

ORIGINAL ARTICLE



Single-Bundle PCL Reconstruction with Remnant Preservation: Midterm Follow-up

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ABSTRACT

Background. Remnant preservation was developed as a routine procedure for posterior cruciate ligament (PCL) reconstruction, but it is not easy. **Objectives.** Our study aimed to evaluate the outcomes of a minimum 5-years follow-up of remnant preservation PCL reconstruction. **Methods.** The study was a prospective cohort analysis of 44 patients who underwent PCL reconstruction with remnant preservation and a minimum 5-years follow-up. Outcome parameters included were modified Cincinnati score, Lysholm knee score, International Knee Documentation Committee (IKDC) subjective score, degree of laxity (Posterior Drawer Test), single-leg hop test, and knee x-ray findings. **Results.** The mean diameter of the hamstring autograft was 8 ± 2.04 mm. The mean of Lysholm knee scores increased from 65.15 ± 10.48 to 86.94 ± 4.80 . The IKDC subjective score increased from 62.55 ± 18.10 (range, 40–65) to 88.65 ± 3.44 (range, 65–100) points, and the Modified Cincinnati Score from 63.32 ± 13.65 to 86.24 ± 1.64 . For Posterior Drawer Test results after surgery, 37 patients (84%) had grade 1, 5 (11%) had grade 2, and 2 (4.5%) had grade 3 of laxity. For the range of motion measurements, 39 (88.6%) patients had normal knee status, 3 (6.8%) presented with flexion deficit $>25^\circ$, and 1 (2.2%) had a $160\text{--}25^\circ$ deficit in flexion, and 1 (2.2%) had a $160\text{--}25^\circ$ deficit in extension. Eight cases had the infection at the local incision site, which was resolved with conservative treatment. **Conclusion.** Remnant preservation in PCL reconstruction with standard and posteromedial portal at a minimum 5-year assessment showed satisfactory clinical, functional outcome, and radiological evaluation outcomes.

KEYWORDS: *Posterior Cruciate Rupture, PCL Reconstruction, Preserving Remnant, Clinical Outcome Score, Radiological Evaluation.*

INTRODUCTION

The posterior cruciate ligament (PCL) is the strongest ligament in the knee joint, which

consists of the anterolateral (AL) and the posteromedial (PM) bundles. Indications for PCL

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surgery may be a PCL rupture with failure of nonoperative treatment, avulsion fracture of PCL, multiple ligament ruptures, chronic rupture with persistent knee instability, or pain. Various techniques include fixation type, single or double-bundle, transtibial, and the tibial inlay or onlay procedures. However, there is still no consensus on which one of these techniques is the recommended procedure for surgery. (1-7)

PCL rupture preserves insertion on the femoral and tibial sides (4). During surgery, the remnant PCL is usually removed to achieve clear visualization of the insertion site. With clear visualization of the posterior compartment, it is easier to make an anatomical tibial tunnel. (1, 4, 8) Mechanoreceptors of the PCL are spread at the surface ligament and bone attachments. This neural network is essential in regulating muscle contraction and maintaining the stability of the lower leg. (4, 9) The PCL remnant increases graft neovascularization. Thus, preserving the PCL remnant may prove helpful in improving the stability, healing, incorporation of the graft, and restoration of proprioceptive ability (1-4, 10).

The purpose of our study was to analyze clinical and radiological outcomes after PCL reconstruction with remnant preservation using the posteromedial portal with a minimum 5-year follow-up. We hypothesized that our PCL technique would result in good outcomes in midterm follow-up.

MATERIALS AND METHODS

Participants. Forty-four patients underwent single-bundle PCL reconstruction with remnant preservation for an isolated PCL rupture between January 2012 and December 2014 after obtaining written informed consent. This cohort prospective was approved by the local Regional Ethics Committee (KE/FK/0520/EC/2018), and the research was conducted at Soeradji Tirtonegoro General Hospitals. The inclusion criteria for the patients were PCL rupture without other ligament rupture and failure of nonoperative treatment. Those with other ligament rupture, meniscal injury, chondral lesion, any deformity of the lower limb, or associated fracture in the lower extremity were excluded from the study. PCL rupture was diagnosed through clinical assessment (posterior sag sign, degree of laxity with posterior drawer test), radiologic knee Telos stress view, and magnetic resonance imaging (MRI).

All subjects were informed about their knee condition and treatment procedures. One experienced surgeon did all the arthroscopic procedures. Patients received comprehensive clinical assessment and radiological examination before their operation and at final follow-up.

Surgical Technique. One orthopedic surgeon (SR) performed all arthroscopic procedures. Patients were put in the supine position. A tourniquet was placed in the proximal thigh, then standard anterolateral, anteromedial, and accessory portals were used. A routine arthroscopy examination was done through standard anteromedial and lateral portals, and a hamstring autograft was used in all cases. The PCL remnant fiber was preserved. For the femoral tunnel creation, the guide wire was put 6-8 mm from the joint surface at the 11 o'clock position for the left knee and the 1 o'clock position for the right knee. The wire was inserted through the footprint of the medial femoral condyle and exited through the skin. Afterward, reaming with the XO Button drill (diameter 5 mm, ConMed; USA) was done up until the medial side of the femoral condyle was reached. It was followed by drilling using a cannulated drill that was sized according to graft diameter until 20-30 mm depth was achieved.

A tibial tunnel was created using a posteromedial portal to ensure PCL tibial attachment site. A PCL guide was inserted through the accessory portal at the center of the PCL insertion on the tibial side. The tibial tunnel was drilled in accordance with graft diameter. Using it, the quadruple hamstring autograft was pulled from the anteromedial tibia through the femoral tunnel. Fixing the femoral side was done using an XO button® (ConMed-Linvatec, USA). Afterward, the graft was pulled out of the anteromedial tibial portal and fixated on the anteromedial side using a Bioabsorbable Screw® (ConMed, USA) while the knee was in 90° flexion and anterior drawer position.

Postoperative Rehabilitation. The affected knee was braced in extension for 4 weeks. After 2 weeks, quadriceps strengthening was started. After four weeks, range of motion exercises was done until 90° flexion was achieved. It was then increased gradually until full flexion was achieved after 8 weeks. Partial weight-bearing was permitted after 4 weeks, and full weight-bearing was permitted after 8 weeks. Patients were allowed return to normal daily activities

after 5 months. After 6 months, noncontact sports were allowed. Patients were assessed through a hop test and were then permitted for competitive sports after 12 months. The author and a senior physiatrist supervised all postoperative rehabilitation.

Functional Outcome Evaluation. Examination of the knee was performed preoperatively and in the final follow-up within a minimum of 5 years. Outcome parameters included were International Knee Documentation Committee (IKDC) grade, Lysholm score, Modified Cincinnati Score, degree of knee range of motion, knee laxity (Posterior Drawer Test), single leg hop test, and x-ray findings.

Statistical Analysis. Wilcoxon signed-rank test was used to analyze mean outcomes of IKDC, Lysholm, and Modified Cincinnati scores with $P < 0.001$ was regarded as significant.

RESULTS

Forty-four patients (44 knees) with complete follow-up documentation for a minimum of 5 years were included in the outcome analysis. The mean age of the patients when the surgery was performed was 27.30 ± 12.6 (16–56) years old. The cause of PCL rupture was traffic accidents for 36 patients, sports for 5 patients, and other causes for 3 patients. The injury site was noted in 35 right and 9 left knees (Table 1).

Table 1. Patients Demographic

Variable	Result
Age, year	27.30 ± 12.6 (16 – 56)
Gender, M/F	Male: 26. Female:18
Mechanism of Injury	Traffic accident:36, sports injury:5, other causes :3
Knee injury Site, R/L	Right: 35, Left: 9
Follow-up time (months)	64 (60 – 74)

Table 2. Clinical Outcome Assessment

	Mean	Mean difference	95% Confidence of Interval	p value
Lysholm Score		-29.84 ± 11.47	$(-34.57) - (-25.10)$	<0.001
Preoperative	65.15 ± 10.48			
Final Follow-up	86.94 ± 4.80			
IKDC Subjective score		-35.10 ± 15.19	$(-41.37) - (-28.83)$	<0.001
Preoperative	62.55 ± 18.10			
Final Follow-up	88.65 ± 3.44			
Modified Cincinnati Score		-33.76 ± 13.67	$(-39.40) - (-28.11)$	<0.001
Preoperative	63.32 ± 13.65			
Final Follow-up	86.24 ± 1.64			

CI: Confidence Interval, Range of motion

Table 3 Posterior Drawer Test: Preoperative and Postoperative

Grade	Preoperative	Postoperative		
		1 year	2 years	Final Follow-up
I (0–5 mm)	0	39	38	37 (84%)
II (6–10 mm)	0	4	5	5 (11%)
III (11–15 mm)	35	1	1	2 (4,5%)
IV (>15 mm)	8	0	0	0 (0%)

Lysholm Score. There was a significant difference between preoperative and final follow-up mean (65.15 ± 10.48 (range, 40–68) and 86.94 ± 4.80 (range, 65–100) points, respectively), ($P < 0.001$) (Table 2).

IKDC Subjective Score. Preoperative and final follow-up mean showed significant increases (62.55 ± 18.10 (range, 40–65) and 88.65 ± 3.44 (range, 65–100) points, respectively) ($P < 0.001$) (Table 2).

Modified Cincinnati Score. There was a significant difference between preoperative and final follow-up mean (63.32 ± 13.65 (range, 50–65) and 86.24 ± 1.64 (range, 60–100) points, respectively), ($P < 0.001$)

(Table 2).

Thirty-nine (88.6%) patients had normal knee range of motion at the final assessment. Three (6.8%) patients had a flexion deficit of more than 25° , one (2.2%) patient had a $16^\circ - 25^\circ$ deficit in flexion, and one (2.2%) patient had a $16^\circ - 25^\circ$ deficit in extension.

Ligament Laxity. The posterior drawer test was used to assess posterior knee translation. Posterior drawer test at final follow-up showed that 37 patients (84%) had grade 1, 5 patients (11%) had grade 2, and 2 (4,5%) patients had grade 3 (Table 3).

Knee Antero-Posterior Standing and Lateral X-ray Examination. Forty-one (93%)

patients had normal knee x-ray findings. Three (6.8%) patients had a mild grade of osteoarthritis, and 1 (2.2%) had moderate grade osteoarthritis.

Patellofemoral Crepitus. Patellofemoral pain and crepitus were present in 12 (27%) patients.

Single-Leg Hop Test. Twenty-five (56.8%) patients reached a distance of 90% or more on the injured leg compared to the standard leg. Fourteen (31.8%) patients reached a distance of 76 – 89% on the injured leg, and six (13.6%) patients achieved less than 70%.

Thigh Muscle Atrophy. Thirty-four (77.2%) patients had less than 10 mm difference in thigh circumference compared to normal limbs, while 10 patients (22.7%) had a difference of more than 10 mm.

Donor Site Morbidity. Eight (18%) patients presented with a stitch abscess, and 5 of these 8 underwent debridement.

Complications and Hardware Removal. Eight (18%) patients complained of numbness around the anterior part of the proximal tibia. Five (11.3%) patients underwent implant removal because of infection or tenderness.

DISCUSSION

The incidence rate of PCL rupture is still not established. Various studies have shown different results ranging from 3% to 37%. (10, 11) Management of PCL rupture is challenging because there is no consensus on which one is the best technique for surgery.

PCL reconstruction aims to restore the normal knee kinematics to improve joint function and to gain nearly normal objective restrain posterior tibial translation post-operatively. Many techniques have been published for PCL reconstruction, including single or double-bundle techniques, autograft or allograft using tunnel position or fixation type, and either preserving or non-preserving remnant. (12) Our study showed that PCL reconstruction preserving remnants using standard and the posteromedial portal could significantly improve clinical and radiological outcomes.

Remnant preservation is essential because remnants could retain a well-vascularized synovial sheet and mechanoreceptors. Some animal studies have shown that remnants could accelerate synovial coverage and revascularization while enhancing the biomechanical aspects of grafts (13).

There are many techniques to visualize the posterior region of the knee joint without sacrificing the PCL remnant. These techniques include creating a posteromedial or posterolateral

tunnel, using the transseptal technique, or using additional equipment such as the 70-degree arthroscope. Arthroscopic surgery with the anterior portal procedure, wherein the arthroscope is inserted into the posterior part of the knee joint across the intercondylar notch, will give good visualization of the posterior compartment. However, some studies reported that for 34% of the cases, it could be challenging to visualize the posterior compartment using the anterior portal only. It may be due to several factors, including intercondylar notch mechanical narrowing, surgeon inexperience, and degenerative joint disease cases. (5, 6, 14-17)

In our study, we used only the posteromedial portal to visualize the knee joint's posterior part clearly while preserving PCL fibers. This technique was more uncomplicated and required a shorter time for surgery because there was no need for creating a posterolateral portal, and no additional equipment was needed. With clear visualization of the posterior compartment, we can make an anatomical tibial tunnel while preserving the PCL remnant.

The technique of preserving the PCL remnant was explicitly developed for PCL reconstruction. Some studies have recently described achieving anatomical tunnel position while preserving the PCL remnant. (14, 17) Jae Ang Sim et al. compared the clinical evaluation between posteromedial and posterior transseptal portal techniques for anatomical tibial tunnel creation with remnant preservation. Their results showed no significant differences in the clinical results for both groups. (18)

Our study evaluated the clinical outcomes using IKDC subjective knee score, Lysholm knee score, and Modified Cincinnati Score preoperatively and 5 years postoperative. We also assessed knee range of motion measurements, single-leg hop test, ligament laxity, thigh atrophy, and knee x-ray findings at the final examination.

IKDC subjective knee score is a self-assessment of the function of the knee and the level of knee activity. Our study found a significant improvement in IKDC score after the final follow-up. Lysholm's score also increased significantly at the final follow-up. The mean Modified Cincinnati score was increased significantly from 63.32 preoperative to 86.24 at final follow-up. This score is based on the intensity of pain, swelling, and overall activity levels such as walking, running, going up and down stairs, and jumping.

For ligament laxity, 37 patients (84%) revealed grade I (0-5 mm) Posterior Drawer Test at final follow-up. Two patients (4.5%) still had grade III results in the Posterior Drawer Test. Overall, there was a significant improvement in the posterior drawer test when using this technique.

Limitation in range of motion post-op may be a problem when performing PCL reconstruction. It may be because of the extended knee immobilization after surgery. There were 5 patients (11.3%) unable to recover to the normal full range of motion. Four could not achieve complete flexion, while one patient had an extension deficit. Laxity or limitation in knee range of motion is still a problem after the PCL reconstruction, with various operating techniques (18). A previous study stated that there was a loss of extension and a flexion deficit after PCL reconstruction (9.15% and 28.9%, respectively), and knee laxity was still observed at the final examination based on the results of the posterior drawer test, KT 1000/2000 test, and Telos radiographs (64.8%, 42.8%, and 47.9%, respectively) (18).

There are several limitations to our study. First, there was no comparison group. Secondly,

this study only considered midterm evaluation. Further long-term studies are still needed to evaluate this technique and confirm our results. Thirdly, this study did not evaluate the proprioceptive activity and healing of the graft, which are the most commonly considered factors for using the remnant preservation technique. However, our study minimized bias by having all arthroscopic procedures done by a single surgeon.

CONCLUSION

PCL reconstruction using standard anterior and posteromedial portals with remnant preservation can achieve significant functional improvement at a minimum of 5 years of follow-up in patients with an isolated PCL rupture.

APPLICABLE REMARKS

- The study recommends that PCL reconstruction using standard anterior and posteromedial portals is enough without the need for additional posterolateral portals.
- The study showed that PCL reconstruction with remnant preservation would increase significant functional outcomes.

REFERENCES

1. Chernchujit B, Samart S, Na Nakorn P. Remnant-Preserving Posterior Cruciate Ligament Reconstruction: Arthroscopic Transseptal, Rod and Pulley Technique. *Arthrosc Tech*. 2017;**6**(1):e15-e20. doi: 10.1016/j.eats.2016.08.031 pmid: 28373934
2. Lee SH, Jung YB, Lee HJ, Jung HJ, Kim SH. Remnant preservation is helpful to obtain good clinical results in posterior cruciate ligament reconstruction: comparison of clinical results of three techniques. *Clin Orthop Surg*. 2013;**5**(4):278-286. doi: 10.4055/cios.2013.5.4.278 pmid: 24340147
3. Jung YB, Jung HJ, Song KS, Kim JY, Lee HJ, Lee JS. Remnant posterior cruciate ligament-augmenting stent procedure for injuries in the acute or subacute stage. *Arthroscopy*. 2010;**26**(2):223-229. doi: 10.1016/j.arthro.2009.07.017 pmid: 20141985
4. Eguchi A, Adachi N, Nakamae A, Usman MA, Deie M, Ochi M. Proprioceptive function after isolated single-bundle posterior cruciate ligament reconstruction with remnant preservation for chronic posterior cruciate ligament injuries. *Orthop Traumatol Surg Res*. 2014;**100**(3):303-308. doi: 10.1016/j.otsr.2013.12.020 pmid: 24679366
5. Alentorn-Geli E, Stuart JJ, James Choi JH, Toth AP, Moorman CT, 3rd, Taylor DC. Posterolateral portal tibial tunnel drilling for posterior cruciate ligament reconstruction: technique and evaluation of safety and tunnel position. *Knee Surg Sports Traumatol Arthrosc*. 2017;**25**(8):2474-2480. doi: 10.1007/s00167-015-3958-0 pmid: 26718637
6. Ahn JH, Ha CW. Posterior trans-septal portal for arthroscopic surgery of the knee joint. *Arthroscopy*. 2000;**16**(7):774-779. doi: 10.1053/jars.2000.7681 pmid: 11027767
7. Voos JE, Mauro CS, Wentz T, Warren RF, Wickiewicz TL. Posterior cruciate ligament: anatomy, biomechanics, and outcomes. *Am J Sports Med*. 2012;**40**(1):222-231. doi: 10.1177/0363546511416316 pmid: 21803977
8. Chen T, Liu S, Chen J. All-Anterior Approach for Arthroscopic Posterior Cruciate Ligament Reconstruction With Remnant Preservation. *Arthrosc Tech*. 2016;**5**(6):e1203-e1207. doi: 10.1016/j.eats.2016.07.011 pmid: 28149714

9. Katonis PG, Assimakopoulos AP, Agapitos MV, Exarchou EI. Mechanoreceptors in the posterior cruciate ligament. Histologic study on cadaver knees. *Acta Orthop Scand*. 1991;**62**(3):276-278. [doi: 10.3109/17453679108993609](#) [pmid: 2042472](#)
10. Fowler PJ, Messieh SS. Isolated posterior cruciate ligament injuries in athletes. *Am J Sports Med*. 1987;**15**(6):553-557. [doi: 10.1177/036354658701500606](#) [pmid: 3425783](#)
11. Shelbourne KD, Davis TJ, Patel DV. The natural history of acute, isolated, nonoperatively treated posterior cruciate ligament injuries. A prospective study. *Am J Sports Med*. 1999;**27**(3):276-283. [doi: 10.1177/03635465990270030201](#) [pmid: 10352760](#)
12. Makris CA, Georgoulis AD, Papageorgiou CD, Moebius UG, Soucacos PN. Posterior cruciate ligament architecture: evaluation under microsurgical dissection. *Arthroscopy*. 2000;**16**(6):627-632. [doi: 10.1053/jars.2000.9238](#) [pmid: 10976124](#)
13. Wang H, Liu Z, Li Y, Peng Y, Xu W, Hu N, et al. Is Remnant Preservation in Anterior Cruciate Ligament Reconstruction Superior to the Standard Technique? A Systematic Review and Meta-Analysis. *Biomed Res Int*. 2019;**2019**:1652901. [doi: 10.1155/2019/1652901](#) [pmid: 31886174](#)
14. Kim YM, Lee CA, Matava MJ. Clinical results of arthroscopic single-bundle transtibial posterior cruciate ligament reconstruction: a systematic review. *Am J Sports Med*. 2011;**39**(2):425-434. [doi: 10.1177/0363546510374452](#) [pmid: 20702860](#)
15. Ahn JH, Chung YS, Oh I. Arthroscopic posterior cruciate ligament reconstruction using the posterior trans-septal portal. *Arthroscopy*. 2003;**19**(1):101-107. [doi: 10.1053/jars.2003.50017](#) [pmid: 12522410](#)
16. Ohishi T, Takahashi M, Suzuki D, Matsuyama Y. Arthroscopic approach to the posterior compartment of the knee using a posterior transseptal portal. *World J Orthop*. 2015;**6**(7):505-512. [doi: 10.5312/wjo.v6.i7.505](#) [pmid: 26301179](#)
17. Bach BR, Jr., Aadalen KJ, Mazzocca AD. An accessory portal for posterior cruciate ligament tibial insertion visualization. *Arthroscopy*. 2004;**20 Suppl 2**:155-158. [doi: 10.1016/j.arthro.2004.04.029](#) [pmid: 15243451](#)
18. Rhatomy S, Utomo DN, Suroto H, Mahyudin F. Knee laxity or loss of knee range of motion after PCL reconstruction: a systematic review and meta-Analysis. *Ann Appl Sport Sci*. 2020;**8**(2):1-24. [doi: 10.29252/aassjournal.938](#)