

Comparison of hamstring and patellar tendon grafts in anterior cruciate ligament reconstruction: A prospective randomized study

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Abstract

Objective: This prospective randomized study was performed to compare the outcomes of two operative methods of anterior cruciate ligament (ACL) reconstruction based on either bone–patellar tendon–bone (BTB) grafts or hamstring tendon (HT) grafts.

Methods: Among 100 patients, 96 completed the full follow-up period and were included in the final analysis (48 in the BTB group and 48 in the HT group). The patients were evaluated preoperatively and 1, 3, 6, and 12 months after ACL reconstruction. The Kujala score, Tegner score, and Knee injury and Osteoarthritis Outcome Score (KOOS) were among the parameters used to evaluate the patients.

Results: Both groups were comparable in terms of sex, age, and body mass index. None of the analyzed scores were significantly different between the BTB and HT groups at either the initial or last visit. Both groups demonstrated improvement at the 12-year follow-up according to the Kujala score and most categories of the KOOS. The Tegner activity level score showed significant improvement in the HT but not BTB group.

Conclusion: Patients undergoing ACL reconstruction with BTB and HT grafts show comparable improvement in functional results after 1 year of rehabilitation.

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Keywords

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Background

Anterior cruciate ligament (ACL) injuries are among the most common problems faced in orthopedic surgery. Around 250 000 ACL injuries are recorded annually in the United States,¹ with the greatest incidence occurring in 15- to 25-year-old players of pivoting sports.² Although several methods of ACL reconstruction exist, the two most common are bone–patellar tendon–bone (BTB) reconstruction using an autograft of the middle third of the patellar tendon and reconstruction using a hamstring tendon (HT) graft.^{3–8} Although previous well-designed studies have compared the outcomes of these two techniques, even with a long follow-up period, any comparison is complicated by the use of different surgical techniques and graft stabilization procedures.^{3–8} In our institution, the standard stabilization method for both BTB and HT grafts incorporates titanium interference screws. This prospective randomized study was performed to compare these two operative methods of ACL reconstruction and identify any differences in their outcomes. Because most studies focusing on this subject have revealed no difference between these two ACL reconstruction grafts,^{3–8} we hypothesized that our two groups would have similar final results in knee function.

Methods

This prospective randomized study involved a group of patients treated for ACL deficiency from 2012 to 2014. The following inclusion criteria were used: (1) age of 18 to 55 years, (2) unilateral ACL reconstruction, (3) chronic knee instability at least 6 months

from injury, and (4) no signs of grade \geq II osteoarthritis on radiographs. The following exclusion criteria were used: (1) age of <18 or >55 years, (2) professional sport player, (3) acute injury, (4) concomitant injury (including collateral ligament, posterior cruciate ligament, and meniscal injury), and (5) contralateral knee injury.

One hundred patients met the study criteria. All provided written informed consent to participate and were randomized into one of two groups of 50 patients each using the envelope method. The first group was treated with the BTB graft approach and the second with the HT graft approach.

ACL deficiency was clinically diagnosed based on physical examination findings (Lachman test, anterior drawer test, and pivot shift test) as well as magnetic resonance imaging results. Anterior knee pain was assessed with the Kujala Scoring Questionnaire.⁹ The activity level was assessed using the Tegner scale.¹⁰ The Knee injury and Osteoarthritis Outcome Score (KOOS) was used to assess knee function.¹¹

All measurements and clinical examinations were performed both preoperatively and 1, 3, 6, and 12 months postoperatively. However, only the observations from the first and last follow-up visits were used for the analysis. The clinical evaluation was performed by a physiotherapist (K.S.) who was involved in the rehabilitation process but not the surgical procedure according to a standardized protocol.

Operative procedure

All patients underwent spinal anesthesia. All single-bundle reconstructions were performed

by two surgeons experienced with ACL reconstruction according to the standard protocol used by the department. First, using a standard femoral guide, the femoral tunnel was made using the anteromedial portal as far as possible on the lateral condyle. Targeting was performed so that the posterior wall of the femur was left with a thickness of 2 to 3 mm. Tibial tunnel positioning was standardized in both groups using the same instrument set. The tibial tunnel was targeted in the center of the footprint of the native ACL using a tibial guide. Both the BTB and HT grafts were stabilized with a titanium interference screw (Linvatec, Utica, NY, USA). The screw diameter was 2 mm less than the bone tunnel diameter for the BTB graft and 1 mm greater than the bone tunnel diameter for the HT graft.

All patients underwent standard postoperative rehabilitation. The rehabilitation protocol started the day after the operation and consisted of partial weight bearing with support by crutches and simple muscle-strengthening exercises. No brace was used in any patient. The crutches were discharged as soon as the patients had good muscle control of the operated knee and reached full extension, usually within the first 2 to 3 weeks. The patients underwent physiotherapy three times a week for the first 6 weeks after surgery, focusing on achieving full extension and strengthening of the quadriceps and hamstring muscles. Jogging was allowed after 4 months, but return to competitive sports was restricted to at least 6 months after surgery.

The study protocol was accepted by the Bioethics Committee of the Medical University of Łódź (resolution RNN/43/13/KE, dated 12 March 2013).

Statistical analysis

Statistical analysis was performed using Statistica 10 (Dell Software, Round Rock, TX, USA). For all tests, the level of significance was taken as $P=0.05$. Quantitative

variables (measurable) are presented both as the number of observations (n) and percentage (%). The Shapiro–Wilk test was used to confirm the normality of the measured data. If the data were found to have a normal distribution, Student's t -test was used for independent and dependent samples. Because most of the variables had a non-normal distribution, non-parametric tests were also used: Wilcoxon's test for consecutive pairs was used to compare two dependent samples, and the Mann–Whitney U test was used for two independent samples. The sex distribution between the groups was compared using the chi-square test.

Results

Among all 100 patients, 96 completed the full follow-up period. Two patients from the BTB group and 2 from the HT group were lost to follow-up; therefore, 48 patients from the BTB group (40 male and 8 female) and 48 patients from the HT group (36 male and 12 female) were included in the final analysis. The data concerning sex, age, and body mass index are presented in Table 1.

A comparison of the preoperative and postoperative results revealed both groups demonstrated an improvement in the Kujala score and in most categories of the KOOS. The Tegner activity score showed a significant improvement in the HT group ($P=0.0004$) but not in the BTB group (Table 2).

No major complications were noted in either group. At 12 months, no patient required ACL revision. No signs of infection were detected. One patient from the BTB group required revision arthroscopy due to an extension deficit, which was resolved by the removal of a cyclops lesion.

Discussion

This prospective randomized study revealed no significant differences in functional

Table 1. Demographic data and comparison of outcomes between BTB and HT groups.

	BTB graft reconstruction	HT graft reconstruction	P value
Male/female (n)	40/8	36/12	0.3
Age in years	31.64 (25–41)	31.64 (18–55)	0.751879
BMI before surgery, kg/m ²	25.19 (22.49–29.39)	24.34 (8.37–29.71)	0.59
BMI at 12 months, kg/m ²	24.86 (22.49–26.31)	24.14 (18.37–29.63)	0.58
Kujal score before surgery	77.73 (53–91)	78.40 (43–100)	0.760783
Kujal score at 12 months	95.55 (90–100)	95.00 (76–100)	0.851382
Tegner score before surgery	5.09 (1–7)	4.39 (1–7)	0.122182
Tegner score at 12 months	5.45 (3–7)	5.23 (2–7)	0.527715
KOOS (pain) before surgery	84.90 (42–100)	88.15 (39–100)	0.379820
KOOS (pain) at 12 months	96.09 (86–100)	96.69 (83–100)	0.716604
KOOS (symptoms) before surgery	81.55 (57–100)	84.85 (25–100)	0.308324
KOOS (symptoms) at 12 months	89.91 (64–100)	92.90 (75–100)	0.796705
KOOS (ADL) before surgery	93.18 (50–100)	96.23 (59–100)	0.760783
KOOS (ADL) at 12 months	99.82 (99–100)	99.85 (96–100)	0.622855
KOOS (sport/rec) before surgery	58.18 (25–80)	59.62 (0–100)	0.760783
KOOS (sport/rec) at 12 months	91.93 (80–100)	90.64 (40–100)	0.743008
KOOS (QOL) before surgery	48.36 (6–88)	47.38 (6–100)	0.823937
KOOS (QOL) at 12 months	81.36 (69–100)	82.36 (59–100)	0.760783

With the exception of age, all data are presented as mean (range).

BTB, bone–patellar tendon–bone reconstruction using the middle third of the patellar tendon; HT, hamstring tendon; BMI, body mass index; KOOS, Knee injury and Osteoarthritis Outcome Score; ADL, activities of daily living; QOL, quality of life; sport/rec, sports/recreation.

Table 2. Comparison of preoperative and postoperative results in BTB and HT groups.

	Type of ACL surgery	Before surgery	At 12 months	P value
Kujala score	HT	78.4 (43–100)	95.0 (76–100)	0.000001
	BTB	77.7 (53–91)	95.5 (90–100)	0.004
Tegner score	HT	4.38 (1–7)	5.2 (2–7)	0.0004
	BTB	5.0 (1–7)	5.5 (3–7)	0.6
KOOS (pain)	HT	88.2 (39–100)	96.7 (83–100)	0.000294
	BTB	84.9 (42–100)	96.1 (86–100)	0.02
KOOS (symptoms)	HT	84.8 (25–100)	92.9 (75–100)	0.003
	BTB	81.5 (57–100)	89.9 (64–100)	0.08
KOOS (ADL)	HT	96.2 (59–100)	99.8 (96–100)	0.2
	BTB	93.2 (50–100)	99.8 (99–100)	0.07
KOOS (sport/rec)	HT	59.6 (0–100)	90.6 (40–100)	0.000002
	BTB	58.18 (25–80)	91.9 (80–100)	0.003
KOOS (QOL)	HT	47.38 (6–100)	82.35 (56–100)	0.000001
	BTB	48.3 (6–88)	81.36 (69–100)	0.009

All data are presented as mean (range).

BTB, bone–patellar tendon–bone reconstruction using the middle third of the patellar tendon; HT, hamstring tendon; ACL, anterior cruciate ligament; KOOS, Knee injury and Osteoarthritis Outcome Score; ADL, activities of daily living; QOL, quality of life; sport/rec, sports/recreation.

outcomes, the Kujala anterior knee pain score, the Tegner activity score, or any aspects of the KOOS between patients undergoing ACL reconstruction by BTB versus HT grafts. All analyzed patients had chronic knee instability, and those with acute injuries were excluded from the study. These criteria made the patients comparable because early versus delayed operative treatment may give different results.¹² Both groups showed improvement in the Kujala score and most aspects of the KOOS at the last follow-up visit compared with the preoperative status, demonstrating the effectiveness of both procedures. However, the HT group demonstrated a more significant improvement in the Tegner score.

The differences between the two graft types are well documented in the literature. Recent data from a 15-year follow-up to a randomized controlled trial showed that BTB and HT ACL reconstructions were comparable in terms of both subjective and objective results, and some of the differences seen in the earlier review were not present at the long-term follow-up.⁶ Similarly, a double-blind randomized clinical trial by Mohtadi et al.⁵ provided clinically valuable results: neither patient-reported nor clinical observations were significantly different among BTB, HT, and double-bundle HT ACL reconstruction techniques during a 2-year follow-up.

These findings are consistent with those of Fu et al.¹³ They noted similar effectiveness for both types of surgical procedures, with only a small difference in postoperative stability, muscle strength, and activity level at 2, 3, and 5 years following the procedure. Another study by Zelic et al.⁷ compared the effectiveness of the two procedures with regard to knee joint stability 2 years following ACL reconstruction. The study included 112 patients: in one group, the graft was taken from the central band of the patellar tendon ($n = 54$ patients; mean age, 28 years), and in the other group, the graft was taken

from the HT ($n = 58$ patients; mean age, 26 years). The evaluation was performed using the Lachman test, pivot shift test, and an apparatus for testing joint laxity (KT-1000 arthrometer; MEDmetric Corp., San Diego, CA, USA). The results revealed no significant difference in knee joint stability between the two surgical techniques 2 years following reconstruction.

Similar results were obtained in a large prospective randomized study by Eriksson et al.⁴ In total, 164 patients were recruited for the study. The patients were allocated to 2 groups based on the type of surgical procedure: 64 patients underwent ACL reconstruction with the central band of the patellar tendon (BTB graft), and the other 100 patients were treated using an HT graft. The patients were evaluated with the following tests before and after the procedure, with a mean intervening period of 31 months: the Stryker knee laxity test, single-leg hop test, Tegner activity scale, Lysholm scale, patellofemoral pain scale, and International Knee Documentation Committee scale. All patients underwent the same rehabilitation procedures. The results revealed no significant differences in the flexibility test results, functional test results, or scores on the various analyzed scales between the BTB and HT groups. Only one slight difference was noted: an insignificant deficit in the extension of the operated knee joint in the BTB group, which is inconsistent with the findings of the present study.⁴

Xie et al.⁸ performed a meta-analysis of 22 articles taken from PubMed, Embase, and the Cochrane Library to compare the effectiveness of the two reconstruction techniques. The analysis encompassed a total of 931 patients who underwent BTB graft transplantation and 999 who underwent semitendinosus and gracilis (STG) tendon graft transplantation. The results revealed no significant difference in stability, flexibility, the degree of graft acceptance/damage,

subjective assessment of functional knee deficit, or range of extension/flexion between the two groups. Patients with the BTB graft performed better in the pivot shift test and more effectively returned to their preinjury activities, while patients with the STG tendon graft had better results regarding knee pain and kneeling.

Stolarczyk et al.¹⁴ noted that the use of a BTB autograft appears to be a better strategy for patients taking part in light athletic disciplines, while the STG tendon graft is better for patients with a lower activity level. In addition, Barenius et al.¹⁵ reported that the technique used for ACL reconstruction does not influence the degree of degenerative changes observed in the knee joint in the later postoperative period. In summary, the results of the present and other well-structured studies do not reveal clear differences in effectiveness between the two surgical techniques. Thus, the graft site should be chosen based on the preferences of the surgeon and patient.

The main limitation of this study is its relatively short follow-up period. However, the main aim of the study was to compare the early results of ACL reconstruction, and the follow-up duration in both analyzed groups was the same; thus, the groups were comparable.

Conclusion

Patients undergoing BTB and HT graft ACL reconstruction have comparable improvement in functional results after 1 year of rehabilitation.

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Not applicable.

Competing interests

The authors declare that they have no competing interests.

Consent for publication

Not applicable.

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Ethics approval

The protocol of the study was accepted by the Bioethics Committee of our institution (resolution RNN/43/13/KE, dated 12 March 2013).

List of abbreviations

ACL, anterior cruciate ligament; BTB, bone-patellar tendon-bone; HT, hamstring tendon; KOOS, Knee injury and Osteoarthritis Outcome Score

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