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Original Article

The influence of popliteus tendon reconstruction on the external rotation instability on patients with anterior cruciate ligament and posterolateral injury

Yao Yao[1,2], Yanfen Qiu[1,2], Jing Chen[1,2], Jia Li[1,2], Shijun Gao[1,2]

[1]Department of Orthopaedic Surgery, [2]The Key Laboratory of Orthopedic Biomechanics of Hebei Province, The Third Hospital of Hebei Medical University, Shijiazhuang 050051, P. R. China

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Abstract: Background: Various surgical techniques to treat posterolateral corner (PLC) injuries have been described. The purpose of this study was to evaluate the influence of popliteus tendon (PT) reconstruction on anterior cruciate ligament (ACL) reconstruction in terms of external rotation laxity and clinical outcomes with tibialis anterior allograft. Methods: Between September 2005 and December 2008, 32 consecutive patients with combined ACL and PLC injuries who underwent the combined ACL-PT reconstruction with tibialis anterior allograft were studied retrospectively. The authors randomly selected 50 patients who underwent isolated ACL reconstruction during the same operative period as the control group. Clinical outcomes were determined from data obtained before surgery and at the last follow-up examination. Result: Postoperatively, mean anterior translation (side-to-side difference) was reduced from 6.8±1.2 mm to 2.0±0.8 mm in study group and from 6.1±1.7 mm to 1.7±0.5 mm. In study group, the dial test at 30° and 90° of knee flexion had significantly decreased from 16.0°±2.3° to 4.6°±2.1° and from 12.7°±2.3° to 3.8°±2.3° at the last follow-up. These differences were statistically significant. With regard to Lysholm and Tegner activity scores, both groups showed statistically improvements at the last follow-up. The IKDC subjective knee evaluation score was 56.2±11.3 preoperatively and 86.3±10.1 postoperatively in study group and 58.6±12.3 preoperatively and 88.6±12.3 postoperatively in control group. At the last follow-up, 29 patients (90.6%) in the study group and 46 patients (92.0%) in the control group had an IKDC knee classification of A or B. Conclusions: The results of combined ACL-PT reconstruction showed as excellent as the isolated ACL reconstruction. Furthermore, the results of the medium-term study indicate that both anteroposterior and external rotation laxity could be improved by combined ACL-PT reconstruction.

Keywords: Posterolateral corner, popliteus tendon, anterior cruciate ligament, external rotation laxity, reconstruction

Introduction

Reconstruction of the anterior cruciate ligament (ACL) is a common procedure to restore knee stability with satisfactory clinical results over the past years. Some factors might affect the graft failure after ACL reconstruction, such as age, graft size, technical errors at the time of surgery, technical errors at the time of surgery and Tegner activity level [1-3]. However, ACL combined the posterolateral corner (PLC) injuries, which was approximately 10% of multi-ligaments injuries, was one of the important factors in the failure of ACL reconstruction [4-6]. Unrecognized and fail to reconstruction of PLC might result in graft failure poor and clinical outcomes. Therefore, it is useful for PLC reconstruction to decrease the risk of cruciate ligaments reconstruction failure [7-9]. Cartwright-Terry et al [10] reported combined ACL-PLC injuries had greater morbidity than isolated ACL injuries. It is possible for sporting and returning to work after surgery. Kim et al [6] also did not identify significant differences between the ACL-PLC and isolated ACL injuries in terms of functional outcomes. However, combined ACL-PLC reconstruction allows less anterior translation than isolated ACL reconstruction.

In some cases, there was an injury model that only external rotation laxity without lateral collateral ligament (LCL) injured combined ACL

Table 1. Demographic data for patients

Variable	Study group	Control group	*P* value
Age	28.3±5.9	29.2±6.2	0.671
Male/female	19/13	28/22	0.763
Left/right	15/17	23/27	0.938
Duration from injury to operation (wk)	7.2±3.3	6.9±2.8	0.630
Mechanism of injury			
Traffic accident	16	26	
Sports injury	13	18	
Fall down	3	6	
Duration of follow-up (mo)	65.3±7.3	63.1±6.9	0.732

rupture. Popliteus tendon (PT) injuries were found in up to 68% of patients operated on for PLC instability, which frequently occurred with injuries to other ligaments. In cadaveric studies, LaPrade et al [11] reported isolated PT reconstruction could reduce the increase in external rotation. Zhang et al [12] reported the isolated popliteofibular ligament (PFL) reconstruction technique was able to restore external rotation to near normal.

To our knowledge, there have been no reports to compare the knee function and external rotation stability on combined ACL and PT reconstruction with those of isolated ACL reconstruction. The authors hypothesized that whether combined ACL and PT reconstruction would significantly improve knee function and restore external rotation stability. The purpose of this study was to evaluate the influence of PT reconstruction on ACL reconstruction in terms of external rotation laxity and clinical outcomes with tibialis anterior allograft.

Materials and methods

Between September 2005 and December 2008, 32 consecutive patients with combined ACL and PLC injuries who underwent the combined ACL-PT reconstruction with tibialis anterior allograft were studied retrospectively. The study group comprised 19 men and 13 women, aged from 19 to 38 years. Follow-up periods ranged from 59 to 70 months. The authors randomly selected 50 patients who underwent isolated ACL reconstruction during the same operative period as the control group. The control group comprised 28 men and 22 women. The follow-up period ranged from 56 to 72 months and their ages from 20 to 33 years (**Table 1**).

To meet the inclusion criteria, all patients have a carefully physical examination. All patients had a preoperative magnetic resonance imaging (MRI) scan. Patients were excluded from the study if they had received previous injury or surgery on the affected knee, an intraarticular fracture, malalignment, or abnormal contralateral knee function. Patients with varus laxity was also excluded from the present study.

The study was approved by Ethics Committee of The Third Hospital of Hebei Medical University. Signed informed consent was obtained from each patient. All of the patients were informed that they were going to be in this study, who did not wish to participate in this study were not enrolled. No child was included in this study.

Surgical technique

All operative procedures were performed by single surgeon. Deep-frozen human tibialis anterior allografts were used in all of the patients. Both tendons were sutured with a No. 5 nonabsorbable Ethibond suture (Ethicon, Somerville, NJ).

Technique for ACL reconstruction

For the tibial side, the tibial guide pin was located at the footprint of the natural ACL insertion site. Then, tibial tunnel preparation using a drill guide within the center of the ACL insertion. For the femoral side, the guide wire was located at the center of the femoral ACL insertion site and then drilled into the lateral femoral condyle at the 10 o'clock for the right knee or 1:30 o'clock on the left knee. Graft was fixed by Retro Button (Arthrex, REF, AR) in the femoral side and bioabsorbable screws (Arthrex, REF, AR) in the tibial side at 10° to 20° of flexion.

Technique for PT reconstruction

For the tibial side, the guide pin was drilled from a point distal and medial to the Gerdy tubercle, exiting at the posterior tibial popliteus sulcus at the approximately 10 mm distal to the margin of the articular cartilage. Then the guide pin was drilled with cannulated reamer for the PT. For the femoral side, the guide pin was drilled into the center of the PT attachment site, aim-

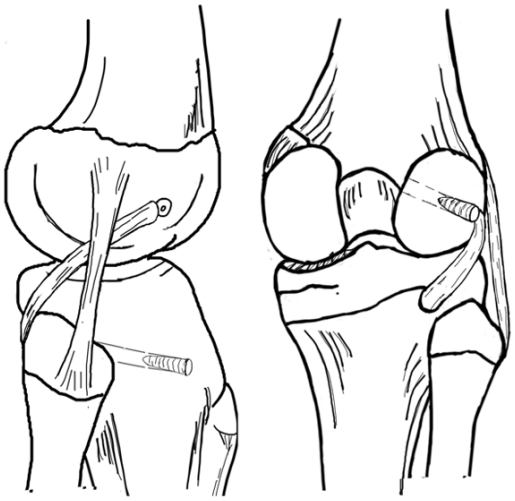

Figure 1. Technique of PT reconstruction.

ing in an anteromedial direction through the distal femur. The graft was fixed within the femoral site with a bioabsorbable screw (Arthrex, REF, AR). Then, the graft was fixed within the tibial tunnel with a bioabsorbable screw (Arthrex, REF, AR) at 10° to 15° of knee flexion (**Figure 1**).

Rehabilitation

Isolated ACL reconstruction: All patients in control group with (ACL reconstruction) started isometric quadriceps-strengthening exercises and range of motion of the knee at the day after the surgery. Full weight bearing and knee flexion of more than 90° was allowed 4 weeks postoperatively. Patients were told to use the brace until the third month. Sports activity was allowed at 1 year after the surgery.

Combined with ACL-PT reconstruction: All the patients in study group (combined with ACL-PT reconstruction) started isometric quadriceps-strengthening exercises immediately after surgery. Passive range-of-motion exercises usually were started on the third postoperative day. Until 4 weeks after surgery, weight bearing was allowed and gradually increased. Closed-chain kinetic exercises started at 6 weeks after surgery. Full weight bearing and knee flexion of more than 90° was allowed 8 weeks postoperatively. At 1 year after surgery, return to full activity was allowed.

Evaluation criteria

Clinical data were collected preoperatively and at the time of the 60 month follow-up. When the follow-up was longer than 5 years, the last data available were used for statistical analysis. Examination of knee laxity included the Lachman test, anterior drawer test (ADT), pivot-shift test, reverse-pivot-shift and dial tests at 30° and 90° of knee flexion. Instrumented anterior-posterior laxity of the affected side and side-to-side differences were measured with the KT-1000 arthrometer (MEDmetric, San Diego, CA). The Lysholm score, Tegner activity score, and International Knee Documentation Committee (IKDC) evaluation (both objective and subjective) were completed preoperatively and at each follow-up evaluation for the functional outcomes. All of the examinations were performed by the senior physicians twice at each time point, both of whom were blinded to the clinical findings (**Figure 1**).

Statistical analysis

SPSS software (Version 17.0; SPSS Inc,) was used for statistical analysis. The Mann-Whitney U test was used to compare the 2 groups in terms of demographic data (age, Injury-to-operation and follow-up duration), mean side-to-side differences as shown on the KT-1000 arthrometer, dial test Lysholm score, Tegner activity score, and IKDC subjective knee evaluation; the X-square test was used for comparing the sex distribution, IKDC knee classification, Lachman test, ADT and pivot-shift test between the groups; the paired t test was used to compare the preoperative and postoperative differences in results. In all analysis, significance was defined as $P<0.05$. Results were presented as mean ± standard deviation.

Result

There were no statistically significant differences between the 2 groups in age, Injury-to-operation and follow-up duration ($P<0.05$). No major neurologic, vascular, or wound complications had been found. No patient needed additional surgery because of recurrent or residual posterolateral laxity. The causes of injuries in study group were traffic accident in 16 cases (50%), sports injury in 13 cases (41%), and fall in 3 cases (9%). The corresponding figures in control group were 26 cases (52%), 18 cases (36%), and 6 cases (12%).

When the preoperative values were compared with the values at the last follow-up, both groups demonstrated significant decreased from 6.8±1.2 to 2.0±0.8 in study group and

Table 2. Comparison of clinical variables between study and control group at the Final Follow-up

Variable	Study group		Control group	
	Preoperative	Last Follow-Up	Preoperative	Last Follow-Up
Lysholm score	59.3±9.8*	90.1±9.2†	65.4±8.7*	91.5±10.3†
Tegner activity score	3.1±0.7	6.1±0.9†	3.3±1.1	6.5±1.2†
IKDC subjective score	56.2±11.3	86.3±10.1†	58.6±12.3	88.6±12.3†
Anterior translation (mm)	6.8±1.2	2.0±0.8†	6.1±1.7	1.7±0.5†

†Significant difference between baseline and the last follow-up after surgery; P<0.05. *Significant difference between Study and Control groups; P<0.05.

Table 3. Comparison of rotational and anterior stability of operated knees at the final follow-up

	Study group	Control group	*P* value
IKDC objective grade			0.632
A	11	16	
B	18	30	
C	2	4	
D	1	0	
Lachman test			0.434
Grade 0	23	42	
Grade I	6	6	
Grade II	2	2	
Grade III	1	0	
Pivot shift test			0.467
Grade 0	21	39	
Grade I	8	8	
Grade II	3	3	
Grade III	0	0	
ADT			0.453
Grade 0	23	43	
Grade I	5	6	
Grade II	2	1	
Grade III	0	0	

from 6.1±1.7 to 1.7±0.5 in control group in terms of anterior translation from the preoperative mean values (P<0.05). However, there was no difference between the 2 groups.

With regard to Lysholm and Tegner activity scores, both groups showed statistically improvements at the last follow-up. The mean preoperative Lysholm score was 59.3±9.8 in study group and 65.4±8.7 in control group. At the last follow up, the scores improved significantly to 90.1±9.2 and 91.5±10.3, respectively. The mean Tegner activity score improved from 3.1±0.7 to 6.1±0.9 in study group and from 3.3±1.1 to 6.5±1.2 in control group. The IKDC subjective knee evaluation score was 56.2±11.3 preoperatively and 86.3±10.1 postoperatively in study group and 58.6±12.3 preoperatively and 88.6±12.3 postoperatively in control group (**Table 2**).

At the last follow-up, 29 patients (90.6%) in the study group and 46 patients (92.0%) in the control group had an IKDC knee classification of A or B. There was no significant difference between the 2 groups. In study group, the dial test at 30° and 90° of knee flexion had significantly decreased from 16.0°±2.3° to 4.6°±2.1° and from 12.7°±2.3° to 3.8°±2.3° at the last follow-up, respectively (P<0.05). At the final follow-up, there were 30 patients showed negative on the reverse pivot-shift test. According to the pivot shift test, ADT, and the Lachman test, no significant differences were found when comparing the study group to the control group according to the tests mentioned above (**Table 3**).

Discussion

The purpose of this study was to analyze the clinical effect of the reconstructed PT in combined ACL and PLC injuries in terms of the external rotation laxity and clinical results with tibialis anterior allograft. This study compared the clinical results between combined ACL and PLC injuries (study group) and isolated ACL injuries (control group). It had hypothesized combined ACL-PT reconstruction would be able to restore anterior translation and external rotation to near normal. The most important finding of the present study was that combined ACL-PLC injuries could be successfully treated by ACL reconstruction combined with reconstruction of PT.

It had demonstrated that the PLC interact functionally with the cruciate ligaments. Combined injuries present less satisfactory results than

isolated injuries. In addition, untreated PLC injuries had been implicated in ACL and PCL reconstruction graft failures. Therefore, it recommended that PLC reconstructed should been done at the time of ACL reconstruction. Dhillon et al [13] found conservative treatment for the patients with concomitant Type B PLC injury, which was graded according to the Fanelli classification, adversely affected the results of ACL reconstruction. Type A PLC injuries showed well without surgery and could be left even when associated with a concomitant ACL tear. Lee et al [14] reported combined chronic ACL-PLC instabilities could be successfully treated by ACL reconstruction combined with reconstruction of the PLC structures. Kim et al [6] demonstrated that combined ACL-PLC reconstruction allowed less anterior translation than isolated ACL reconstruction. However, they did not identify significant differences between the two groups in terms of functional outcomes. In these studies, the posterolateral stability after combined ACL-PLC reconstruction was no difference compared to that obtained when patients with isolated ACL injuries treated by ACL reconstruction. In the current study, patients with isolated ACL injuries did slightly better than those combined ACL-PLC injuries as evaluated using the functional scores at the last follow up. However, there was no statistically significant differences between the 2 groups.

Many techniques of PLC reconstruction had been attempted which did not present satisfactory results. Following anatomy and biomechanical studies, it has been shown that PT, PFL and LCL to be the key static stabilizing structures of the PLC. Pasque et al [15] had demonstrated that the PT, PFL, LCL and posterolateral capsular structures function as a unit, which suggested all of these should be reconstruction during the surgery. Zhang et al [12] studied the LCL-intact PLC injury model and suggested the PFL reconstruction technique was able to restore external rotation to near normal. However, in their study, the techniques involving PT reconstruction over constrained external rotation during laxity testing. LaPrade et al [11] indicate that the major ligament-like role of the PT within the knee is as a primary stabilizer to external rotation. An anatomic PT reconstruction can restore external rotation stability to knees with popliteus tendon injury. They also found increases in anterior translation near extension of between 1.5 and 2.6 mm after cutting the PT compared with the intact state, which suggested PT reconstruction was useful for restoring anterior translation stability. In the present study, our PT reconstruction technique significantly decreased external rotation laxity compared to the PLC injuries, which were able to restore its function to the knee. Furthermore, it is important to place the graft of PT during the reconstruction a more favorable alignment for resisting external tibial rotation compared with the native PT.

Limitation

There are a few limitations in this study. There was lack of another control groups of patients who were treated by double bundle ACL reconstruction technique or different PLC reconstruction technique. Whether double bundle technique would show better clinical results compared to single bundle technique to restore the external rotation stability. No instruments had been used to measure the external rotatory instability with the dial test compared to measure anterior translation with KT-1000. Furthermore, since this study was a retrospective trial, prospective multiple-center studies and long-term data are needed to be assessed.

Conclusion

In conclusion, the results of combined ACL-PT reconstruction showed as excellent as the isolated ACL reconstruction. Furthermore, the results of the medium-term study indicate that both anteroposterior and external rotation laxity could be improved by combined ACL-PT reconstruction.

Disclosure of conflict of interest

None.

Authors' contribution

JL carried out the conception and design of the study and acquisition and interpretation of data, and drafted the manuscript. XG and SH participated in imaging analysis and carried out the acquisition and interpretation of data. SG revised the manuscript critically for important intellectual content and gave final approval of the version to be published. All authors read and approved the final manuscript.

Address correspondence to: Dr. Jia Li, Department of Orthopaedic Surgery, The Third Hospital of Hebei Medical University, Shijiazhuang 050051, P. R. China; The Key Laboratory of Orthopedic Biomechanics of Hebei Province, The Third Hospital of Hebei Medical University, Shijiazhuang 050051, P. R. China. Tel: +86-311-88602016; Fax: +86-311-88602316; E-mail: ljlyqbwin2010@yeah.net

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