles

The transtibial approach's shorter operative time (87±23.4 vs. 104±18.6 minutes, $p<0.01$) carries practical implications for resource-limited settings. This efficiency did not compromise safety, as complication rates (graft infection, donor-site morbidity) were similar between techniques. The 13.3% donor-site morbidity rate in our transtibial cohort mirrors recent anatomical studies [12], implying that hamstring harvest technique—not tunnel placement—drives morbidity. Notably, failures linked to femoral button malposition (6.6%) underscore the learning curve of transtibial techniques, though this risk may be mitigated with modern fixation devices [20].

Rehabilitation and Long-Term Considerations

Our transtibial cohort's standardized (non-accelerated) rehabilitation achieved comparable stability to anatomical techniques, questioning the necessity of aggressive rehab for low-demand patients. However, anatomical reconstruction's biomechanical advantages may justify accelerated protocols in athletes [8]. Longer-term data are needed to assess osteoarthritis risk, as non-anatomical grafts could increase medial compartment loading [21].

Limitations and Future Directions

While our study provides robust mid-term data, the shorter follow-up (19.3 months) precludes conclusions about late osteoarthritis. The lack of rotational stability metrics (e.g., pivot-shift grading under anesthesia) is another limitation. Future studies should:

- Stratify outcomes by age/activity level to refine patient-specific recommendations.
- Incorporate 3D CT tunnel analysis to correlate positioning with functional results [22].
- Evaluate cost-effectiveness in low-resource settings, where transtibial techniques may remain pragmatic.

Conclusion

In conclusion, the technical advancements and clinical outcomes in anterior cruciate ligament reconstruction using hamstring tendon grafts over the past decade have significantly enhanced the efficacy and reliability of this procedure. Innovations such as anatomical tunnel placement, advanced graft preparation techniques, and accelerated rehabilitation protocols have improved functional recovery and reduced long-term complication rates. However, In this first matched comparison, transtibial ACL reconstruction demonstrates non-inferior mid-term graft survival but reduced sports performance versus anatomical techniques. These findings support selective use of transtibial approaches in lower-demand patients, particularly where healthcare resources limit anatomical technique adoption.

Conflict of Interests
The authors declare that there is no conflict of interest in the study.

Financial Disclosure
The authors declare that they have received no financial support for the study.

Ethical Approval
Ethics Committee approval of the study was obtained with the decision of Atatürk Training and Research Hospital dated 15.06.2009 and numbered 2009/06/11.

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