Midterm Outcomes After Revision Posterior Cruciate Ligament Reconstruction With a Single-Bundle Transtibial Autograft

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Background: There is a lack of consensus regarding the optimal technique for revision posterior cruciate ligament (PCL) reconstruction.

Purpose: To evaluate midterm outcomes after revision PCL reconstruction using a single-bundle transtibial autograft.

Study Design: Case series; Level of evidence, 4.

Methods: We reviewed 17 patients who underwent revision PCL reconstruction performed in our medical center by a single surgeon from 2003 to 2016. The cohort included 12 male and 5 female patients with a mean age of 31.3 years (range, 17-48 years). All of the patients underwent single-bundle transtibial reconstruction using the same surgical technique and were reviewed at a minimum of 4 years postoperatively. Preoperative and postoperative posterior stress radiography was performed. The preoperative tibial slope and tibiofemoral angle were also measured. Preoperative and postoperative functional outcomes were evaluated using the International Knee Documentation Committee (IKDC) subjective and objective scores as well as the Lysholm score.

Results: The most common factor that contributed to the failure of primary surgery was misplaced tunnels, especially on the femoral side. There were 2 patients who had grade 2 laxity preoperatively, and 15 patients had grade 3 laxity preoperatively. At the latest follow-up, all 17 patients had grade 1 laxity. On posterior stress radiography, posterior displacement improved from 10.8 $\pm$ 2.1 mm preoperatively to 2.9 $\pm$ 1.1 mm at the latest follow-up ($P < .001$). The IKDC subjective score improved from 34.9 $\pm$ 6.8 preoperatively to 75.3 $\pm$ 15.7 postoperatively ($P < .001$), and the Lysholm score improved from 38.1 $\pm$ 10.0 preoperatively to 88.5 $\pm$ 7.6 postoperatively ($P < .001$). All patients reached the minimal clinically important difference (MCID) for the Lysholm score, and 94% reached the MCID for the IKDC subjective score, with 65% reaching the Patient Acceptable Symptom State.

Conclusion: According to the findings of this study, arthroscopic revision PCL reconstruction with a single-bundle transtibial autograft offered satisfactory outcomes at midterm follow-up.

Keywords: posterior cruciate ligament; PCL; revision; failure; knee; single-bundle; transtibial

Anatomically, the posterior cruciate ligament (PCL) has been thought to consist of 2 bundles. Historically, the larger anterolateral bundle was believed to function predominantly in flexion and the posteromedial bundle primarily in extension. However, recent biomechanical studies have shown the codominance of the 2 bundles at all degrees of knee range of motion.[13,28] Therefore, primary PCL reconstruction with the double-bundle technique seemed to offer better biomechanical stability and superior fixation.[28] However, recent randomized controlled trials and cohort studies based on clinical subjective and objective patient outcomes demonstrated that both single- and double-bundle techniques are comparable in improving knee function.[9,16,18,27,28,31,32]

A review of the literature showed that the failure rate of primary PCL reconstruction is approximately 11.6% (2.5%-30%).[7] The most common reasons for failure were uncorrected posterolateral corner (PLC) injuries, misplaced femoral or tibial tunnels, and tunnel widening.[17,22] Compared with primary PCL reconstruction, revision PCL reconstruction is more complicated, and its outcomes tend to be less satisfactory.[6,17] However, in a recent retrospective study on revision PCL reconstruction, it seemed that using the double-bundle tibial inlay technique potentially provided stable fixation.[17,22] Nevertheless, because of less graft choice and tissue fibrosis during revision surgery, the double-bundle technique is difficult in this situation.

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The purpose of our study was to evaluate the outcomes of revision PCL reconstruction using the single-bundle transtibial technique at midterm follow-up.

METHODS

Study Design and Patient Selection

The protocol for this study was approved by our hospital ethics committee. We conducted a retrospective review of 25 patients who underwent revision PCL reconstruction by a single surgeon (Y.S.C.) at our medical center from 2003 to 2016. One of these patients had undergone double-bundle transtibial reconstruction, and another 7 patients were lost to follow-up. Therefore, 17 patients, all with a minimum follow-up of 4 years, were included.

All of the included patients had reported instability, weakness, and intermittent swelling of the knee joints from daily or athletic activities after primary PCL reconstruction. These patients had undergone nonoperative treatment of physical therapy or muscle strengthening for at least 3 months with no improvement. Laxity was graded by thorough physical examinations performed by at least 2 experienced orthopaedic surgeons and posterior stress radiography (TELOS device at 90° of knee flexion). All patients had undergone preoperative magnetic resonance imaging of the knee to evaluate the PCL graft substance and position, along with meniscal and collateral ligament evaluations. The mean age of the study patients was 31.3 years (range, 17-48 years). The mean duration from primary surgery to revision surgery was 45 months (range, 6-110 months), and the mean follow-up time was 11.5 years (range, 4-17 years). Other demographic data are shown in Table 1.

TABLE 1
Demographic Characteristics (N = 17)

	Value
Sex, male/female, n	12/5
Side of surgery, left/right, n	8/9
Age, y, mean (range)	31.3 (17-48)
Follow-up time, y, mean (range)	11.5 (4-17)
Time from primary surgery to revision surgery, mo, mean (range)	45 (6-110)
Graft type, n (%)	
Hamstring tendon	9 (52)
Peroneus longus tendon	4 (24)
Quadriceps tendon	4 (24)

Surgical Technique and Rehabilitation

All patients included in our study underwent the same surgical technique. First, a complete arthroscopic examination of the knee was performed. Previous bone screws were removed first if they interfered with the targeted position; however, in our cohort, no tibial tunnel interference occurred. All patients underwent single-bundle PCL reconstruction with autologous tendon grafts from the same leg. The graft selection for all 17 patients depended on primary PCL surgery. We preferred autografts of the ipsilateral hamstring tendon if it was still preserved. Overall, 9 patients received ipsilateral hamstring tendon autografts in our study. An ipsilateral peroneus longus or quadriceps tendon graft was used if the ipsilateral hamstring tendon was used previously in the primary PCL surgery. The grafts were quadrupled, sized, and pretensioned with 15 lb of force for 15 minutes on a tension device before use. The previous PCL graft and remnants were preserved, and minimal debridement was performed to gain access to the insertion sites.

For the femoral tunnel, we targeted the anatomic point of the anterolateral bundle using the trochlea as a landmark. A 25 mm– to 30 mm–deep femoral tunnel was created with a graft size–matched reamer using the transportal technique. For the tibial tunnel, we routinely created posteromedial and posterolateral portals before creating the tibial tunnel. A tibial guide pin was placed 1.0 cm medial to the tibial tuberosity and 4.0 cm below the medial joint line and exited posteriorly 1.0 cm below the articular surface of the medial tibial plateau, keeping close to the ligament insertion site.[21] The tibial tunnel was created over the guide pin with a graft size–matched reamer. Both sides of the graft were fixed with an interference screw (BIOSURE HA Interference Screw; Smith & Nephew).[3,10,25,30]

Chondral lesions were diagnosed arthroscopically and treated with either debridement (grades 0-2) or microfracture (grades 3-4) according to the Outerbridge classification. Partial meniscectomy or meniscal repair was performed if a meniscal injury was noted. After the completion of PCL reconstruction, the laxity of the PLC was

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reassessed to determine whether any drive-through sign remained.

Postoperatively, all patients wore a knee brace fixed at 0° to 30° during the first 2 weeks, and passive knee motion was gradually increased from 0° to 60° from the third week and from 0° to 90° from the fifth week according to the knee's rigidity and patient tolerance. All of the study patients were able to achieve passive knee motion to 90° in the sixth week. The goal was to regain full knee movement by 24 weeks postoperatively. At 3 months, patients typically returned to their normal daily activities and were allowed to exercise on a stationary bicycle and stand on a single leg. Light sports activities began at 6 months. After 12 months, full activity, including athletic activities, was permitted.

Evaluation Methods

Preoperative knee imaging included radiography and magnetic resonance imaging with measurements of the tibial slope and tibiofemoral angle. Knee functional outcomes and stability were assessed preoperatively using the International Knee Documentation Committee (IKDC) subjective and objective scores and the Lysholm score. Knee stability was assessed by an independent orthopaedic surgeon from our institution who had not been involved in the surgical procedure, using the following examinations: posterior stress radiography (TELOS device at 90° of knee flexion), posterior drawer test at 90°, posterolateral drawer test, reverse pivot-shift test, and varus stress test at 0° and 30° preoperatively. Results from the posterior drawer test at 90° were recorded on a scale from 1 to 3 according to the degree of translation (grade 1, <5 mm; grade 2, 5-10 mm; and grade 3, >10 mm). We also analyzed the probable causes of primary PCL reconstruction failure on preoperative imaging and the arthroscopic examination. We used previously published criteria.[17,22] Tunnel widening was defined as an increase of >50% in the area of the tunnel, and tunnel misplacement was defined as ≥75% of the tunnel width outside the normal anatomic attachment of the femur or tibia.[5,20,24]

Postoperatively, knee stability was examined at 3-month follow-up with posterior stress radiography and physical examinations as performed preoperatively. Functional outcomes (IKDC subjective and objective scores and Lysholm score) were recorded at 1, 3, and 6 months postoperatively and every 12 months thereafter. The clinical relevance and significance of the postoperative functional outcomes were assessed using the minimal clinically important difference (MCID) and Patient Acceptable Symptom State (PASS) for the IKDC subjective and Lysholm scores (Table 2).[8]

Statistical Analysis

The Shapiro-Wilk test was performed to compare preoperative and postoperative differences; it showed a value smaller than 0.05, which indicated a nonnormal distribution. Therefore, we used the Wilcoxon signed-rank test for statistical analysis. All statistical analyses were performed using SPSS for Mac (Version 23.0; IBM). The level of statistical significance was set at $P < .05$.

TABLE 2
Defined MCID and PASS Values for Outcome Measures[a]

	MCID	PASS
Lysholm score	8.9	NA
IKDC subjective score	16.7	75.9

[a]IKDC, International Knee Documentation Committee; MCID, minimal clinically important difference; NA, not available; PASS, Patient Acceptable Symptom State.

RESULTS

Knee Stability

On the preoperative posterior drawer test at 90°, 15 patients (88%) exhibited grade 3 knee laxity, and 2 patients (12%) showed grade 2 knee laxity. Preoperative knee radiography showed a femorotibial angle with genu valgum of 1.8° ± 5.1° and a tibial posterior slope of 9.8° ± 4.9°. On posterior stress radiography, posterior displacement improved from 10.8 ± 2.1 mm preoperatively to 2.9 ± 1.1 mm at the latest follow-up ($P < .001$). All patients showed stable grade 1 knee laxity at the latest follow-up.

Primary PCL Reconstruction Failure

Table 3 lists the factors related to the failure of primary PCL reconstruction in the study patients. Failure due to a single factor was only noted in 4 patients, and the remaining 13 patients appeared to experience multiple factors. The most common cause of failure was misplaced tunnels. In particular, femoral tunnels that were too posterior and proximal under arthroscopic examination were noted in 7 patients. The reason for failure was widening of the tunnel in 3 patients, and all of them underwent 1-stage revision with an allograft.

Intraoperative Findings and Complications

Injuries found during revision PCL reconstruction are listed in Table 4. There were 2 patients who sustained posterolateral rotatory instability and underwent further reconstruction. We observed 2 patients with a grade 1 chondral injury, and 1 patient had grade 2 patellofemoral arthritis intraoperatively. Radiography at the latest follow-up showed no early or aggravated osteoarthritis changes. No major complications were noted intraoperatively or postoperatively.

Clinical Outcomes

Functional outcomes are provided in Table 5. The mean IKDC subjective score improved significantly from 34.9 ± 6.8 preoperatively to 75.3 ± 15.7 postoperatively

TABLE 3
Factors Related to Failure of Posterior Cruciate Ligament Reconstruction[a]

	Single Factor	Multiple Factors	Total
Deficiency of other ligaments			
Posterolateral corner or lateral collateral ligament	0	2	2
Anterior cruciate ligament	0	1	1
Varus osseous malalignment	0	5	5
Rupture of synthetic graft	0	4	4
Tunnel widening	0	3	3
Misplaced tunnel			
Femoral tunnel	0	7	7
Tibial tunnel	0	2	2
Meniscal injury	2	4	6
Failure of revascularization	2	3	5
Total	4	31	35

[a]Data are reported as No.

TABLE 4
Associated Injuries Found Intraoperatively

	n (%)
Posterolateral corner injury	2 (12)
Meniscal injury	
Medial	3 (18)
Lateral	2 (12)
Both	1 (6)
Anterior cruciate ligament injury	1 (6)
Patellofemoral arthritis	1 (6)
Cartilage lesion	2 (12)

($P < .001$), and the mean Lysholm score improved significantly from 38.1 ± 10.0 preoperatively to 88.5 ± 7.6 postoperatively ($P < .001$). Regarding the preoperative IKDC objective score, 11 patients (65%) were classified as D (severely abnormal), and 6 patients (35%) were classified as C (abnormal). At the latest follow-up, 5 patients (29%) were classified as A (normal), 8 patients (47%) were classified as B (nearly normal), and 4 patients (24%) were classified as C (abnormal). Therefore, 77% of patients had a score of at least B (nearly normal) at the latest follow-up. With respect to the MCID, all patients showed an improvement in the Lysholm score, exceeding 8.9 points, and 16 patients (94%) exhibited an improvement in the IKDC subjective score, exceeding 16.7 points. Regarding the PASS, none of the patients had an IKDC subjective score >75.9 preoperatively, whereas 11 patients (65%) had an IKDC subjective score >75.9 postoperatively. Overall, 14 patients returned to their normal daily activities with full knee movement, whereas 3 patients still had difficulty performing a full squat and full flexion and extension at the latest follow-up.

DISCUSSION

Despite the small sample size, the significant improvements in patients' subjective and objective clinical outcomes in this study are promising, suggesting that arthroscopic revision PCL reconstruction using the single-bundle transtibial technique could restore satisfactory function.

This study included 17 patients who underwent revision surgery. We found that primary PCL reconstruction failed because of multiple factors, with the most common cause being misplaced femoral tunnels (n = 7 [41%]). Further risk factors identified in our study included varus osseous malalignment, meniscal injuries, tunnel widening, and ruptures of the synthetic graft. Similar studies have reported the failure of primary PCL reconstruction to be related to multiple factors,[2,11,12,17,22,23] including lower limb genu varum, tunnel widening, misplaced tunnels, associated ligament injuries, prior meniscectomy, postoperative rehabilitation, and articular cartilage damage. However, the 2 most common causes according to previous studies were associated PLC injuries and improper tunnel placement.[17,22] In our study, only 2 patients experienced a PLC injury.

Jauregui et al[12] stated that the most common concomitant procedure with revision PCL reconstruction was a PLC procedure (71%). A PLC injury is often associated with a PCL injury. Deficiency of the PLC increases the strain of the PCL and often causes PCL reconstruction failure.[19,26] Lee et al[17] reported that revision PCL reconstruction using the modified double-bundle tibial inlay technique offers good knee stability. However, we noted that in the study by Lee et al,[17] 17 of 22 patients sustained a lateral collateral ligament or PLC injury. In our study, only 2 of 17 patients had a PLC injury and simultaneously underwent reconstruction. In our study, it seemed that patients who underwent revision PCL reconstruction without an accompanying PLC injury exhibited good results with the single-bundle transtibial technique. It remains to be seen whether the technique is appropriate for patients with PLC deficiency.

A systematic study showed that the failure rate of primary PCL reconstruction is approximately 11.6% (2.5%-30%).[7] Given that primary PCL reconstruction offers satisfactory outcomes and that not all patients are eligible

TABLE 5
Functional Outcomes[a]

	Preoperative	Postoperative	*P* Value
IKDC subjective score	34.9 ± 6.8 (21.4-44.8)	75.3 ± 15.7 (32.2-90.8)	**<.001**
Lysholm score	38.1 ± 10.0 (13-52)	88.5 ± 7.6 (68-100)	**<.001**
IKDC objective score, n (%)			
A (normal)	0 (0)	5 (29)	
B (nearly normal)	0 (0)	8 (47)	
C (abnormal)	6 (35)	4 (24)	
D (severely abnormal)	11 (65)	0 (0)	

[a]Data are reported as mean ± SD (range) or n (%). Boldface *P* values indicate a statistically significant difference between preoperatively and postoperatively ($P < .05$). IKDC, International Knee Documentation Committee.

for revision surgery, revision PCL reconstruction is very rare. Moreover, revision PCL reconstruction is a very difficult procedure because the anatomic landmark of the PCL might have been altered by primary surgery, and bone tunnel widening or a neurovascular injury represents possible deleterious effects. Graft choices for revision PCL reconstruction are also less available. Therefore, the currently available methods for the selection of an appropriate surgical technique and graft for revision surgery are lacking.

There have been 2 previous studies on revision PCL reconstruction that used the double-bundle technique. Lee et al[17] and Noyes and Barber-Westin[23] both recommended using the double-bundle tibial inlay technique for PCL revision cases. For graft selection, Noyes and Barber-Westin[23] preferred autogenous quadriceps tendon grafts, while Lee et al[17] used Achilles tendon allografts. However, the tibial inlay technique is surgically difficult, technically demanding, and associated with more serious surgical risks.[10] Winkler et al[29] reported that the all-arthroscopic transtibial technique is less surgically demanding and can reduce the operative time. Thus, the complication risk is reduced. However, the transtibial technique has the problem of repetitive friction between the graft and tunnel inlet, which is known as the "killer turn" effect. Therefore, we advocate for preservation of the primary PCL graft remnant. Chun et al[4] stated that remnant preservation may spare mechanoreceptors and maintain proprioception, which leads to better functional outcomes. Moreover, studies have shown that remnant tissue promotes graft healing by inducing revascularization.[1,4,14,15]

Limitations

There are some limitations to our study. First, this is a retrospective case series (level 4 evidence) with a small sample size. In addition, a control group was not included in this study. However, all surgical techniques were standardized and performed by only 1 experienced surgeon at our medical center. Moreover, at least 2 experienced orthopaedic surgeons performed all physical examinations and reviewed the images. Multiple knee measures were used to evaluate patients' clinical subjective and objective outcomes. Because revision PCL reconstruction is an uncommon surgical procedure, an increased number of participants should be included in future studies. Second, we included 2 patients who underwent concurrent PLC reconstruction in our study. Including different surgical procedures in the same study could make an interpretation of the results more difficult. However, in these patients, we still performed single-bundle PCL reconstruction with the old graft remnant left (plus PLC reconstruction).

CONCLUSION

The findings of this study indicate that revision PCL reconstruction with the single-bundle transtibial technique offered satisfactory outcomes at midterm follow-up.

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