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Long-term outcomes after arthroscopic single-bundle reconstruction of the posterior cruciate ligament: A 7-year follow-up study

Rui Wang, Bin Xu, Lei Wu and Honggang Xu

Abstract

Objective: Arthroscopy is the most popular technique in posterior cruciate ligament (PCL) reconstruction surgery. However, no consensus on long-term outcomes after arthroscopic PCL reconstruction has been reached. This study was performed to evaluate the long-term outcomes after arthroscopic autologous hamstring or allogeneic tendon single-bundle reconstruction of the PCL.

Methods: Fifty-eight patients who underwent arthroscopic PCL reconstruction in Anhui, China from 2007 to 2009 were included. The follow-up period ranged from 56 to 83 months. During the follow-up, the Lysholm knee score and Tegner activity score were used to assess knee function. The KT-2000 arthrometer (MEDmetric Corp., San Diego, CA, USA) was used to assess the stability of the reconstructed PCL.

Results: The mean Lysholm score, mean Tegner score, and mean forward and backward displacements were not significantly different between the final follow-up and 1 year after the surgery. Additionally, no significant differences were observed in any of the above-mentioned parameters between autologous and allogeneic reconstruction at the final follow-up.

Conclusion: Both autologous and allogeneic reconstruction had few complications and satisfactory long-term outcomes.

Keywords

Posterior cruciate ligament, autologous reconstruction, allogeneic reconstruction, Lysholm score, Tegner score, arthrometry

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Department of Sport Injury & Arthroscopy, The First Affiliated Hospital of Anhui Medical University, Anhui, China

Corresponding author:
Bin Xu, Department of Sport Injury & Arthroscopy, The First Affiliated Hospital of Anhui Medical University, No. 218 Jixi Road, Shushan District, Hefei 230022, China.
Email: youchen100@126.com

Introduction

The posterior cruciate ligament (PCL) is one of the most important structures in the maintenance of stability and can prevent excessive rotation of the knee.[1] After injury, PCL recovery takes an extremely long time. Previous studies have demonstrated that injury of the PCL increases knee instability, leading to articular cartilage damage, meniscus injury, and osteoarthritis.[2–4] In general, the incidence of PCL injury is lower than that of anterior cruciate ligament (ACL) injury because PCL injury occurs only when the knee is bent at the time the trauma occurs. However, in the areas of uneven terrain in Eastern China and rural regions of this part of the country, simple PCL injuries are very common, with most injuries caused by motorbike traffic accidents. For decades, arthroscopy has been the most popular technique in PCL reconstruction because of its various advantages, including a small incision and wide field of vision. However, different studies of long-term outcomes after arthroscopic PCL reconstruction have reported disparate results without uniform findings.[5,6] For example, some patients showed no distinct improvement in knee stability after surgery.[4] To clarify this issue, the present study investigated the long-term outcomes in 58 patients who underwent arthroscopic PCL reconstruction from 2007 to 2009 in our hospital.

Methods

Patients

This case series is reported in line with the PROCESS guidelines.[7] The patients included in this study were hospitalized in the Department of Sport Injury and Arthroscopy of the First Affiliated Hospital of Anhui Medical University from 2007 to 2009. This study was approved by the Ethics Committee of the First Affiliated Hospital of Anhui Medical University, and all patients provided written informed consent for publication of their information. The same surgeon performed all of the surgeries using the same fixation material such as plates and screws. Another doctor in the same department who did not participate in the surgeries performed the follow-up. The follow-up was conducted by a doctor–patient double-blind experiment.

Inclusion and exclusion criteria

PCL injury was diagnosed by the following criteria: (1) demonstration of PCL discontinuity on magnetic resonance imaging, (2) a positive posterior drawer test and tibia sinking test, (3) a >10-mm backward shift of the tibia as measured by a KT-2000 arthrometer (MEDmetric Corp., San Diego, CA, USA), and (4) willingness to undergo arthroscopic minimally invasive surgery.

Patients were excluded from this study if they had multiple ligament injuries caused by knee dislocation; no trauma history; combined osteoarthritis, rheumatism, or rheumatoid arthritis; severe heart, brain, or kidney disease; or severe surgical incision site infection.

Among the study group, 41 patients underwent 4-strand autogenous semitendinosus reconstruction, and the remaining 17 patients underwent deep hypothermia allogeneic tendon reconstruction.

Surgical procedure

In all patients, a standard anteromedial or anterolateral operative approach was used to treat intra-articular hyperplasia, hypertrophy, and congestion of the synovial membrane. During the surgery, the PCL was confirmed to be fractured or nearly fractured (i.e., >70% of the PCL was ruptured, the remaining fibers lacked elasticity, and the intraoperative posterior drawer test was positive). In patients with a torn meniscus, the meniscus was sutured or partially dissected. In 23 patients who underwent 4-strand autogenous semitendinosus reconstruction, an oblique incision about 3 to 4 cm long was made 2 cm from the medial border of the tibial tuberosity. The fascia was then slit, and the attachment of the pes anserinus was separated. Using a tendon lifter for assistance, the semitendinosus tendon and gracilis tendon were removed and neatly trimmed. The tendons were sutured using nonabsorbable sutures (W4843, ETHIBOND^{TM}; Ethicon, Somerville, NJ, USA) and woven into a 12-cm-long tendon graft with a diameter of 8 to 9 mm. In the 11 patients who underwent deep hypothermia allogeneic tendon reconstruction, the tendons were soaked in saline containing vancomycin (1000 mg/L) at room temperature for 30 min and then pretensioned at 80 N. The tendons were then sutured and woven as described above. When the diameter of the tendon graft was <8 mm, the suture density was increased to 8 mm in diameter. The remaining attachment of the PCL, 5 mm away from the margin of the articular cartilage, was taken as the positioning point. The patient's knee was bent to an angle of 100° to 110°, and a guide pin was placed. A hollow drill (diameter of 4.5 mm) was used to measure the length of the femoral tunnel. An appropriate hollow drill was then selected to enlarge the tunnel according to the length and diameter of the graft. The devitalized tissue was removed, and only the tibial attachment point of the PCL was retained. After selecting a point 18 to 25 mm from the lower side of the tibial plateau as the positioning point, the tibial tunnel was prepared using a tibial locator according to the length and diameter of the graft. Finally, using a traverse device for assistance, the graft was placed into the femoral tunnel and tibial tunnel. The tendon was then strengthened at a position of 60° using the anterior drawer test, and the tibia was fixed using an interface screw (Smith & Nephew, London, UK). The femoral tendon graft was fixed by a flip-button plate. The tibial tunnel tendon graft stump was sutured with wire anchors (Smith & Nephew). After washing the joint cavity, the incisions were closed with pressure bandages.

After surgery, each patient's knee was immobilized with a chuck brace, and each patient was advised about the need for limited weight bearing during ambulation. A cold compress was used to cover the surgical area, and the patients were encouraged to perform quadriceps isometric contraction training. Two to 4 weeks after the surgery (and for the following 2 months), the patients were allowed to slowly bend their knee to a 90° angle. They were permitted to try to bend their knee 120° only when the posterior drawer test was negative. Limited weight bearing on the affected limb was permitted, depending on the recovery of the quadriceps. Competitive sports were prohibited for the first 6 months after the surgery and for as long as the first 9 months in patients who had undergone allogeneic tendon reconstruction.

Data collection

All patients' Lysholm knee score, Tegner activity score, and KT-2000 measurements were assessed before the surgery; 3, 6, and 12 months after the surgery; and at the final follow-up. The Lysholm score consists of eight questions assessing joint instability after knee ligament reconstruction, and scores of 70 to 100 points indicate that knee function is significantly affected. The reliability, effectiveness, and sensitivity of this score have been internationally recognized. The Tegner activity score is often associated with the Lysholm score and corresponds to the patient's activity level, especially the level of activity of a particular exercise type; the total possible score is 10 points. The KT-2000 measurements indicate the distance between the two tibias before and after a movement. These measurements represent a new auxiliary means for the diagnosis of cruciate ligament injury and efficacy evaluation.

Statistical analysis

Quantitative data are shown as mean ± standard deviation. Differences among more than two groups were assessed by two-way analysis of variance followed by the post-hoc Student's t-test, and differences between two groups were assessed with Student's t-test. A P value of <0.05 was considered statistically significant.

Results

Patient demographics

The clinical and functional outcomes are summarized in Table 1. The follow-up duration ranged from 56 to 83 months. The final study group comprised 58 patients (32 male, 26 female) aged 16 to 59 years (mean age, 32.02 ± 10.24 years). Among these 58 patients, 39 had injured their right knee and 19 had injured their left knee. Traffic accidents (n = 28) were the most common cause of the injuries, followed by sports-related injuries (n = 18) and falling-related injuries (n = 12). Eleven patients had a combined meniscus injury, and four patients had a combined articular cartilage injury. The average interval from the time of injury to treatment was 6.72 ± 2.95 months (range, 2–13 months).

Table 1. Summary of clinical and functional outcomes.

Variables	Results
Patients	58
Age (years)	32.02 ± 10.24
Sex	
Male	32
Female	26
Side	
Right	39
Left	19
Interval to surgery (months)	6.72 ± 2.95
Graft	
Hamstring	41
Allograft	17
Follow-up (months)	71.62 ± 7.24
Cause of injury	
Traffic accidents	28
Sports-related injuries	18
Falling-related injuries	12
Lysholm functional score#	87.68 ± 8.33
Tegner activity score#	8.00 ± 1.21
AP translation by KT-2000 (mm)#	3.18 ± 2.60

Data are presented as n or mean ± standard deviation. #1-year postoperative outcome. AP, anterior-posterior.

Table 2. Lysholm scores, Tegner activity scores, and arthrometer measurements.

	Lysholm score	Tegner activity score	KT-2000 (mm)
1-year post-reconstruction assessment	87.68	8.00	3.18
Final follow-up	85.38	7.70	4.07
P value	0.288	0.214	0.338

One-year postoperative follow-up results

At the 1-year postoperative clinical observation, the Lysholm scores of 35 patients were >90. Fifteen patients had Lysholm scores of 80 to 90, and six patients had Lysholm scores of 60 to 80. Two patients had Lysholm scores of <60. The mean Lysholm score was 87.68 (Table 2). The Tegner scores of 40 patients were >8 points, and 15 patients had scores of 6 to 8 points. The remaining three patients

Table 3. Comparison between autograft and allograft groups at final follow-up.

	Lysholm score	Tegner activity scores	KT-2000 (mm)
Autograft (41 cases)	86.23	7.68	4.06
Allograft (17 cases)	85.02	7.74	4.20
P value	0.154	0.112	0.364

had Tegner scores of <6 points. The mean Tegner score was 8.0 (Table 2). In 31 patients, the anterior-posterior shift as measured by the KT-2000 was <2 mm. In 17 patients, the displacement was 2 to 5 mm, and in 7 patients, it was 5 to 10 mm. In three patients, the displacement was >10 mm. The mean forward and backward displacement was 3.18 mm (Table 2).

Final follow-up results

All patients underwent a comprehensive assessment at the final follow-up. In 34 patients, the Lysholm score was >90; in 16 patients, it was 80 to 90; and in 5 patients, it was 60 to 80. Only three patients had a Lysholm score of <60. The mean Lysholm score was 85.38 (Table 2). In 39 patients, the Tegner score was >8; in 15 patients, it was 6 to 8; and in 4 patients, it was <6. The mean Tegner score was 7.7 (Table 2). Forward and backward displacement was <2 mm in 29 patients, 2 to 5 mm in 20 patients, 5 to 10 mm in 6 patients, and >10 mm in 3 patients. The mean forward and backward displacement was 4.07 mm (Table 2). None of the above-mentioned parameters were significantly different between autologous and allogeneic reconstruction at the final follow-up (Table 3). In addition, no significant differences were observed in the mean Lysholm score, mean Tegner score, or mean forward and backward displacement at the final follow-up compared with at 1 year after the surgery (Table 2).

Discussion

Arthroscopic PCL reconstruction is one of the most common surgical options for PCL injury.[8,9] Although this procedure has been carried out extensively in recent years, increasing evidence suggests that the long-term prognosis may be unsatisfactory, with recurrent laxity and knee instability being much more common in PCL than ACL reconstruction. This has been attributed to the "killer turn" formed when preparing the tibial tunnel,[10] in which the tendon graft forms an acute angle and scratches the sub-tibial cortical bone.[11] The friction can lead to tendon graft injury and affect the creeping substitution by bone marrow mesenchymal cells and fibroblasts. No effective solution to this problem has been identified to date. To reduce the friction, some researchers have made a secondary incision behind the articular cavity and anchored the tendon graft to the intra-articular tibial tunnel opening with an interface screw.[12] However, this resulted in no obvious improvement compared with traditional PCL reconstruction. In the present study, a PCL tibial locator was used to help create the tibial tunnel opening 1.8 to 2.0 cm below the surface of the tibial plateau, and the angle between the tunnel and tibial plateau was adjusted to 50° to 60° to reduce wear of the tendon graft. The dual-fixation method was employed to further reduce postoperative displacement of the tendon graft; i.e., an absorbable interference screw was placed in the tunnel, and the tendon graft stump was anchored to expose the tunnel outside. The postoperative follow-up examination confirmed that this method achieved a more satisfactory clinical outcome, including improved recovery of the motor function of the knee.

In healthy adults, the anatomical diameter of the PCL is 11 to 13 mm, which is much larger than that of the ACL. However, the diameter of the four strands of the hamstring tendon is only 7 to 9 mm, which is much smaller than that of the PCL. Some researchers have advocated deep hypothermia allograft reconstruction to maintain the tension and strength of tendon grafts in the period shortly after PCL reconstruction.[13] However, deep hypothermia allograft reconstruction leads to different degrees of graft rejection and affects the creeping substitution by bone marrow mesenchymal cells and fibroblasts.[13] Other researchers have asserted that tendon grafts with a diameter of <8 mm are not suitable for PCL reconstruction because they aggravate the friction caused by the "killer turn."[13]

To prevent reconstruction failure caused by thin tendon grafts in the present study, we wove the unabsorbed sutures with the tendon grafts to ensure that the diameter of the tendon grafts was >8 mm. Three of the 17 patients who underwent deep hypothermia allograft reconstruction developed knee joint swelling, which was relieved by treatment with a steroid; no other severe complications occurred. All three patients recovered well. Furthermore, the knee function scores of the patients who underwent allograft reconstruction showed little difference from those of patients who underwent autologous reconstruction. These findings were likely due to the firm fixation of the graft, increased angle of the "killer turn," and relatively conservative rehabilitation exercises.

The recovery time after PCL reconstruction is much longer than that after ACL reconstruction. The appropriateness of encouraging patients to perform knee flexion function training as soon as possible after surgery is controversial.[14] We believe that the performance of training exercises to strengthen quadriceps isometric contraction in the early postoperative period could improve the ligament balance and muscle strength around the joint. However, to reduce the negative effects of early postoperative graft tendon creeping substitution and the friction that occurs when the tendon grafts grow into the tibia, we were very conservative in limiting the patients' early knee flexion: the patients could bend their knee to 90° 1 month after surgery and continue to maintain this angle during the next month. Two months after surgery, after completing the outpatient review and determining that no obvious lower limb muscle atrophy was present and that the muscle strength had been restored well, the patients could try to bend their knee to 120°. In this study, the mean forward and backward displacement of the tibia was satisfactory after healing of the tendon allografts 1 year postoperatively. Additionally, no patients showed significant knee injury after surgery and were able to independently complete all of their daily work after performing strengthening exercises for the patella and low-frequency, low-intensity knee training.

In addition to knee flexion functional training, the following factors can affect patients' postoperative outcomes: graft size, postoperative compliance with rehabilitation exercise, postoperative adherence to medical advice, patient's occupation, reduced bone mass, and reduced muscle power around the knee joint, especially the quadriceps femoris.

The single-bundle reconstruction of the cruciate ligament using hamstring tendons or allogeneic tendons performed in the present study has been the main surgical method for nearly 20 years. According to the literature, this method is also commonly applied worldwide.[15] The patient's condition is evaluated prior to the use of allogeneic tendons, and all patients are required to provide written informed consent. Although serious complications such as joint infection and graft rejection are possible, no such complications were observed in the present study. However, as noted in some studies, the healing of tendon allografts containing bone marrow is relatively slow.[16] Thus, the postoperative rehabilitation program in such patients is somewhat conservative. In the present study, as shown by the long-term follow-up results, there were no significant differences between patients treated with allogeneic versus autologous tendon allografts. A flip-button plate with absorbable screws was the most common method used to fix the graft. Many reports on the use of this method have been published in recent years.[17,18]

However, there were still some sources of selection bias in the present study because of the patients' social, economic, and cultural statuses. During the long-term follow-up, patients with a poor or low socioeconomic level showed poor adherence to the rehabilitation program and failed to give feedback to doctors during the telephone and outpatient follow-ups. Patients who did not complete the follow-up were excluded from the final analysis. Some patients' lack of appreciation of the value of the postoperative rehabilitation affected the positive feedback as well as frequency and quality of communication with the doctors, especially with respect to the patients' knee scores. Such selection bias cannot be circumvented.

As in other studies,[16,19,20] anterior-posterior shifting of >5 mm still occurred in the present study. In some cases, the anterior-posterior shifting was >10 mm. In one of the five patients with anterior-posterior shifting of 5 to 10 mm, the displacement had expanded to 10 mm at the final follow-up. Furthermore, three patients with original displacements of >10 mm showed no improvement in the degree of displacement at the final follow-up. These results illustrate that the measures we adopted played a limited role in preventing long-term recurrent relaxation of the reconstructed PCL. We have since performed an animal experiment to investigate this problem.

In conclusion, the results of the present study showed few complications and satisfactory long-term outcomes for both autologous and allogeneic reconstruction. We hope that these findings can help to promote postoperative recovery following PCL reconstruction and reduce recurrent relaxation.

Declaration of conflicting interests

The authors declare that there is no conflict of interest.

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