Patients With Isolated PCL Injuries Improve From Surgery as Much as Patients With ACL Injuries After 2 Years

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Background: Reports on outcome after posterior cruciate ligament (PCL) reconstruction often contain both isolated PCL and combined knee ligament injuries. This makes it difficult to conclude on the outcome after reconstruction of isolated PCL injuries.

Purpose: To investigate the outcome after PCL reconstruction in patients with an isolated PCL injury and to compare this with the outcome of patients treated with reconstruction after isolated anterior cruciate ligament (ACL) injuries.

Study Design: Cohort study; Level of evidence, 3.

Methods: Seventy-one patients with an isolated PCL injury that was reconstructed surgically and who had registered in the Norwegian Knee Ligament Registry between 2004 and 2010 were included in this study. Patients with isolated ACL reconstructions (n = 9661) who had registered in the same period were included for comparison. Knee Injury and Osteoarthritis Outcome Score (KOOS) was used as the patient-reported outcome measure. Preoperative and 2-year postoperative KOOS scores were compared. Changes in KOOS score reported by the PCL patients were compared with changes reported by the ACL patients.

Results: At the 2-year postoperative follow-up of the PCL-reconstructed patients, the patient-reported outcome was improved, measured by KOOS as follows: pain, 15.1 (95% CI, 8.5-21.8; $P < .001$); symptoms, 0.9 (95% CI, –6.6 to 8.3; $P = .82$); activities of daily living, 13.2 (95% CI, 6.6-13.9; $P < .001$); sports, 20.7 (95% CI, 11.8-29.4; $P < .001$); and quality of life, 26.6 (95% CI, 18.9-34.2; $P < .001$). According to the KOOS, the incremental improvements were similar for PCL and ACL patients. Time from injury to surgery was longer for the PCL patients compared with ACL patients (median, 21.5 vs 8.0 months; $P < .001$).

Conclusion: Patients undergoing PCL reconstruction can expect the same improvements in KOOS score as patients undergoing ACL reconstruction. However, PCL patients start out with an inferior score on average and consequently end up at a lower score compared with ACL patients for all KOOS subscales.

Keywords: PCL; knee; ACL; register study; single-bundle surgery

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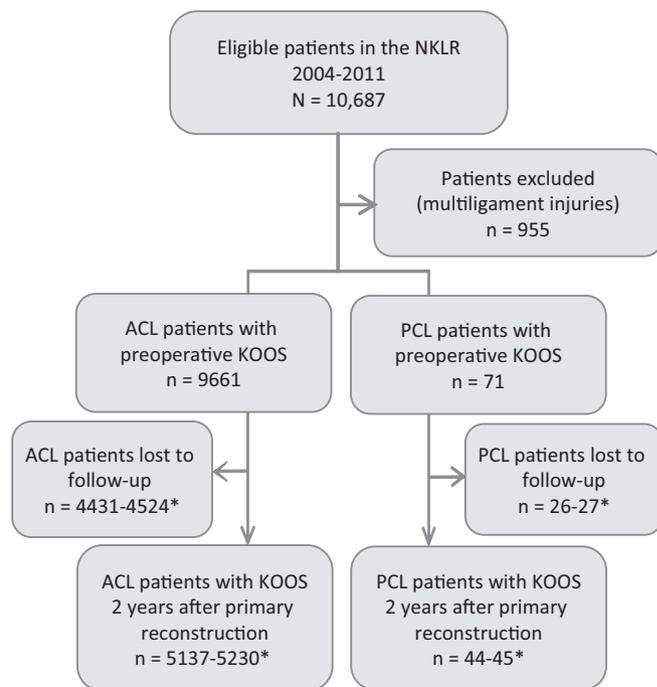††Norwegian Knee Ligament Registry, Bergen, Norway.

Isolated posterior cruciate ligament (PCL) ruptures are less common knee injuries compared with anterior cruciate ligament (ACL) ruptures. Isolated PCL injuries account for approximately 17% of all knee ligament injuries.[11] In a newly published article examining the epidemiology of all knee injuries among US high school athletes, the prevalence of ACL injuries was 25.4% and that of PCL injuries was 2.4%.[21] Although isolated PCL injuries are not uncommon in contact sports, such as American football, rugby, and soccer, few studies have reported the treatment and follow-up of isolated PCL injuries. Thus, it is difficult to provide evidence-based advice to patients concerning their treatment options. The majority of isolated PCL injuries are benign when it comes to regaining preinjury activity level.[19] However, the injury can be disabling for the affected patient, and it commonly results in a long recovery period. In some cases, the athlete may never compete again at the same level.[18,19] Usually, a nonoperative

approach is first tried; for the majority of patients, this treatment approach results in a return to the preinjury activity level.[16,19] Limited research is available to provide universal guidelines for the nonoperative treatment approach, but active rehabilitation, including a PCL brace, and focusing on regaining range of motion, strength, and stability training (focusing on quadriceps strength in particular) have been described in several studies.[19] In a previous study, 22 of 133 patients with a grade I or II injury (partial ruptures) were unable to return to playing sports at any level after a standard regimen of nonoperative treatment.[19] No similar studies have reported on grade III (total rupture) injuries, although total ruptures take longer to rehabilitate and are considered to be more serious injuries.[16] Some injuries are initially missed and may be recognized months after the actual injury,[16] which could make a nonoperative treatment approach using a PCL brace less likely to succeed because the healing potential for the injured PCL is better in the first weeks after an injury. Patients with poor outcomes after nonoperative treatment are considered for surgical treatment. The definition of a poor outcome varies because there is limited research available to provide guidelines for defining poor outcome. A score of <44 on the Knee injury and Osteoarthritis Outcome Score (KOOS) quality of life (QoL) subscale has previously been suggested to signify treatment failure in terms of evaluating patient outcomes after ACL reconstruction.[2] Because of the limited data available, the surgical indications may differ from country to country. There may also be variations from one hospital to another. Further research in this area is needed. There is a lack of knowledge on the surgical treatment of PCL injuries compared with a control group with nonoperative treatment. The same is true when it comes to comparing results after PCL reconstruction with other ligament reconstructions. Additionally, the existing literature on PCL injuries is dominated by case studies composed of isolated, complete, and combined PCL injuries, making it difficult to apply these findings to isolated PCL injury patients. Consequently, there is a need to further scrutinize isolated PCL injuries.

The aim of this study was to evaluate postoperative results 2 years after primary PCL reconstruction and to compare the results to postoperative results 2 years after primary ACL reconstruction. ACL surgery has been established as a procedure that provides nearly normal restoration of knee function and marked improvement in quality of life assessments.[13,22] Our hypothesis was that 2 years after ligament reconstruction surgery, patients with a PCL injury benefit as much from surgery as patients with an ACL injury, as measured by the KOOS knee function score.

METHODS

Patients were included from the Norwegian Knee Ligament Registry (NKLR). The NKLR was established in 2004. The main objective of the registry was to prospectively register all surgical procedures on cruciate ligaments in Norway and to monitor the outcomes. Every hospital in Norway reports cruciate ligament reconstructions to the registry. Both primary and revision procedures are reported. The report rate

Figure 1. Flowchart showing the inclusion of patients in the current study. ACL, anterior cruciate ligament; NKLR, Norwegian Knee Ligament Registry; PCL, posterior cruciate ligament. *Different numbers indicate the different Knee injury and Osteoarthritis Outcome Scale (KOOS) subgroups.

to the registry is approximately 86%.[25] The patients complete the KOOS report preoperatively and at 2, 5, and 10 years postoperatively. Informed consent is obtained from all patients for the preoperative KOOS score. The surgeon completes a form postoperatively, with information regarding the findings and specifications of the performed procedure. The registry has been described in more detail in previous studies.[4-6,25]

The KOOS questionnaire is a self-administered knee function score that consists of 42 questions divided into 5 different subscales: pain, other symptoms, activities of daily living (ADL), function in sports/recreation, and knee-related QoL. It was developed in the 1990s by Roos et al.[15] The KOOS score includes the Western Ontario and McMaster Universities (WOMAC) Osteoarthritis Index in its complete and original format, and it is a validated and reliable tool for measuring knee function in patients with osteoarthritis and for several types of knee injuries, including ACL injuries, meniscal injuries, and cartilage injuries.[14] Each subscale ranges from 0 (worst) to 100 (best). A difference of 8 to 10 points in a subscale is usually considered to represent a clinically relevant effect. It is recommended to evaluate each subscale independently when considering outcome measures.[15] In this study, the calculation of each subscale score and the treatment of missing data were performed according to the guidelines of Roos et al.[15]

A total of 10,687 patients with primary ACL and PCL reconstructions were registered in the NKLR between 2004 and 2010. Only patients with an isolated ACL or PCL

TABLE 1
Demographics of Patients Included and Patients Lost to Follow-up[a]

	PCL Injuries		ACL Injuries	
	Lost to Follow-up (n = 26-27)	Postoperative (n = 44-45)	Lost to Follow-up (n = 4431-4524)	Postoperative (n = 5137-5230)
Age at injury, y, mean ± SD	23.7 ± 9.3	23.3 ± 10.3	25.8 ± 9.4	26.7 ± 10.2
Age at surgery, y, mean ± SD	26.0 ± 9.2	27.7 ± 10.8	27.7 ± 9.9	28.7 ± 10.6
Median time from injury to surgery, mo	22.5	20.5	8.0	8.0
Sex, male/female, n	16/10	19/26	2871/1640	2649/2502
	61.5%/38.5%	42.2%/57.8%	63.6%/36.4%	51.3%/48.7%
Meniscal lesions,[b] n (%)	3 (11.5)	5 (11.1)	2217 (49.3)	2539 (49.2)
Cartilage lesions (ICRS grade 1-4),[b] n (%)	6 (23.1)	14 (31.1)	1033 (23.0)	1301 (25.2)

[a]ACL, anterior cruciate ligament; ICRS, International Cartilage Research Society; PCL, posterior cruciate ligament.
[b]Some knees had multiple lesions.

TABLE 2
Results 2 Years After Primary ACL and PCL
Reconstruction, as Measured by KOOS[a]

KOOS Subscale	Mean Score, Preop/2-y Follow-up	Change (95% CI)	P Value
Symptoms			
ACL (n = 5230)	72.7/77.3	5.1 (4.1 to 5.2)	<.001
PCL (n = 45)	63.4/64.3	0.9 (–6.6 to 8.3)	.82
Pain			
ACL (n = 5149)	74.3/84.9	10.5 (10.2 to 11.1)	<.001
PCL (n = 45)	57.5/72.6	15.1 (8.5 to 21.8)	<.001
ADL			
ACL (n = 5150)	83.1/91.2	8.1 (7.7 to 8.6)	<.001
PCL (n = 45)	68.7/81.9	13.2 (6.6 to 19.9)	<.001
Sports			
ACL (n = 5137)	43.1/66.1	23.0 (22.2 to 23.8)	<.001
PCL (n = 44)	25.6/46.3	20.7 (11.8 to 29.4)	<.001
QoL			
ACL (n = 5192)	34.9/66.6	31.7 (31.0 to 32.4)	<.001
PCL (n = 45)	26.4/53.0	26.6 (18.9 to 34.2)	<.001

[a]ACL, anterior cruciate ligament; KOOS, Knee injury and Osteoarthritis Outcome Scale with subgroup symptoms, pain, activities of daily living (ADL), sports/recreation, and knee-related quality of life (QoL); PCL, posterior cruciate ligament; Preop, preoperative.

injury were included to avoid the effects of having more complex knee ligament injuries included in the current trial. Here, we define isolated PCL ruptures as PCL injuries with or without concomitant meniscal or cartilage damage but without any other ligament injury or injuries to the posterolateral corner. We also excluded patients with fractures, patella tendon ruptures, and other serious injuries (nerve and blood vessel injuries), as these are special cases (Figure 1). Patients with concomitant meniscal and cartilage injuries were included because they are commonly associated with both isolated ACL and PCL injuries. A total of 9661 patients with primary isolated ACL ruptures and 71 patients with primary isolated PCL ruptures were initially included (Figure 1). There was a loss of patients to follow-up, with demographic data presented in Table 1. The

median patient age at the time of surgery (±SD) was 26.2 ± 9.9 years for ACL patients and 23.4 ± 9.8 years for PCL patients. KOOS score at 2-year follow-up was 2.1 ± 0.2 years. Autografts were most commonly used with both ACL (99.8%) and PCL (95.8%) ruptures; hamstring and patella tendon grafts were applied: 71.1% hamstring tendons in the ACL reconstructions and 78.9% hamstring tendons in the PCL reconstructions. The distribution of meniscal and cartilage lesions found during surgery in the isolated ACL- and PCL-injured knees registered in the NKLR register have been described in a previous study.[1]

In the present study, all patients from these cohorts who had completed the KOOS scale at 2-year follow-up were included, representing a total of 5192 (56%) patients with isolated ACL ruptures and 45 (65%) patients with isolated PCL ruptures.

Statistical analyses were performed using R software (http://www.R-project.org) and SPSS Statistics for Windows (version 21.0; IBM Corp). Data were compared with the results from a previous study.[1] Mean KOOS subscale scores for the different subgroups were calculated preoperatively for both the ACL and PCL groups. These values were then compared with the corresponding values at the 2-year follow-up, and 95% CIs were calculated based on paired-sample *t* tests. Then, the changes in the PCL patients were compared with the relative changes in the control group (ACL patients). The chi-square test was used to compare the categorical data. The correlation was calculated using the Pearson correlation coefficient.

RESULTS

The delay to surgery was longer for PCL patients compared with ACL patients (median, 21.5 vs 8.0 months; $P < .001$). None of the improvements observed in the KOOS subscale scores differed significantly between PCL and ACL patients. There were significantly greater numbers of meniscal lesions among ACL patients ($P < .001$) and cartilage lesions (International Cartilage Repair Society [ICRS] score, 1-4) among PCL patients ($P = .02$).
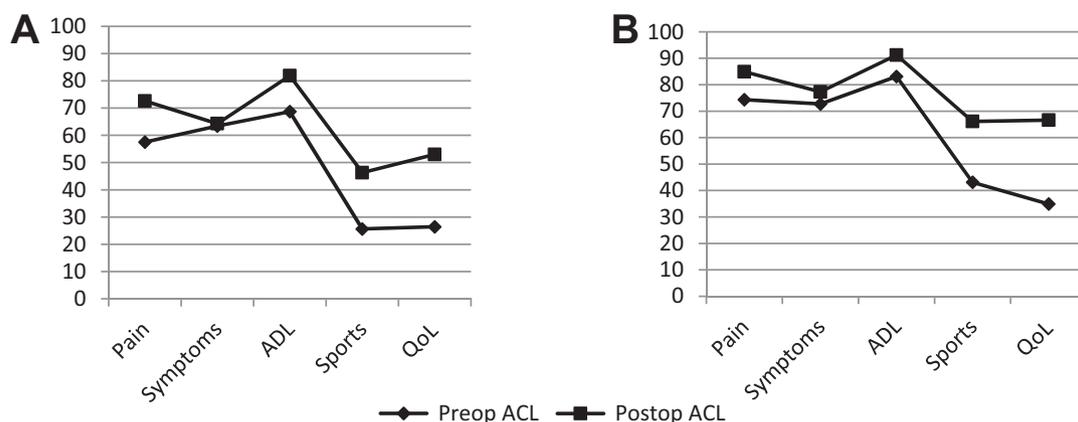
Figure 2. (A) Pre- and postoperative PCL KOOS score. (B) Pre- and postoperative ACL KOOS score. ACL, anterior cruciate ligament; ADL, activities of daily living; KOOS, Knee injury and Osteoarthritis Outcome Score; QoL, knee-related quality of life; PCL, posterior cruciate ligament.

At postoperative follow-up, the score increase for PCL patients ranged from 0.9 to 26 for all KOOS subscales. The score increase for PCL patients was significant and clinically relevant for all subgroups, except for the symptoms subscale (Table 2). PCL patients demonstrated greater postoperative improvements in the pain and ADL subgroups than ACL patients (Table 2); however, this finding is not statistically significant. For PCL patients, the greatest change was observed in QoL (26.6 points). There was a significant correlation between the preoperative QoL score and that at follow-up, with a Pearson correlation coefficient of $r = 0.3$ ($P = .04$).

For the ACL group, the scores were significantly increased in all subgroups, although the symptom score only increased by 4.7 and the ADL score increased by 8.1 points; neither of these increases is considered to be clinically relevant (Table 2). During the follow-up period, 428 patients (4.4%) had their ACLs revised, and 1 patient (1.4%) underwent revision surgery after primary PCL reconstruction.

DISCUSSION

The key finding of the present study was that at 2 years, the improvements in the KOOS subjective outcome scores in patients with isolated PCL injuries are equivalent to that in ACL patients. This result is novel because previous studies have not included a comparison group for the observed improvement other than the preoperative scores in the group studied. PCL patients have overall lower KOOS subscale scores both preoperatively and at 2 years. The differences in the KOOS score cannot be explained by sex, time from injury to surgery, or patient age.[1] Further and larger studies are needed to address why PCL patients have lower knee function scores compared with ACL patients.

Previous studies have claimed that there is a higher threshold for the surgical treatment of PCL injuries compared with ACL injuries,[8] which can partly be explained by the incidence of the injuries and perhaps, by the fact that the PCL surgery is more technically demanding than ACL

surgery. Whereas ACL injuries are fairly common and many orthopaedic surgeons have broad experience in treating such injuries, the opposite is true of PCL injuries. Thus, there is a lack of consensus regarding both how to treat the patients and when to perform surgical reconstruction, which also implies that the preoperative score used in many studies as the baseline might vary between different studies. Part of the improvement observed might be related to a focused rehabilitation program and not necessarily the surgical procedure itself. The nonoperative treatment approach and the duration of the rehabilitation program for both ACL and PCL patients should be fairly similar in terms of regaining range of motion, stability, and muscle strength. It has been suggested that, as is evident in this study, instability is the primary issue in the ACL-injured knee and that pain might be the primary issue in knees with PCL injuries[1] (Figure 2). However, to assess the benefits of surgery, a commonly used knee score, such as the KOOS scale, is important. In addition, the use of comparable knee surgery procedures makes it possible to evaluate these issues more objectively compared with baseline scores. Based on our results, it is evident that there is no difference between the observed improvements in patients with isolated PCL injuries and those seen in patients with ACL injuries. It is likely the previously suggested value of 44 points or less on the KOOS QoL measurement can be used as a guideline when choosing surgical treatment. As demonstrated in the current study, there is a significant correlation between the preoperative QoL score and that at follow-up. According to the guidelines for treating ACL injuries provided by the American Academy of Orthopaedic Surgeons, important indications for surgery are the preinjury activity level and the fear of future giving-way episodes. Preoperative screening programs evaluating patients as either copers or noncopers have also been considered to be important for outcomes.[3] These factors may also be important for PCL injuries, but further studies are needed. The time elapsed from injury to surgery might also explain some of the differences in the number of cartilage injuries.[20] Over time, many patients with PCL injuries develop medial and

patellofemoral osteoarthritis.[18] In some cases, this development can be explained by the greater number of injuries to the articular cartilage. Another important explanation is the altered biomechanics of the medial and patellofemoral joint of a PCL-deficient knee.

Whether single-bundle surgery is the ideal technique for treating PCL injuries based on the anatomy is a matter of debate.[24] A recent cadaveric biomechanical study has demonstrated differences in results depending on whether the single- or double-bundle technique was used.[7] Similarly, a recent clinical study has also reported better stability using the double-bundle technique.[9] This finding may alter our surgical approach to treating these patients in the future, and as such, there is potential for even more substantial improvements in functional outcomes than those observed in the current study. Further clinical trials are warranted to determine if this is the case.

One limitation of our study is that we only examined isolated PCL injuries. The results for combined injuries may differ, but this investigation was not within the scope of our current study. Our study was based on data from a registry; thus, there is also the potential for underreporting of associated injuries, which could theoretically affect the results in either direction. Another limitation is that we do not have a matched control group for the study population. The registration rate of 86% could also theoretically affect the results. The registry contains no objective clinical information and no grading of injuries. The operations have been performed by several surgeons using different grafts for reconstruction. This might affect the results in either way. The true baseline KOOS values could be either lower or higher than what is found in the registry. In the majority of cases analyzed in this study, the surgeries used the single-bundle technique with hamstring autograft, which could result in smaller benefits of surgery compared with other techniques. However, these data were included in the registry, and if double-bundle surgery for PCL injuries becomes more commonly used, it can be evaluated by future studies. Another limitation of the study—the use of a nationwide registry that reported the results from 1 specific country—can also be considered a strength. However, other studies have demonstrated that the registry's knee ligament results are comparable with the results in neighboring countries and the United States. Whether the results can be extended to other regions, including Asia, must be investigated further in similar studies from these regions.[5,10,12]

We performed a follow-up of 63% of the KOOS scores at 2 years, which is similar to other registry studies. This represents a lower follow-up than we hoped for and a loss to follow-up of more than one-third of the patients. However, there were no obvious characteristics of the patients who did not provide KOOS measurements at the 2-year follow-up (see Table 1), except that more women participated in the follow-up. This finding was true for both ACL and PCL patients. It is also a consistent finding in survey response rates (based on sex) from other (medical) research fields.[17,23] It is unknown if or how this finding affects the results, but there are no significant differences in the preoperative or postoperative scores between men and women.

CONCLUSION

Patients suffering from isolated PCL injuries benefit as much as ACL patients from surgery, according to incremental increases in KOOS scores at 2 years, despite the fact that PCL-injured patients have an overall lower KOOS score preoperatively and at the 2-year follow-up. Additionally, PCL patients wait longer for primary reconstruction than ACL patients, which might reduce functional improvement after surgical treatment.

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