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An isolated rupture of the posterior cruciate ligament results in reduced preoperative knee function in comparison with an anterior cruciate ligament injury

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Abstract
Purpose To investigate differences in preoperative knee function (Knee Injury and Osteoarthritis Outcome Score, KOOS), the time period from injury to surgery, and associated injuries when comparing primary isolated posterior cruciate ligament (PCL) and primary anterior cruciate ligament (ACL) reconstructions.
Methods Isolated primary ACL and PCL reconstructions registered in the Norwegian National Knee Ligament Registry from 2004 through 2010 were included (n = 71 primary PCLs and 9,649 primary ACLs). Linear regression analysis was used to evaluate the preoperative KOOS subscale values.
Results The preoperative KOOS in the PCL group (n = 71) and ACL group (n = 9,649) was significantly different for the subscales symptoms (mean difference, −8.4; 95 % CI: −12.8 to −4.0), pain (mean difference, −15.9; 95 % CI: −20.3 to −11.4), activities of daily living (mean difference, −12.9; 95 % CI: −17.4 to −8.4), sport and recreation (mean difference, −15.9; 95 % CI: −22.6 to −9.3), and quality of life (mean difference, −7.9; 95 % CI: −12.4 to −3.5). The primary isolated PCL-reconstructed knees had a median time from injury to surgery of 21 months in comparison with 8 months for ACL injuries. The ACL-injured knees had more associated injuries (meniscus and full-thickness cartilage lesions) than the PCL-injured knees.
Conclusion Surgically treated knees with an isolated rupture of the PCL exhibited worse knee function preoperatively compared with knees with an isolated ACL injury; in addition, the delay to surgery was longer. Meniscal lesions were found more frequently in ACL-injured knees.
Level of evidence Prospective cohort study, evidence Level I.

Keywords Posterior cruciate ligament · Anterior cruciate ligament · Knee function · Time from injury to surgery · Registries

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Introduction

An isolated posterior cruciate ligament (PCL) injury accounts for approximately 17 % of all knee injuries [3, 17]. The PCL is the strongest ligament in the knee, and its total tear results in posterior translation of the tibia as well as increased strain on the medial femoral condyle [9] and posterolateral structures. Anterior cruciate ligament (ACL) injuries in the knee are frequently treated surgically (50 %) [12]; while, surgery was performed in only four out

of 142 patients (3 %) in a cohort using non-operative management of isolated PCL injuries [22]. Recent publications reported PCL reconstruction surgery is the preferred treatment. In one study, six of 23 (26 %) patients with PCL injuries, with less than 10 mm posterior translation, underwent reconstruction [15]. It is unclear whether reconstruction of isolated PCL injuries should be performed more often. Patients with isolated PCL tears may have few functional limitations; although in one study, 26 % of patients reported feeling residual instability [22]. The preoperative rehabilitation period should probably be the same for both PCL and ACL injuries to achieve the full range of motion and regain muscle strength. Accordingly, one would expect the period from injury to surgery to be similar in the two groups. The preoperative knee function may be similar in the two groups, given that poor knee function in spite of a preoperative rehabilitation programme is an indication of operative treatment in isolated ACL and PCL injuries. As described above, there are reports that 50 % of patients underwent operative treatment for isolated ACL injuries and 26 % for isolated PCL injuries [12, 15]. Associated injuries, such as in the cartilage and meniscus, are frequent in both ACL- and PCL-injured knees, with increasing time periods between injury and surgery [4, 10].

The current study investigates the following three hypotheses:

1. The time period from injury to surgery is the same in PCL and ACL injuries.
2. Associated injuries in PCL- and ACL-deficient knees, defined as meniscal tears and full-thickness cartilage lesions on the day of surgery, occur at the same frequency.
3. The preoperative knee function evaluated by the Knee Injury and Osteoarthritis Outcome Score (KOOS) is the same in PCL- and ACL-reconstructed knees.

Finally, the effect of isolated PCL versus ACL injuries on the various preoperative KOOS subscales is estimated.

Materials and methods

Since June 2004, in Norway, surgeries of the ACL and PCL and associated injuries have been prospectively registered in the Norwegian National Knee Ligament Registry (NKLR). The NKLR has been described previously, and registration is reported to be 97 % complete [11, 24]. Informed consent is provided with the preoperative KOOS form and a standardized surgery form. Previously, it was estimated that a change or difference of 10 points in any of the subscales in KOOS represents a clinically significant difference [11]. Both primary and revision surgeries are registered as well as subsequent knee surgeries. Registration includes previous surgeries; sex; age; activity causing the injury; date of injury; concomitant cartilage lesions with localization, size, ICRS (International Cartilage Repair Society) grading and treatment; concomitant meniscal lesions and treatment; choice of graft; and fixation. Data from stress X-rays and preoperative MRIs are not included in the registry. The information forwarded to the registry is based on the individual knee surgeon or knee group algorithm for the diagnosis of the isolated posterior cruciate ligament with the final summary of injuries diagnosed during the operative procedure. In the current study, full-thickness cartilage lesions were grouped as ICRS grade 3 and 4 [19]. The registry contained 10,575 primary cruciate ligament reconstructions by the end of 2010. We defined an isolated ACL or PCL injury when there were no other registered injuries except from meniscal or cartilage lesions. Of the 295 PCL-reconstructed injuries in the registry, 71 (24 %) were isolated. The registered injuries associated with the PCL were 190 total ACL ruptures, 2 partial ACL ruptures, 122 medial collateral ruptures, and 73 posterior lateral corner injuries. In addition, 16 injuries, including fractures and vessel and nerve injuries, were excluded. The Consort flow chart in Fig. 1 illustrates the case allocation for the cohort included in the analyses. Demographics of the patients with isolated PCL and ACL reconstructions are reported in Tables 1 and 2 outlines the meniscal and cartilage injuries registered. The knee injuries were diagnosed based on the pre- and intraoperative evaluation by the orthopaedic knee surgeon and often included MRI and stress X-rays. However, this information is not provided to the registry and, thus, could not be reported in the study.

Data collection and processing

The NKLR database was searched for cases with primary PCL and ACL injuries from 2004 to 2010. A total of 10,575 cases were eligible for further analyses. The three most common activities at injury were reported to illustrate possible differences in the cause of ACL and PCL injuries. Time from injury was registered in months.

Ethics

Participation in the NKLR is voluntary, for both surgeons and patients. Patients sign an informed consent, and the NKLR is approved by the Norwegian Data Inspectorate. All data extracted from the registry are anonymized.

Statistical analysis

Linear regression analyses were used to determine the effect of PCL versus ACL injuries on the different

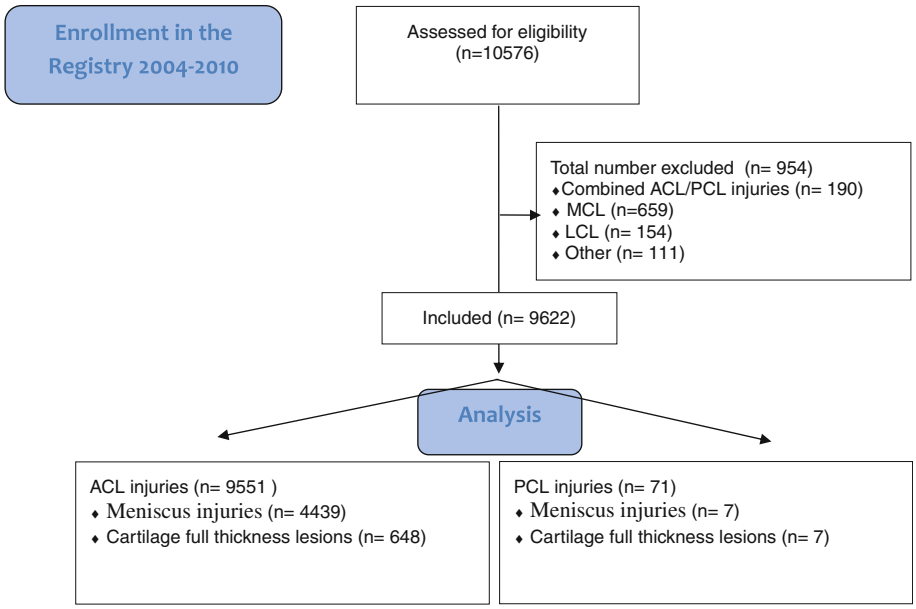

Fig. 1 Consort flow diagram

Table 1 Demographics of the patients included in this study

	Isolated PCL injury N = 71	Isolated ACL injury N = 9,551
Gender (number of male/female)	35/36	5,458/4,093
Months from injury to surgery	21.5	8.0
Meniscus injury	9.9 %	46.5 %
Cartilage injury	9.9 %	6.8 %
Mean age at surgery (±SD)	23.4 ± 9.8	26.2 ± 9.9

Table 2 Registered injuries on the meniscus and full-thickness cartilage (ICRS grade 3 and 4) in PCL-injured knees (n = 71) versus ACL-injured knees (n = 9,090)

	Isolated PCL injury	Isolated ACL injury
Lateral meniscus	5	2322
Medial meniscus	3	3048
Cartilage injury Medial femur condyle	6	399
Lateral femur condyle	0	121
Trochlea	2	53
Lateral tibia	0	51
Medial tibia	1	81
Patella	0	80

These numbers represent all injuries diagnosed during the reconstructive procedure for the cruciate ligament

subscales of the KOOS. In the multivariate analyses, we adjusted for sex, age at time of surgery, months from injury to surgery, meniscal tears, and full-thickness cartilage lesions. The Wilcoxon rank test was used when comparing time to surgery and age in the ACL and PCL groups. The chi-squared test was used when comparing categorical data. The software package R was used for the statistical analyses (http://www.R-project.org).

Results

The three most common causes of isolated PCL injuries were 17 traffic accidents (24 %), 15 soccer injuries (21 %), and 12 team handball injuries (17 %). For isolated ACL injuries, soccer accounted for 3,953 cases (41 %), team handball for 1,457 cases (15 %), and skiing for 1,256 cases (13 %). The only difference noted in cause of injury was that traffic accidents were more commonly the cause in isolated PCL injuries than in ACL injuries. The time from injury to surgery was longer for the isolated PCL injuries than for isolated ACL injuries, with a median of 21 and eight months, respectively (Fig. 2. The mean age in the two groups was similar at the time of reconstruction, as reported in Table 1.

Full-thickness cartilage injuries were found more frequently in PCL-injured knees (9.9 %) than ACL-injured knees (6.8 %), but the difference was not statistically significant. Meniscal lesions were more common in ACL-injured knees compared with PCL-injured knees, with frequencies of 46.5 and 9.9 %, respectively ($p < 0.001$). Patients with isolated PCL ruptures undergoing surgery reported lower mean preoperative KOOS than patients with isolated ACL ruptures. The scores from both groups are shown in Fig. 3. The effect of a PCL injury versus ACL injury on the KOOS subscales varied from −7.9 for the

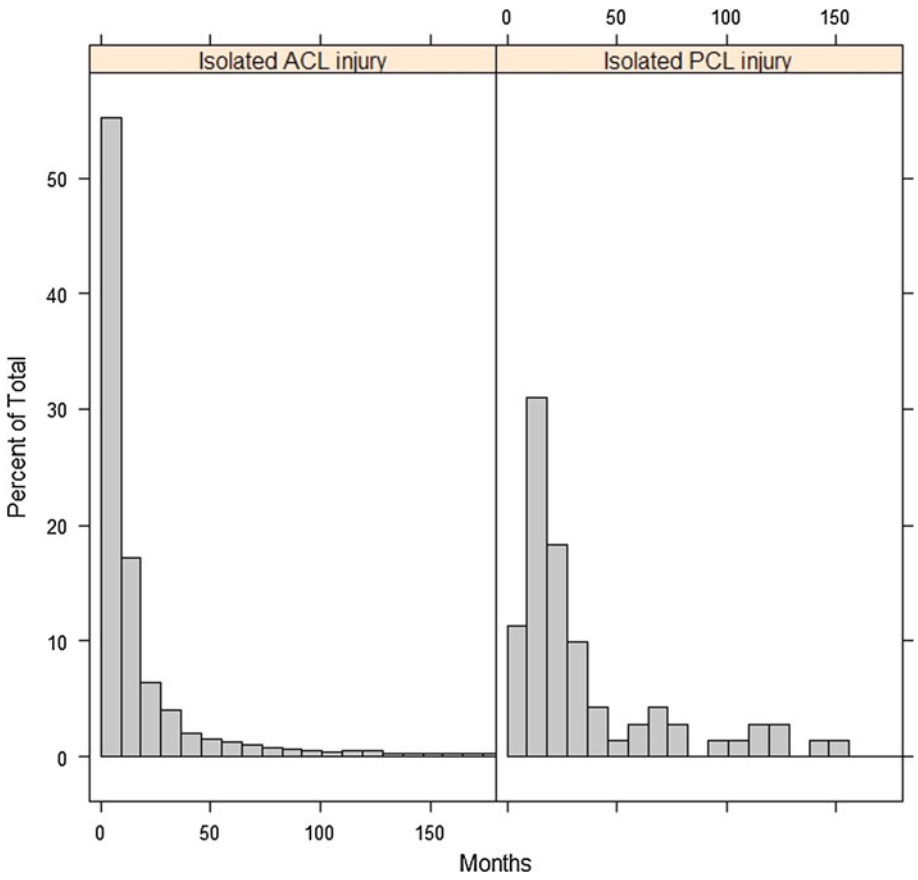

Fig. 2 Time from injury to reconstruction in months

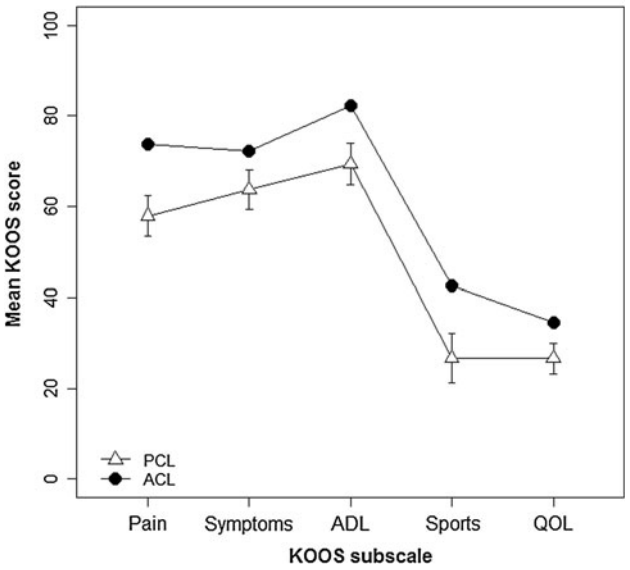

Fig. 3 Preoperative KOOS values in ACL- and PCL-reconstructed knees

quality of life subscale to −16.0 for the sports and recreation subscale. The corresponding adjusted effects ranged from −8.7 to −17.8. Both the unadjusted and adjusted effects of PCL versus ACL injury are reported in Table 3.

Discussion

The major finding in the current study is that an isolated rupture of the PCL is associated with significantly lower knee function, as evaluated by the KOOS at the time of reconstruction, compared with an isolated ACL rupture. It was previously reported that a significant proportion of knee anterior ligament injuries can be managed with a structured rehabilitation programme [6]. There is little knowledge available on the rehabilitation of patients with PCL injuries, although functional adaptation for the instability (6–10 mm) has been described for the isolated posterior cruciate–deficient knee [1, 8]. One reason for the observed differences in preoperative knee function in this study may be that the threshold for knee ligament surgery is higher for the isolated PCL injury than for the ACL injury. Surgeons may feel that the PCL reconstruction is more technically demanding or that the current techniques are not sufficient to restore normal knee function; thus, the observed difference could be caused partly by selection bias. A delay in treatment has also been observed by other researchers [21]. Other authors have reported that surgical decisions should be made less than 1 year from injury and before cartilage damage is present [13]. However, it is difficult to determine whether a cartilage lesion has

Table 3 Differences in the Knee Injury and Osteoarthritis Outcome Score (KOOS) between PCL- and ACL-injured knees

KOOS subscales	Unadjusted differences PCL- vs. ACL-injured knees (95 % CI)	Missing data	Adjusted differences[a] PCL- vs. ACL-injured knees (95 % CI)	Missing data
Pain	−15.9 (−20.4 to −11.5)	1,402	−16.5 (−20.9 to −12.2)	1,761
Symptoms	−8.5 (−12.8 to −4.1)	1,348	−9.5 (−13.9 to −5.2)	1,708
ADL	−12.9 (−17.4 to −8.5)	1,422	−13.7 (−18.0 to −9.4)	1,778
Sport/recreation	−16.0 (−22.6 to −9.4)	1,474	−17.8 (−24.3 to −11.3)	1,827
QoL	−7.9 (−12.4 to −3.5)	1,399	−8.7 (−13.2 to −4.3)	1,756

ADL activity of daily living, *QoL* quality of life

[a] In multivariate analyses, the differences are adjusted for the effects of gender, age, days from injury to surgery, meniscal lesions, and full-thickness cartilage lesions

occurred at the time of the knee injury or is acquired in the time span from injury to surgery.

In the current study, the incidence of cartilage injuries was not significantly different between ACL and PCL-injured knees, but PCL reconstructions were delayed more than ACL reconstructions. Despite a longer time period between injury and surgery, which likely increases the load on the medial compartment, there were not more meniscal tears or full-thickness cartilage lesions at the time of surgery for PCL injuries compared with those for ACL injuries. The final diagnosis of the associated injuries as meniscus and cartilage lesions is made during the reconstructive procedure. Thus, it is not possible to determine whether they were present since the injury occurred or are a result of the untreated stable knee. Accordingly, such information is not provided to the registry. A prior study reported that the frequency of cartilage lesions in the first 12 months was not increased in ACL-injured knees, although an increase was found when reconstructive surgery was delayed more than 12 months [20].

It is surprising that the isolated PCL injuries have a much lower KOOS in comparison with isolated ACL injuries. The reasons for this are not clear. The isolated PCL rupture may cause alterations in biomechanical loading of the knee cartilage and to the posterolateral corner, resulting in decreased knee function. It might also be that preoperative management of the isolated PCL injury needs further improvement, such as a new dynamic brace to optimize the preoperative knee function [14]. In ACL reconstructions, it has been observed that the preoperative knee function is a strong predictor of the final knee function after surgical treatment. It is recommended that reconstruction is not performed until quadriceps strength is less than 20 % reduced compared with the uninjured side [7]. This might be even more important in the PCL-injured knee where the quadriceps are the major posterior stabilizer, although this might also be a risk factor for patellofemoral arthritis [5]. A follow-up study on a cohort of subjects with PCL reconstructions showed patients did not regain knee function to the same level as ACL-reconstructed knees, although improved results were recently reported [16]. A review of studies on PCL treatments revealed the designs of the studies were too weak to make firm conclusions [23]. Lately, double-bundle PCL reconstructions were reported, although the result does not seem to be clearly different from that of the single bundle [2, 16, 18].

The major weakness of the current study is the probability of being misled by the individual knee surgeon or the MRI examination by missing the posterolateral corner injury, especially because no stress X-ray measurements from the current cohorts are part of the registry data. The possibility of overlooked associated injuries is a weakness of all registries. Arthroplasty registries have implied that registry data can never replace the information provided by a well-performed randomized clinical trial (RCT), but can more accurately reflect daily practice compared with RCTs where the treatment is often optimized.

The null hypotheses in the current study were rejected. Isolated PCL-injured knees that underwent surgery had an inferior preoperative knee function evaluated with KOOS, a significantly longer time period between injury and surgery, and less meniscal lesions at the time of surgery compared with ACL-injured knees scheduled for surgery. These results suggest the need for improved preoperative and postoperative training, as well as a surgical reconstruction technique for the isolated PCL injury. The clinical relevance of the study is that isolated PCL injuries scheduled for surgery have inferior knee function compared with ACL-injured knees. In addition, our results suggest that the decision for either operative or non-operative treatment should be made earlier.

Conclusion

The isolated PCL-injured knee demonstrated significantly inferior preoperative knee function in comparison with the isolated ACL-injured knee scheduled for surgery. The inferior knee function cannot be explained by sex, time from injury to surgery, or age. Further basic and clinical research on posterior cruciate knee ligaments is warranted

to determine the optimal treatment for this challenging knee injury.

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