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Combined PCL and PLC Reconstruction Improves Residual Laxity in PCL Injury Patients with Posterolateral Knee Laxity Less Than Grade III

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Purpose: To compare the short-term clinical and radiologic outcomes of combined posterior cruciate ligament (PCL) and posterolateral complex (PLC) reconstruction to those of isolated PCL reconstruction (PCLR) for patients with posterolateral knee laxity less than grade III.

Materials and Methods: We retrospectively reviewed 49 patients (51 knees) who underwent PCLR between January 2008 and December 2015. Patients with a minimum follow-up of 24 months were included and divided into two groups (group A, isolated PCLR; group B, combined PCL and PLC reconstruction). Clinical outcomes were evaluated as the International Knee Documentation Committee (IKDC) subjective, Lysholm, and Tegner activity scale scores. Radiologic outcomes were also assessed using the side-to-side differences in posterior tibial translation via stress radiographs.

Results: A total of 30 cases were analyzed. There were no significant differences in the Lysholm and Tegner activity scale scores between the two groups preoperatively and at the final follow-up. However, group B showed a higher IKDC subjective score compared to group A at the final follow-up (group A, 72.8±8.9; group B, 77.7±10.1; $p<0.05$). Regarding the radiologic outcomes, group B also showed a significantly less side-to-side difference in posterior tibial translation compared to group A at the final follow-up (group A, 4.8±2.3 mm; group B, 3.8±2.1 mm; $p<0.05$).

Conclusion: Combined PCL and PLC reconstruction resulted in improved clinical and radiologic outcomes than isolated PCLR in patients who have less than grade III posterolateral laxity of the knee. In cases of PCL rupture with ambiguous PLC injury, combined PCL and PLC reconstruction may help to improve posterior residual laxity of the knee.

Key Words: Knee, posterior cruciate ligament, posterolateral complex, posterolateral rotatory instability

INTRODUCTION

Posterior cruciate ligament (PCL) injuries account for 38% of knee injuries and rarely occur in isolation, and up to 95% of PCL tears are associated with other ligament tears.[1] In general, surgical treatment is recommended for symptomatic complete PCL rupture and combined PCL injury with another ligament rupture.[1] One of the most common causes of unsatisfactory results after PCL reconstruction (PCLR) is the failure to identify other injured structures, such as the posterolateral complex (PLC).[2]

The PLC of the knee is important for stabilizing structures in the varus and rotational stability through all ranges of motion and the PLC interacts synergistically with the PCL to limit posterior translation and external rotation.[3-5] Although PCL injuries can be diagnosed clinically[4] and by using magnetic resonance imaging (MRI),[5] PLC injuries can be frequently overlooked or misdiagnosed.[2,6] Undiagnosed PLC injuries are not only a cause of chronic pain and chronic posterolateral rotatory instability but also a major cause of the failure of PCLR.[3,4,6]

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Recent biomechanical studies have reported that isolated PCLR, whether single- or double-bundle, could not fully restore the normal knee kinematics in PCL/PLC-deficient knees.[4,6-9] In such cases, residual laxity after isolated PCLR can be controlled successfully with PLC reconstruction.[3,8-10] Grade II posterior translation PCL injuries accompanied by PLC insufficiency treated by reconstruction of both structures have shown good clinical outcomes.[11,12] However, as mentioned above, accompanying PLC injuries can be frequently overlooked or misdiagnosed. As the assessment of the degree of posterolateral knee laxity relies on physical examination, the results may sometimes be inaccurate or ambiguous between grades II and III. Furthermore, there may be cases where the physical examination for posterolateral knee laxity is not accurately performed due to pain, despite severe PLC injuries corresponding to grade III. Nevertheless, few studies investigated whether surgical treatments are advisable for ambiguous PLC injuries with posterolateral knee laxity less than grade III for patients with PCL injuries. Considering that inadequate treatment for posterolateral knee laxity accounts for a significant portion of the causes of PCLR failure, an investigation of the appropriate treatment for patients with PCL injuries accompanied by ambiguous PLC injuries is required.

The present study aimed to retrospectively compare the clinical outcomes and radiologic outcomes after isolated single-bundle PCLR and combined single-bundle PCL and PLC reconstruction in patients who have less than grade III posterolateral laxity of the knee. We hypothesized that combined PCL and PLC reconstruction could improve the clinical outcomes and radiologic outcomes.

MATERIALS AND METHODS

Patients selection and evaluation

Ethical approval was obtained from the National Health Insurance Service Ilsan Hospital's Institutional Review Board (NHIMC 2022-07-004). We retrospectively reviewed 49 patients (51 knees) who underwent PCLR between January 2008 and December 2015. PCLR was performed in case of symptomatic grade III PCL tears. For patients who were considered to have PLC injuries of less than grade III in addition to PCL injuries, an isolated PCLR was performed from 2008 to 2011, and combined PLC reconstruction was performed since 2012. All patients underwent MRI and Telos posterior stress radiography of the knee (Fig. 1). In addition, the patients underwent a dial test of 30° and 90° flexion for both knees preoperatively (Fig. 2). Of the patients reviewed, patients with a minimum follow-up of 24 months were eligible for inclusion in the study. The exclusion criteria were as follows: 1) more than 10° of dial test in 30° flexion of the knee joint, 2) definite PLC injury in MRI, 3) concomitant ligament injuries other than the PCL, 4) previous surgical history on the affected knee, 5) instability of the bilateral knee, 6) PCL avulsion fracture, 7) severe meniscal injury requiring subtotal or total meniscectomy, or 8) inadequate follow-up duration of fewer than 24 months (Fig. 3).

We assessed the patients' age, sex, body mass index, and duration from injury to surgery. We used the International Knee Documentation Committee (IKDC) subjective, Lysholm, and Tegner activity scale scores at the preoperative time and the final follow-up to compare the clinical outcomes. Knee laxity was assessed using side-to-side differences in the posterior tibial laxity, as shown on stress radiographs at the preoperative time and the last follow-up.

We checked the Intraclass Correlation Coefficients (ICC) to identify the agreement degree during radiologic evaluation. Three independent observers measured posterior laxity in stress x-ray. The average value of the measurements was used for evaluation.

Surgical procedure

All operations were performed in the same procedure by one surgeon. PCLR was performed via the anterolateral transtibial single-bundle PCLR using a 1-incision technique.[12] To reconstruct the PCL more conveniently, three unique portals were used: a high medial parapatellar portal, a far anterolateral portal, and a high posteromedial portal.[12] PCL guide inserted through the medial parapatellar portal was passed through the intercondylar notch and positioned approximately 1.5 cm below

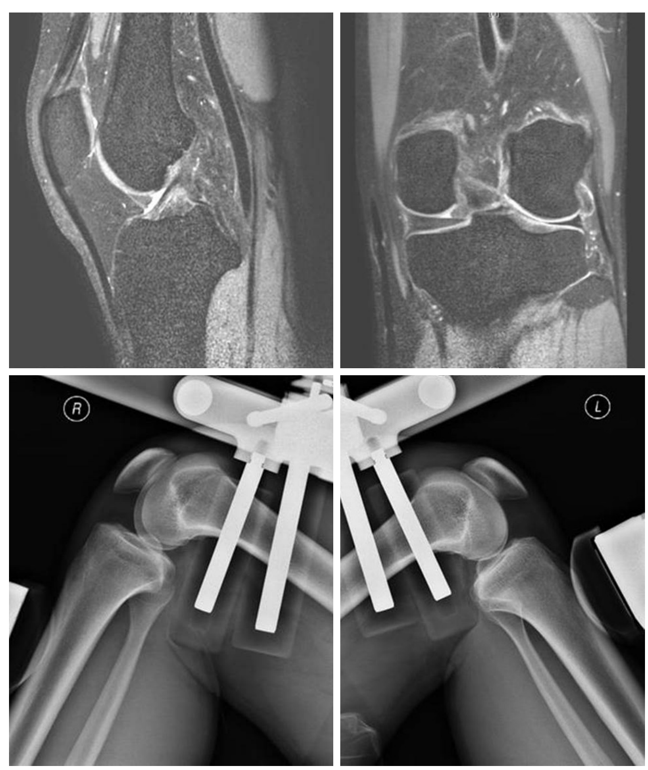

Fig. 1. Preoperative MRI and Telos posterior stress radiography. The left knee of a 19-year-old male with popliteal pain and posterior instability of the joint due to a slip. Magnetic resonance image shows contour buckling, laxity, and increased signal in the posterior cruciate ligament. Posterior Telos stress radiographs indicate posterior instability of the left knee.

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Fig. 2. Dial test. The examiner rotates the patient's tibia externally to check the posterolateral corner injury at 30° and 90° flexion for both knees.

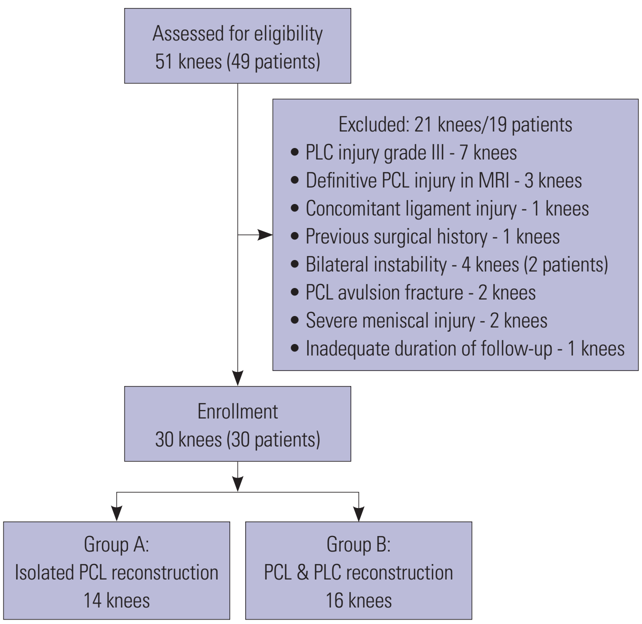

Fig. 3. Flow diagram.

the articular surface and just lateral to the midline on the PCL fossa for the tibial tunnel.[12] The tunnel was created on the anterolateral tibial cortex to reduce graft angulation.[12] The femoral socket was made with the far anterolateral portal.[12] The center of the femoral socket was placed 8 mm posterior to the articular junction at the 10:30 o'clock position for the left and the 1:30 o'clock position for the right knee.[12] For femoral fixation, the bone plug was trimmed to 11 mm wide and 25 mm long.[12] The constructed tendon was 11 mm wide and 60 mm long.[12] The fixation of grafts in the femoral socket and tibial tunnel was achieved using bioabsorbable interference screws.[12]

PLC reconstruction was performed with anatomic lateral collateral ligament (LCL) and popliteus tendon reconstruction with a posterior tibialis allograft for PLC insufficiency.[13] Skin incision was made from the anterior aspect of the fibular head to the lateral femoral epicondyle.[13] For popliteus tendon reconstruction, the tibial tunnel was created from the Gerdy tubercle to a point 1 cm inferior to the posterior joint line and 5 mm medial to the posterior side of the tibiofibular joint.[13] The proximal insertion site was located at the superior margin of the anterior one-fifth to the popliteal sulcus, which was approximately 10 mm anterior and 15 mm distal to the lateral femoral epicondyle at the isometric point where migration of the tendon was <2 mm during knee flexion and extension.[13] For LCL reconstruction, a fibular tunnel was made from the anteroinferior aspect of the fibular head 10 mm above the peroneal nerve to the point just posteromedial to the LCL of the fibular head.[13] The femoral tunnel for LCL reconstruction was placed just above the lateral femoral epicondyle.[13] The tendon was fixed using a bioabsorbable interference screw and the distal tendon of the reconstructed popliteus was sutured to the posterosuperior ligamentous tissue near the fibular head to restore the popliteofibular ligament function.[13]

For isolated PCLR, Achilles tendon allografts were used in all cases. For combined PCL and PLC reconstruction cases, allo-Achilles tendon grafts were used for PCLR, and allo-posterior tibialis tendon grafts were used for PLC reconstruction in all cases. Postoperative radiographs were taken immediately to examine appropriate tunnel positioning (Fig. 4).

All patients were immobilized in extension with a hinge knee PCL brace for 4 weeks with passive range of motion exercise allowed. Toe-touch weight bearing was allowed after postoperative 4 weeks. At 8 weeks, the brace was removed, walking was allowed, and closed kinetic chain exercise was started. Return to sports involving pivoting and, jumping was allowed after 9 months.

Statistical analysis

The Fisher's exact test and the Wilcoxon rank-sum test were used for determining significant differences in demographic factors among patients, as well as for the pre-and post-operative evaluation of the IKDC, Tegner activity scale, and Lysholm scores. The Mann-Whitney test was also used to analyze the posterior laxity using the Telos device. All statistical analyses were performed with SPSS version 23 software (IBM Corp., Armonk, NY, USA). The statistical significance level was set at $p<$ 0.05 for all tests.

RESULTS

Patient demographics

Thirty patients were included in this study. Group A comprised 14 patients who underwent isolated PCLR. Group B consisted of 16 patients who underwent combined PCL and anatomic PLC reconstruction. Among these 16 patients, there were no definite PLC injuries in MRI, and less than 5° of rotation in 30° flexion of the knee joint with the dial test was seen in four patients, and 5°–10° rotation was noted in 12.

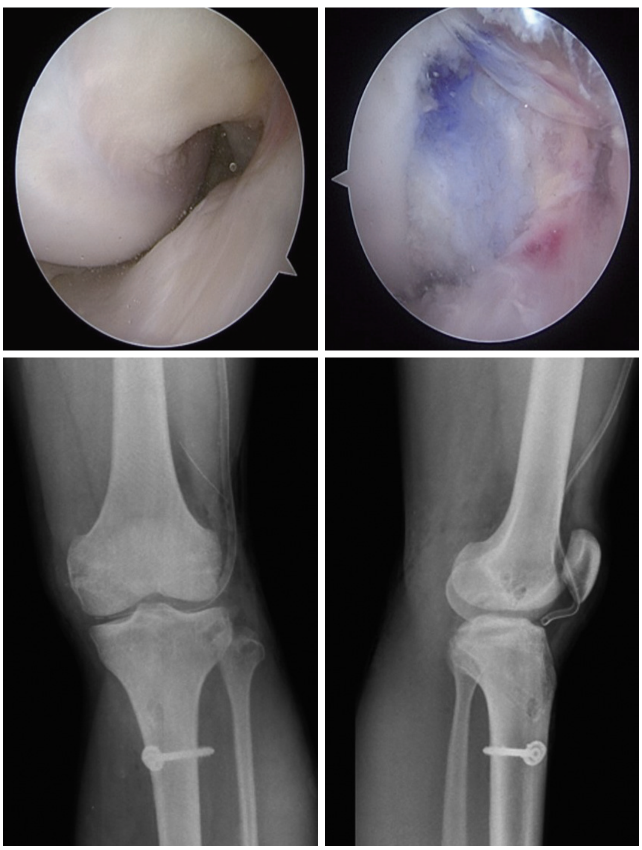

Fig. 4. Arthroscopic findings and postoperative radiographs. Arthroscopic findings show chronic rupture of the PCL and anatomical reconstruction. Radiographs show the femoral and tibiofibular tunnel positions of the PCL and posterolateral complex reconstruction. PLC, posterolateral complex; PCL, posterior cruciate ligament.

Mechanisms of trauma in all patients are listed in Table 1. Group A consisted of 14 patients, including 12 male and 2 female patients, while group B consisted of 16 patients, including 15 male and 1 female. The mean (±standard deviation) age of patients was 32.4±12.4 years in group A and 29.8±13.7 years in group B. The mean duration from injury to surgery was 7.85 weeks in group A and 8.47 weeks in group B (Table 1). There were no significant between-group differences in age, sex, duration from injury to surgery, and postoperative follow-up period between the two groups.

Clinical outcome

The IKDC subjective scores, Tegner activity scale scores, and Lysholm scores were improved in both groups during at least 2 years of follow-up after surgery. There were no significant differences between the groups in Tegner activity scale scores and Lysholm scores preoperatively and at the final follow-up (Table 2). However, group B showed a significantly higher IKDC subjective score compared to group A at the final follow-up (group A, 72.8±8.9; group B, 77.7±10.1; $p<0.05$). The postoperative knee range of motion was 135.1°±11.4° and 130.8°±12.1° in groups A and B, respectively, without significant differences between the groups at the last follow-up. There were no clini-

Table 2. Isolated PCLR Compared to Combined PCL and PLC Reconstruction in Clinical Outcomes

	Group A: Isolated PCL reconstruction (n=14)	Group B: Combined PCL and PLC reconstruction (n=16)	*p* value
Preoperative IKDC score	33.8±13.1	35.1±11.7	0.08
Final IKDC score	72.8±8.9	77.7±10.1	<0.05
Preoperative Lysholm score	35.8±8.1	37.1±10.2	0.38
Final Lysholm score	85.4±9.2	86.7±7.4	0.53
Preoperative Tegner score	1.5±0.9	1.6±1.1	0.24
Final Tegner score	3.9±1.4	4.3±1.3	0.09
Knee ROM at last follow-up (°)	135.1±11.4	130.8±12.1	0.64

PCL, posterior cruciate ligament; PLC, posterolateral complex; PCLR, PCL reconstruction; IKDC, International Knee Documentation Committee; ROM, range of motion.

Table 1. Demographic Data between Isolated PCLR Group and Combined PCL and PLC Reconstruction Group

	Group A: Isolated PCL reconstruction (n=14)	Group B: Combined PCL and PLC reconstruction (n=16)	*p* value
Age (yr)	32.4±12.4	29.8±13.7	0.08
Sex (male:female)	12:2	15:1	0.59
BMI (kg/cm^2)	23.8±3.1	24.7±3.2	0.75
Elapsed duration from injury to surgery (weeks)	7.85±3.26	8.47±3.45	0.83
Follow-up period (months)	32 (24–58)	37 (28–61)	0.43
Mechanism of injury (sports injury/traffic accident/fall injury)	5/8/1	12/3/1	0.08

PCL, posterior cruciate ligament; PLC, posterolateral complex; PCLR, PCL reconstruction; BMI, body mass index.
Data are presented as mean±standard deviation or n (%).

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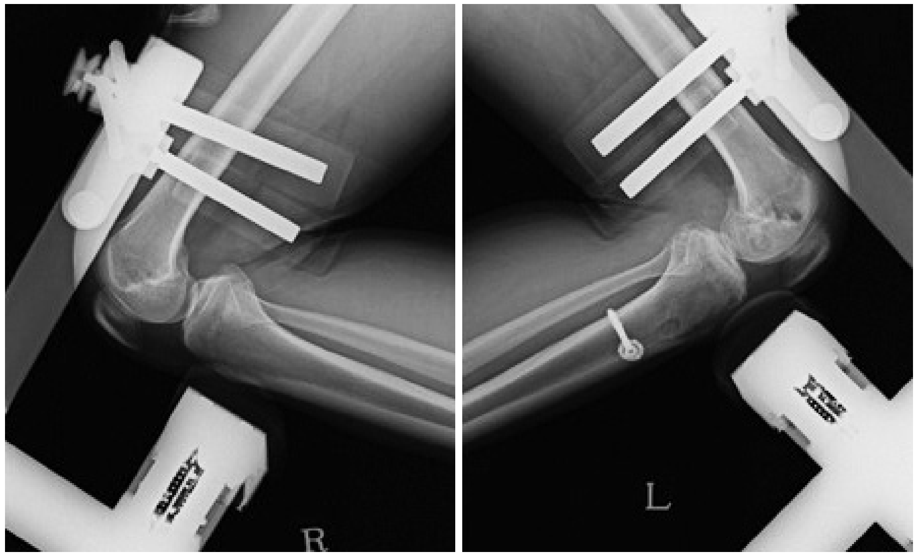

Fig. 5. Postoperative posterior Telos stress radiographs. Posterior Telos stress radiography showing side-to-side differences in posterior instability at the sixth postoperative month in the same patient shown in Fig 1.

cally detectable complications, such as peroneal nerve palsy, in both groups, during the follow-up period.

Side-to-side differences on posterior draw test

Side-to-side differences in the posterior tibial translation were assessed preoperatively and postoperatively using Telos posterior stress radiography (Fig. 5). There was no statistically significant difference in side-to-side difference in posterior tibial translation between the two groups preoperatively (group A, 11.8±4.3 mm; group B, 12.2±4.1 mm). However, group B showed a significantly less side-to-side difference in posterior tibial translation compared to group A at the final follow-up (group A, 4.8±2.3 mm; group B, 3.8±2.1 mm; $p<0.05$) (Table 3). The ICC for inter-observer variability was 0.88. There was at least good inter-observer agreement in all of the measurements performed.

Table 3. Side-to-Side Difference on Telos Posterior Stress Radiographs

	Group A: Isolated PCL reconstruction (n=14)	Group B: Combined PCL and PLC reconstruction (n=16)	*p* value
Preoperative SSD (mm)	11.8±4.3	12.2±4.1	0.29
Final SSD (mm)	4.8±2.3	3.8±2.1	<0.05

PCL, posterior cruciate ligament; PLC, posterolateral complex; SSD, side-to-side difference.

DISCUSSION

The principal finding of this study was that in patients with PCL injury and concomitant PLC injuries corresponding to less than grade III posterolateral knee laxity, combined PCL and PLC reconstruction provided relatively improved surgical outcomes compared to isolated PCLR. When PCLR is planned, this study could provide a basis for planning surgical strategies for those with an ambiguous preoperative posterolateral laxity of the knee.

An accurate assessment of the severity of PLC injury is challenging.[14,15] Several physical examinations, including the dial test, external rotation recurvatum test, and posterolateral drawer test, can be used to evaluate the degree of PCL injuries.[16] Among these examinations, the dial test has been considered a relatively objective method for diagnosing PLC injury.[7,17,18] However, since these examinations are highly dependent on the examiner, the results can be subjective and inaccurate. Furthermore, in the case of an acute injury, an evaluation will be more difficult due to pain. MRI is a useful tool for evaluating ligament injuries of the knee. However, the anatomy of the posterolateral structures is complicated, and it is difficult to adequately depict them using standard imaging methods due to the relative obliquity of their orientation.[19] In this context, a significant number of patients diagnosed with PCL injury may be exposed to the risk of not receiving appropriate treatment for PLC injuries. Indeed, undiagnosed PLC injuries are known to be a major cause of the failure of PCLR. Therefore, although it is important to accurately evaluate the severity of PLC injuries, it is also necessary to investigate the treatment strategies for patients with PCL injuries accompanied by not severe or ambiguous PLC injuries. Accordingly, in this study, we compared the surgical outcomes of an isolated PCLR and combined PCL and PLC reconstruction in patients with less than grade III posterolateral knee laxity.

Our study revealed that for patients with PCL injuries accompanied by posterolateral knee laxity less than grade III, combined PCL and PLC reconstruction showed relatively favorable surgical outcomes compared to an isolated PCLR. The corresponding results were found not only in the clinical score but also in the radiologic outcomes. The results of this study were consistent with the findings in the previous study. In many previous studies, residual posterior laxity after the isolated PCLR was thought to be due to an associated and untreated PLC injury.[17-19] Kim, et al.,[20] reported that combined PCL and PLC reconstruction could result in better clinical outcomes and posterior knee laxity compared to isolated PCLR in patients with PCL injuries with mild posterior translation. Although the study by Kim, et al.,[20] differs from ours since they included patients with grade III posterolateral knee laxity, their findings suggest the beneficial effects of combined PLC reconstruction on clinical outcomes and knee stability in PCLR. Harner, et al., reported that an isolated PCLR without concomitant PLC reconstruction would result in significant increases in graft forces in reconstructed PCL grafts, potentially resulting in elongation of the graft tissue, failure of the initial fixation, or failure at the graft−bone interface.[3,9,10] Furthermore, none of the patients included in our study showed complications associated with concomitant PLC reconstruction. Accordingly, even if patients for whom PCLR is required show less than grade III posterolateral knee laxity, there is no reason to hesitate undergoing combined PLC reconstruction due to various potential benefits.

PCL injuries are frequently accompanied by other ligament injuries, and PLC accounts for a significant number of them. Considering that it is difficult to evaluate the degree of PLC injuries accurately and that the major cause of the failure of PCLR is untreated PLC injuries, the necessity of PLC reconstruction should be emphasized regardless of the degree of posterolateral laxity of the knee. This study could serve as a basis for planning surgical strategies for patients with PCL injuries accompanied by an ambiguous posterolateral knee laxity.

There are several limitations of this research. First, this study was not a randomized but a retrospective case-control study. Therefore, we could not completely exclude the bias in patient selection and radiographic measurements. Second, the number of included patients was small. Third, we performed the dial test in a conscious state, which could make the test unclear. Fourth, since the patients in this study underwent single-bundle reconstruction using allograft, caution is required in the interpretation of results in the cases of other surgical techniques. Fifth, our study had a relatively short follow-up period. In addition, we could not investigate varus and external rotational instability after reconstruction since, only posterior laxity could be measured, which is a limitation of the retrospective nature of this study. Moreover, these were only single-bundle PCLR with allografts. The reason for the residual laxity after surgery may be that the isolated PCLR was performed with allografts, as allografts may exhibit delayed healing and remodeling compared to autografts.[10,20] Further prospective randomized studies should be conducted in a larger population to reinforce the results of our study.

In conclusion, combined single bundle PCL and PLC reconstructions improved clinical and radiologic outcomes, especially residual posterior laxity, compared to isolated PCLR in patients who have less than grade III posterolateral laxity of the knee. In patients who need PCLR with ambiguous PLC injury, combined PCL and PLC reconstruction could be helpful in restoring the posterior stability of the knee.

AUTHOR CONTRIBUTIONS

Conceptualization: Han-Kook Yoon and Sang-Hoon Park. Data curation: Heemin Choi, Sang-Hoon Park, and Hyun-Cheol Oh. Formal analysis: Joong-Won Ha and Sang-Hoon Park. Funding acquisition: Sang-Hoon Park. Investigation: Sang-Hoon Park and Hyun-Cheol Oh. Methodology: Han-Kook Yoon and Sang-Hoon Park. Project administration: Han-Kook Yoon and Sang-Hoon Park. Resources: Heemin Choi, Sang-Hoon Park, and Hyun-Cheol Oh. Software: Heemin Choi, Sang-Hoon Park, and Hyun-Cheol Oh. Supervision: Joong-Won Ha, Sang-Hoon Park, and Han-Kook Yoon. Validation: Sang-Hoon Park and Hyun-Cheol Oh. Visualization: Heemin Choi, Sang-Hoon Park, and Hyun-Cheol Oh. Writing—original draft: Han-Kook Yoon and Sang-Hoon Park. Writing—review & editing: Sang-Hoon Park and Hyun-Cheol Oh. Approval of final manuscript: all authors.

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