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Inferior clinical outcomes and higher subjective treatment failure after revision compared to primary posterior cruciate ligament reconstruction: A propensity score-matched analysis

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Abstract

Purpose: To compare subscales of the Knee injury and Osteoarthritis Outcome Score (KOOS), concomitant injuries and failure rates between patients undergoing primary and revision posterior cruciate ligament reconstruction (PCLR).

Methods: This study was based on three major Scandinavian knee ligament registries (Sweden, Norway, Denmark). Patients undergoing primary and revision PCLR between 2005 and 2019 were included. Demographic characteristics, concomitant injuries and KOOS subscales were queried. A 3:1 propensity score matching was performed (i.e., three primary PCLR patients were matched to one revision PCLR patient). Subjective treatment failure was assessed at final follow-up and was defined as <44 points on the KOOS knee-related quality of life (QoL) subscale.

Results: A total of 135 patients who underwent primary PCLR (mean age, 30.0 ± 11.0 years) were matched with 45 patients who underwent revision PCLR (mean age, 29.0 ± 10.5 years) and analysed after a mean follow-up of 21.7 ± 5.5 months. At the time of surgery, there was no difference in concomitant meniscus (40% vs. 36%, $p = 0.63$), cartilage (12% vs. 4%, $p = 0.15$), anterior cruciate ligament (53% vs. 40%, $p = 0.13$) and neurovascular (1% vs. 7%, $p = 0.057$) injuries. There were no between-group differences in any preoperative KOOS subscales. Postoperatively, KOOS QoL subscale was significantly lower after revision PCLR compared to primary PCLR (35.9 ± 23.0 points vs. 51.7 ± 23.6 points, $p = 0.005$). At final follow-up, 55% and 70% of patients met the criterion for subjective treatment failure after primary and revision PCLR, respectively ($p = 0.32$).

Abbreviations: ACL, anterior cruciate ligament; ADL, activities of daily living; CI, confidence interval; DKRR, Danish knee ligament reconstruction registry; IKDC, International Knee Documentation Committee; KOOS, knee injury and osteoarthritis outcome score; MCID, minimal clinically important difference; MD, mean difference; NKLR, Norwegian knee ligament register; PCL, posterior cruciate ligament; PCLR, posterior cruciate ligament reconstruction; PLC, posterolateral corner; PMC, posteromedial corner; PROMs, patient-reported outcome measures; QoL, knee-related quality of life; SKLR, Swedish knee ligament register; Sport/Rec, sport and recreation function; STROBE, strengthening the reporting of observational studies in epidemiology.

Conclusion: Both primary and revision PCLR resulted in significant clinical improvements. However, more than 50% of the patients in each group experienced subjective treatment failure, indicating generally poor prognostic outcomes. Nevertheless, patients undergoing primary PCLR demonstrated significantly better knee-related QoL compared to patients undergoing revision PCLR.

Level of Evidence: Level II, prospective observational cohort study.

KEYWORDS

failure, knee, multiligament, posterior cruciate ligament, registry, revision

INTRODUCTION

Encouraging clinical and functional improvements after primary posterior cruciate ligament (PCL) reconstruction (PCLR) have been reported in recent years, suggesting that surgical treatment may be favourable over non-surgical treatment in the setting of primary PCL injuries, especially in young and athletic patients [10, 26, 28, 35]. However, PCLR failure rates of 2%–18%, which may be as high as 50% when subjective failure is considered, present a major therapeutic challenge to orthopaedic surgeons treating patients with PCL injuries [10, 23, 33].

PCLR failure is a debilitating knee injury that impairs function and quality of life, posing a substantial burden on affected patients [18, 25, 37]. Despite progress in the treatment of primary PCL injuries, the body of evidence on the occurrence and management of recurrent PCL injuries remains insufficient [9, 36, 37]. To date, PCLR failure has been defined heterogeneously and may refer to structural failure (e.g., PCLR graft rupture), objective failure (e.g., persistent or recurrent posterior knee laxity), or subjective failure (poor functional outcomes) [23, 33]. While seldom discussed, the multifactorial nature of PCLR failure has previously been described, and includes bone tunnel malplacement, varus malalignment, decreased posterior tibial slope and untreated concomitant ligamentous injuries [24, 33, 38].

The contribution of anatomical factors, tibiofemoral malalignment and persistent ligamentous instability is consistent with the multifactorial aetiology of anterior cruciate ligament (ACL) reconstruction failure [30, 34, 39, 40]. Large-scale studies have reported that revision ACL reconstruction is associated with inferior clinical outcomes and higher failure rates than primary ACL reconstruction [14, 15, 21]. Given the low incidence of PCL injuries requiring surgical treatment and the even lower incidence of revision PCLR, studies comparing primary and revision PCLR are sparse, and are limited to small case series assessing revision PCLR outcomes [7, 18, 25]. Although significant improvements in patient-reported outcome measures (PROMs) and posterior knee laxity have been reported, individuals can also suffer from considerable restrictions in physical activity after revision PCLR [7, 18, 25]. Additionally, only 65% of patients were reported to achieve a patient acceptable symptom state after revision PCLR, and almost 15% of patients required revision surgery [7, 9]. The previous findings prompt critical assessment of the clinical efficacy of revision PCLR compared to primary PCLR.

The purpose of this study was to compare subscales of the Knee injury and Osteoarthritis Outcome Score (KOOS), concomitant injuries and failure rates between patients undergoing primary and revision PCLR after a minimum 1-year follow-up. It was hypothesised that revision PCLR results in inferior KOOS subscales, more concomitant injuries and a higher failure rate than primary PCLR.

MATERIALS AND METHODS

This prospective observational cohort study was approved by the ethical review authorities of Sweden (No.: 2020-03559; 2021-01002). The manuscript was prepared according to the strengthening the reporting of observational studies in epidemiology (STROBE) cohort reporting guidelines [31].

Three Scandinavian knee ligament registries, including the Swedish knee ligament register (SKLR) [1], Norwegian knee ligament registry (NKLR) [12] and Danish knee ligament reconstruction registry (DKRR) [19], were used in this study. Detailed information on the SKLR, NKLR and DKRR has previously been described elsewhere [1, 12, 23, 27, 29, 32]. The key characteristics of the registries are outlined below.

Swedish Knee Ligament Register (SKLR)

The SKLR represents a nationwide database initiated in 2005 with prospectively collected patient-, injury- and surgical-related data on knee ligament injuries. Private and public hospitals across Sweden participate in the data collection on a voluntary basis.

Preoperatively and 1, 2, 5 and 10 years postoperatively KOOS subcales are collected [29, 32]. A registration rate for ACL reconstructions >90% has been reported [1], suggesting a similarly high capture rate for PCLR.

Norwegian Knee Ligament Registry (NKLR)

The NKLR was initiated in 2004. The NKLR prospectively collects data from patients undergoing cruciate ligament surgery across Norway. Since 2017, data registration has been mandatory for public and private hospitals in Norway. Demographic, surgical-related and clinical data including subsequent knee surgery and revision surgery are collected by the surgeon. Preoperatively and 2, 5 and 10 years postoperatively KOOS subcales are collected. A registration rate of up to 98% has been reported [12, 23].

Danish Knee ligament Reconstruction Registry (DKRR)

The DKRR is a prospective nationwide database recording primary and revision knee ligament reconstructions across Denmark that was initiated in 2005. Registration to the DKRR is mandatory for public and private hospitals and a registration rate of 85%–92% has been reported. Demographic, surgical-related and clinical data are collected by the surgeon. Preoperatively and 1, 5 and 10 years postoperatively KOOS subcales and the Tegner acitivity scale are collected [27].

Inclusion and exclusion criteria

Patients undergoing primary or revision PCLR between 2005 and 2019 that were registered in the SKLR, NKLR or DKRR were screened for eligibility. Both patients with isolated and combined PCLR that had a minimum one-year follow-up were included in the study. Fractures, tendon injuries, infectious or inflammatory arthritis, concurrent osteotomy and missing data resulted in exclusion from the study.

Outcome measures

The KOOS subscales symptoms, pain, activities of daily living (ADL), sport and recreation function (Sport/Rec) and knee-related quality of life (QoL) were obtained from the SKLR, NKLR and DKRR at baseline (preoperatively) and at the available registry-specific follow-ups. Given varying follow-ups across the three registries, a mean follow-up time was calculated. The KOOS QoL subscale was considered the primary outcome measure. According to a previous study, <44 points on the KOOS QoL subscale was defined as subjective treatment failure [23]. In addition, demographic data (e.g., age at the time of surgery), injury mechanism and concomitant injuries (e.g., ACL, meniscus and cartilage injury at the time of surgery) were collected from the respective registries.

Propensity score matching

Given the expected low number of patients undergoing revision PCLR and to reduce selection bias between groups, a 3:1 caliper matching was performed (i.e., three primary PCLR patients were matched to one revision PCLR patient). Caliper matching is a specific form of propensity score matching, in which a maximum allowable difference (i.e., caliper) in the propensity score between matched individuals is predefined. Caliper matching ensures that only patients with sufficiently similar baseline characteristics are matched [2]. Exact matching was performed on key clinical variables including sex, country (i.e., Sweden, Norway or Denmark), and the presence of concomitant meniscal or cartilage injuries. For the age at surgery, a tolerance of ±0.5 on the natural logarithmic scale of age was allowed, enabling a controlled yet flexible age match. In addition, the matching algorithm was optimised for concomitant neurovascular injuries, side of injury and injury mechanism.

Statistical analysis

G*Power (Erdfelder, Faul, Buchner, Lang, HHU Düsseldorf) was used for a priori sample size calculation. According to a previous study evaluating outcomes of PCLR, a difference of 10 points in the KOOS QoL subscale was considered clinically relevant [20]. In addition, a standard deviation of 25 points for the KOOS QoL subscale was assumed based on a previous study for a priori sample size calculation [23]. The KOOS QoL subscale was used for sample size calculation as it was defined as the primary outcome measure and has been shown to have the largest effect size [8]. To achieve a statistical power of 0.8, a total sample size of 52 patients was required (effect size, 0.4; level of significance, 0.05).

Categorical variables were presented as count (n) and proportion (%). Continuous variables were presented as mean, standard deviation (SD) and range. For comparison between groups (primary PCLR vs. revision PCLR) Fisher's Exact test was used for dichotomous variables and the Chi-Square test was used for non-ordered categorical variables. Group comparison of continuous variables was performed

using the Fisher's non Parametric permutation test. The confidence interval (CI) for then mean difference between groups is based on Fishers non-parametric permutation test. KOOS subscales over time (preoperative vs. final follow-up) were compared using the Wilcoxon Signed Rank test. Statistical analysis was performed using the SAS statistical analysis system (SAS/STAT, V.9.4; SAS Institute). The level of significance was set at $p < 0.05$.

RESULTS

A total of 428, 789 and 833 patients from the SKLR, NKLR and DKRR, respectively, were screened for eligibility for this study. After excluding 1213 patients, a total of 837 patients were included in this study. Detailed information on patient enrollment is shown in Figure 1.

Primary PCLR was performed in 792 patients with a mean age of 33.1 ± 12.6 years at the time of surgery. Revision PCLR was performed in 45 patients with a mean age of 29.0 ± 10.5 years at the time of surgery. Patients who underwent revision PCLR were on average 4.1 years younger than patients undergoing primary PCLR (95% confidence interval [CI]: 0.40; 7.85 years; $p = 0.030$). In both primary and revision PCLRs, male patients were predominant, and sports-related injuries represented the most common injury mechanism. After propensity score matching, 135 patients with primary PCLR and 45 patients with revision PCLR were analysed and no between-group differences were found in demographic variables. Demographic data before and after propensity score matching can be found in Table 1.

Concomitant injuries and surgical procedures

ACL (52%) and meniscus injuries (40%) were the most frequent concomitant injuries in patients who underwent primary and revision PCLR. Cartilage injuries occured more frequently in the primary PCLR group (12% vs. 4%, $p = 0.15$), whereas neurovascular injuries occurred more frequently in the revision PCLR (1% vs. 7%, $p = 0.057$) group, but the difference was not statistically significant. No statistically significant differences in concomitant injuries and surgical procedures between primary and revision PCL reconstruction were observed before and after propensity score matching (Table 2).

Clinical outcomes and treatment failure

KOOS subscales were analysed preoperatively and after a mean follow-up of 21.0 ± 6.2 months before

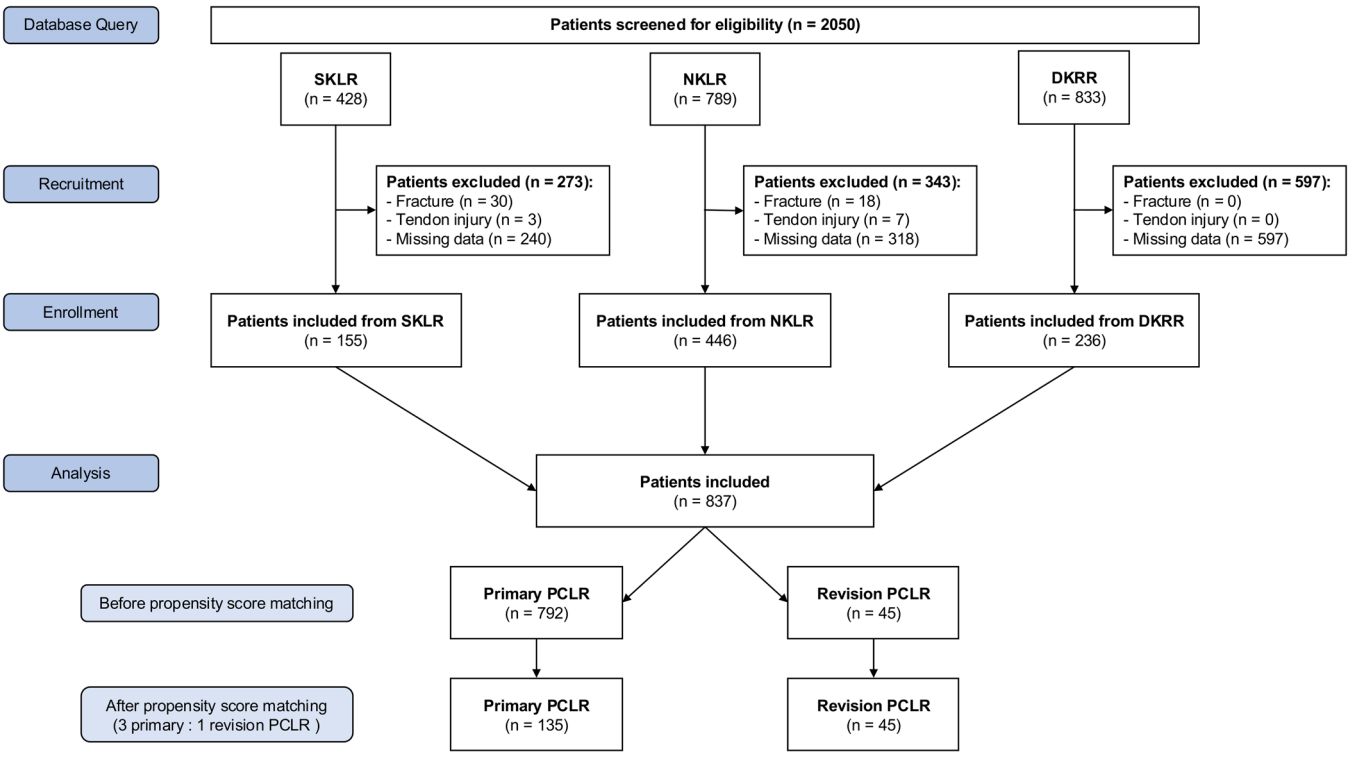

FIGURE 1 Flowchart of patient enrollment. DKRR, Danish Knee Ligament Reconstruction Registry; NKLR, Norwegian knee ligament registry; PCLR, posterior cruciate ligament reconstruction; SKLR, Swedish knee ligament register.

TABLE 1 Demographic data before and after propensity score matching.

Variable	Before propensity score matching				After propensity score matching			
	Total ($N = 837$)	Primary PCLR ($n = 792$)	Revision PCLR ($n = 45$)	p-value	Total ($n = 180$)	Primary PCLR ($n = 135$)	Revision PCLR ($n = 45$)	p-value
Register				0.69				>0.99
SKLR, n (%)	155 (19%)	148 (19%)	7 (16%)		28 (16%)	21 (16%)	7 (16%)	
NKLR, n (%)	446 (53%)	419 (53%)	27 (60%)		108 (60%)	81 (60%)	27 (60%)	
DKRR, n (%)	236 (28%)	225 (28%)	11 (24%)		44 (24%)	33 (24%)	11 (24%)	
Age,[a] (years)	32.9 ± 12.5	33.1 ± 12.6	29.0 ± 10.5	0.030	29.8 ± 10.8	30.0 ± 11.0	29.0 ± 10.5	0.61
BMI, (kg/m^2)	27.1 ± 7.2	27.2 ± 7.3	25.6 ± 4.5	0.24	25.8 ± 4.7	25.9 ± 4.8	25.6 ± 4.5	0.79
Injury to surgery, (years)	2.5 ± 4.0	2.5 ± 4.1	2.0 ± 2.5	0.68	2.3 ± 2.7	2.4 ± 2.7	2.0 ± 2.5	0.63
Males, n (%)	528 (63%)	502 (63%)	26 (58%)	0.54	104 (58%)	78 (58%)	26 (58%)	>0.99
Right knee, n (%)	404 (48%)	385 (49%)	19 (42%)	0.50	84 (47%)	65 (48%)	19 (42%)	0.61
Injury mechanism				0.42				0.97
Sports related, n (%)	475 (57%)	449 (57%)	26 (58%)		101 (56%)	75 (56%)	26 (58%)	
Traffic related, n (%)	171 (21%)	159 (20%)	12 (27%)		50 (28%)	38 (28%)	12 (27%)	
Other, n (%)	182 (22%)	175 (22%)	7 (16%)		29 (16%)	22 (16%)	7 (16%)	

Note: Categorical variables are expressed as count (percentage). Continuous variables are expressed as mean ± standard deviation.

Abbreviations: BMI, body-mass-index; DKRR, Danish knee ligament reconstruction registry; NKLR, Norwegian knee ligament registry; PCLR, posterior cruciate ligament reconstruction; SKLR, Swedish knee ligament register.

[a]Age at surgery.

propensity score matching and 21.7 ± 5.5 months after propensity score matching.

Statistically significant improvements in the KOOS subscales pain (mean difference [MD] 10.2, 95% CI [8.4; 12.0]), Sport/Rec (MD 18.4, 95% CI [15.9; 20.9]), QoL (MD 21.8, 95% CI [19.5; 24.1]) and ADL (MD 12.1, 95% CI [10.2; 14.0]) were observed from baseline to final follow-up (all $p < 0.001$) after primary PCLR. After revision PCLR, statistically significant improvements from baseline to final follow-up in the KOOS subscales Sport/Rec (MD 17.2, 95% CI [4.4; 29.6]), QoL (MD 10.6, 95% CI [1.7; 19.3]) and ADL (MD 11.7, 95% CI [1.1; 22.1]) were found (all $p < 0.05$, Table 3).

Preoperatively, no statistically significant differences were found between primary and revision PCL reconstruction for all KOOS subscales before and after propensity score matching. At final follow-up, the KOOS QoL subscale was found to be significantly inferior after revision PCL reconstruction compared to primary PCL reconstruction before (35.9 ± 23.0 vs. 51.2 ± 24.1, $p = 0.002$) and after (35.9 ± 23.0 vs. 51.7 ± 23.6, $p = 0.005$) propensity score matching (Figure 2). No differences were observed for the other KOOS subscales (Table 3).

Preoperatively, 84% of both primary and revision PCL reconstruction patients fulfilled the criterion for subjective treatment failure (KOOS QoL subscale < 44 points), both before and after propensity score matching. At final follow-up, subjective treatment failure was observed in 47% of patients who underwent primary PCLR and in 70% of patients who underwent revision PCLR ($p = 0.051$) before propensity score matching. After propensity score matching, subjective treatment failure at final follow-up was observed in 55% and 70% of patients with primary and revision PCLR, respectively ($p = 0.32$).

DISCUSSION

The most important finding of this study was that significant improvements in PROMs can be expected after both primary and revision PCLR. However, short-term subjective outcome is inferior after revision compared to primary PCLR. In particular, there was impairment in knee-related QoL observed after revision PCLR, with more than two thirds of patients meeting the criterion for subjective treatment failure (KOOS QoL < 44 points) at the final follow-up. Notably, even after primary PCLR, despite overall improvement in KOOS subscales, more than half of the patients fulfilled the criterion for subjective treatment failure, underscoring that

TABLE 2 Concomitant injuries and surgical procedures before and after propensity score matching.

	Before propensity score matching				After propensity score matching			
Variable	Total (*N* = 837)	Primary PCLR (*n* = 792)	Revision PCLR (*n* = 45)	*p*-value	Total (*n* = 180)	Primary PCLR (*n* = 135)	Revision PCLR (*n* = 45)	*p*-value
PCL graft, *n* (%)				0.12				0.14
BPTB autograft, *n* (%)	2 (< 1%)	2 (< 1%)	0 (0%)		0 (0%)	0 (0%)	0 (0%)	
Hamstring autograft, *n* (%)	166 (20%)	162 (20%)	4 (9%)		27 (15%)	23 (17%)	4 (9%)	
QT autograft, *n* (%)	71 (8%)	66 (8%)	5 (11%)		16 (9%)	11 (8%)	5 (11%)	
Allograft, *n* (%)	115 (14%)	106 (13%)	9 (20%)		24 (13%)	15 (11%)	9 (20%)	
Other, *n* (%)	37 (4%)	37 (5%)	0 (0%)		5 (3%)	5 (4%)	0 (0%)	
Missing, *n* (%)	446 (53%)	419 (53%)	27 (60%)		108 (60%)	81 (60%)	27 (60%)	
Meniscus injury, *n* (%)	336 (40%)	320 (40%)	16 (36%)	0.63	64 (36%)	48 (36%)	16 (36%)	>0.99
Medial, *n* (%)	59 (7%)	57 (7%)	2 (4%)		7 (4%)	5 (4%)	2 (4%)	
Lateral, *n* (%)	64 (8%)	59 (7%)	5 (11%)		20 (11%)	15 (11%)	5 (11%)	
Both, *n* (%)	213 (25%)	204 (26%)	9 (20%)	0.59	37 (21%)	28 (21%)	9 (20%)	>0.99
Cartilage injury, *n* (%)	100 (12%)	98 (12%)	2 (4%)	0.15	8 (4%)	6 (4%)	2 (4%)	>0.99
Patella, *n* (%)	24 (3%)	23 (3%)	1 (2%)	>0.99	3 (2%)	2 (2%)	1 (2%)	>0.99
Trochlea, *n* (%)	17 (2%)	16 (2%)	1 (2%)	>0.99	1 (1%)	0 (0%)	1 (2%)	0.50
Medial femoral condyle, *n* (%)	47 (6%)	46 (6%)	1 (2%)	0.53	5 (3%)	4 (3%)	1 (2%)	>0.99
Lateral femoral condyle, *n* (%)	14 (2%)	14 (2%)	0	0.92	0 (0%)			
Medial tibal condyle, *n* (%)	21 (3%)	20 (3%)	1 (2%)	>0.99	1 (1%)	0 (0%)	1 (2%)	0.50
Lateral tibal condyle, *n* (%)	6 (1%)	6 (1%)	0	>0.99	0 (0%)			
Neurovascular injury, *n* (%)	13 (2%)	10 (1%)	3 (7%)	0.057	6 (3%)	3 (2%)	3 (7%)	0.33
ACL injury, *n* (%)	435 (52%)	417 (53%)	18 (40%)	0.13	92 (51%)	74 (55%)	18 (40%)	0.12
Meniscus treatment				0.86				0.74
No treatment, *n* (%)	221 (66%)	209 (65%)	12 (75%)		41 (64%)	29 (60%)	12 (75%)	
Repair, *n* (%)	48 (14%)	46 (14%)	2 (13%)		11 (17%)	9 (19%)	2 (13%)	
Partial resection, *n* (%)	61 (18%)	59 (18%)	2 (13%)		10 (16%)	8 (17%)	2 (13%)	
Repair + partial resection, *n* (%)	6 (2%)	6 (2%)	0		2 (3%)	2 (4%)	0 (0%)	
Cartilage treatment				0.77				0.64
Debridement, *n* (%)	27 (13%)	26 (13%)	1 (7%)		4 (11%)	3 (14%)	1 (7%)	
Microfracture, *n* (%)	4 (2%)	4 (2%)	0					
No treatment, *n* (%)	181 (85%)	168 (85%)	13 (93%)		31 (89%)	18 (86%)	13 (93%)	
ACL reconstruction, *n* (%)	396 (47%)	380 (48%)	16 (36%)	0.14	85 (47%)	69 (51%)	16 (36%)	0.10

Note: Categorical variables are expressed as count (percentage).

Abbreviations: ACL, anterior cruciate ligament; BPTB, bone-patellar tendon-bone; PCL, posterior cruciate ligament; PCLR, posterior cruciate ligament reconstruction; QT, quadriceps tendon.

TABLE 3 KOOS subscales before and after propensity score matching.

Variable	Before propensity score matching				After propensity score matching			
	Total ($N = 837$)	Primary PCLR ($n = 792$)	Revision PCLR ($n = 45$)	p-value	Total ($n = 180$)	Primary PCLR ($n = 135$)	Revision PCLR ($n = 45$)	p-value
Preoperative KOOS subscales								
Symptoms	66.3 ± 17.8	66.4 ± 17.6	64.0 ± 20.7	0.39	67.5 ± 18.5	68.7 ± 17.6	64.0 ± 20.7	0.14
Pain	63.4 ± 20.6	63.6 ± 20.4	60.0 ± 23.0	0.27	63.0 ± 21.2	63.9 ± 20.6	60.0 ± 23.0	0.29
ADL	68.4 ± 22.3	68.4 ± 22.2	67.5 ± 24.9	0.76	68.5 ± 23.7	68.8 ± 23.3	67.5 ± 24.9	0.74
Sport/Rec	25.9 ± 24.8	26.2 ± 24.8	21.9 ± 25.0	0.24	25.0 ± 25.1	26.0 ± 25.1	21.9 ± 25.0	0.36
QoL	28.4 ± 18.9	28.5 ± 19.0	27.9 ± 17.6	0.92	28.0 ± 19.1	28.1 ± 19.7	27.9 ± 17.6	1.00
Postoperative KOOS subscales								
Symptoms	67.9 ± 19.4	68.2 ± 19.2	61.6 ± 23.2	0.11	66.5 ± 19.3	67.9 ± 18.0	61.6 ± 23.2	0.16
Pain	74.3 ± 19.5	74.6 ± 19.4	68.8 ± 21.2	0.20	73.5 ± 19.3	74.8 ± 18.7	68.8 ± 21.2	0.21
ADL	81.7 ± 19.0	81.8 ± 18.8	80.0 ± 22.1	0.64	81.7 ± 18.7	82.2 ± 17.7	80.0 ± 22.1	0.59
Sport/Rec	43.5 ± 28.5	43.8 ± 28.4	37.5 ± 30.9	0.34	42.0 ± 29.9	43.2 ± 29.7	37.5 ± 30.9	0.45
QoL	50.5 ± 24.2	51.2 ± 24.1	35.9 ± 23.0	0.002	48.1 ± 24.3	51.7 ± 23.6	35.9 ± 23.0	0.005

Note: Continuous variables are expressed as mean ± standard deviation.

Abbreviations: ADL, activities of daily living; KOOS, Knee injury and osteoarthritis outcome score; PCLR, posterior cruciate ligament reconstruction; QoL, knee-related quality of life; Sport/Rec, sport and recreation function.

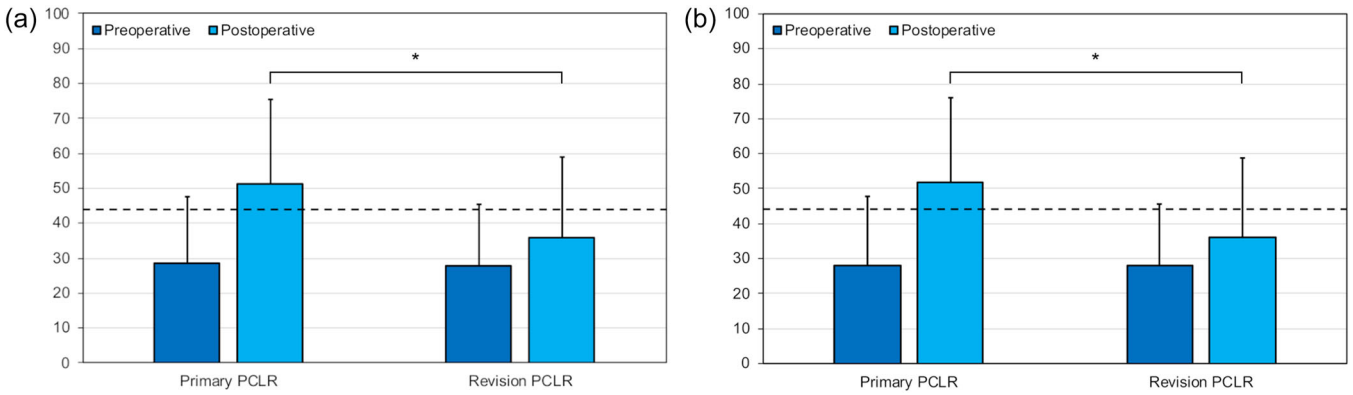

FIGURE 2 KOOS QoL subscale preoperatively and at final follow-up before (a) and after (b) propensity score matching. The dotted line indicates the threshold value for subjective treatment failure (KOOS QOL < 44 points). KOOS, knee injury and osteoarthritis outcome score; QoL, knee-related quality of life; *, statistically significant difference ($p < 0.05$).

knee-related QoL remains limited after PCLR. This clinically meaningful finding highlights the substantial residual symptom burden following PCLR.

These results are concordant with existing literature suggesting considerable functional impairment associated with PCLR failure [18, 25]. One study investigated 40 patients with 52 failed surgical procedures (i.e., PCLR, PCL repair etc.) for the treatment of PCL injuries [24]. The authors reported that surgical failure was multifactorial, with concomitant ligamentous injuries, bone tunnel misplacement and varus malalignment being the most common contributing factors. An average of 42 months after the failed PCL surgery, 71% of patients reported moderate to severe pain during daily activities, 75% had ceased sports activities and 49% rated their knee condition as poor [24]. These findings are consistent with other studies that have reported similarly poor outcomes after failed PCLR [7, 18]. In the present study, no significant differences in preoperative KOOS subscales were found between patients undergoing primary and revision PCLR. However, 84% of patients in both groups met the criterion of subjective treatment failure preoperatively. Taken together, PCLR failure is associated with substantial limitations in quality of life, activities of daily living and physical activity. Impairment in knee-related QoL appears to be

even more pronounced in the case of recurrent PCL insufficiency, as in failed PCLR. The high rate of patient-reported suboptimal outcomes warrants comprehensive patient assessment and subsequent revision PCLR, addressing concomitant factors predisposing patients to multiple PCLR failures.

A recent study retrospectively evaluated midterm outcomes in 17 patients undergoing revision PCLR using a single-bundle transtibial technique. After a mean follow-up of 11.5 years, revision PCLR resulted in significant improvements in the International Knee Documentation Committee (IKDC) Subjective Knee Form (34.9 ± 6.8 vs. 75.3 ± 15.7) and Lysholm Score (38.1 ± 10.0 vs. 88.5 ± 7.6). In addition, significantly improved posterior knee laxity assessed by stress radiography (10.8 ± 2.1 vs. 2.9 ± 1.1 mm) was observed after revision PCLR [7]. Another study evaluated 22 patients undergoing revision PCLR using a double-bundle tibial-inlay technique after a minimum 2-year follow-up. Significant improvements in subjective and objective clinical outcomes were reported. At the final follow-up, 77% of patients could return to normal activities of daily living and 14% of patients were classified as poor according to the Orthopädische Arbeitsgruppe Knie scoring system [18]. The referenced studies represent small case series without comparison between primary and revision PCLR [6, 18]. In the present study, significant improvements in KOOS subscales after both primary and revision PCLR were found. In addition, significantly worse results were observed in the KOOS QoL subscale after revision compared to primary PCLR highlighting the severe effects of PCLR failure. Although no minimal clinically important difference (MCID) values have been specifically established for KOOS subscales following isolated or primary PCLR, Lind et al. [20] considered an improvement of 10 points in the KOOS QoL subscale to be clinically relevant. Furthermore, a recent systematic review synthesising MCID values after knee ligament reconstruction reported a MCID of 12.4 points for the KOOS QoL subscale [22]. Considering these reference values, the observed improvements in the KOOS QoL subscale in this study indicate a clinically relevant change after primary PCLR (pre- to postoperative, 28.1 ± 19.7 vs. 51.7 ± 23.6), but not after revision PCLR (pre- to postoperative, 27.9 ± 17.6 vs. 35.9 ± 23.0).

A recent study from the NKLR reported that subjective treatment failure (KOOS QoL < 44 points) and objective treatment failure (revision surgery) can be found in up to 50% and 4% of patients 2 years after primary PCLR, respectively [23]. The findings align with the present study, showing subjective treatment failure in 47% of patients before and 55% of patients after propensity score matching after primary PCLR. The rate of subjective treatment failure was even higher after revision PCLR, affecting 70% of patients. Although no statistically significant difference in the proportion of patients fulfilling the criterion for subjective treatment failure was observed between primary and revision PCLR, the high proportion in both groups highlights a generally unsatisfactory level of patient-perceived outcome. This underscores that subjective treatment failure represents a major clinical concern after PCLR, independent of surgical status, and should be interpreted separately from KOOS QoL subscale, which did show group differences.

Revision PCLR is indicated in symptomatic patients after failed primary PCLR and has been considered as a salvage procedure [25]. Previous studies have demonstrated that primary PCLR failure is multifactorial, with many contributing factors being surgically modifiable [7, 24, 33]. This study demonstrated that clinical outcomes and in particular the knee-related QoL are inferior after revision compared to primary PCLR. Cumulatively, these findings underscore the importance of a comprehensive diagnostic work-up and precise surgical technique in primary PCLR. Notably, concomitant injuries to the posterolateral corner (PLC) and posteromedial corner (PMC) of the knee have been reported in approximately 64% and 58%, respectively, of patients with an acute PCL injury [4]. Such associated injuries have been shown to alter knee kinematics and adversely affect clinical outcomes following isolated PCLR [11, 17]. Moreover, combined PCL and PLC/PMC injuries are challenging to detect [5], which may increase the risk of these concomitant injuries being overlooked during the initial diagnostic workup. Modifiable risk factors should be identified after primary PCL injury and if necessary addressed during primary PCLR to optimise outcomes and minimise the risk of PCLR failure.

Limitations

Although three major Scandinavian knee ligament registries were used for patient enrollment in this study, the number of patients remains limited. Additionally, well-known limitations of registry studies such as the risk of selection bias, confounding factors like the criteria for treatment decision-making, and missing data have to be acknowledged [3]. However, major strengths of this study include the combination of data from three national knee ligament registries, which enhances the generalisability of the findings, and the use of propensity score matching, which helps to reduce the risk of bias. The absence of information of modifiable risk factors is another limitation. Moreover, the KOOS subscales represent subjective treatment outcomes, which may not accurately reflect the patient's actual clinical condition. Although the cut-off for subjective treatment failure used in this study has been reported previously [23], it is important to note that this

threshold was originally defined for subjective treatment failure after ACL reconstruction and may not accurately reflect PCLR failure [13]. Another limitation is the heterogeneity of injury patterns, as more than half of the patients had concomitant ACL injury. Although previous studies have shown comparable results between isolated and combined PCLR [16, 33], this heterogeneity may have biased the results and should be considered when interpreting the findings of this study. Yet the findings of this study represent the first and largest comparison of primary and revision PCLR to date and provide helpful insights about patient outcomes and short-term prognosis after primary and revision PCLR.

CONCLUSIONS

Both primary and revision PCLR resulted in significant clinical improvements. However, more than 50% of the patients in each group experienced subjective treatment failure, indicating generally poor prognostic outcomes. Nevertheless, patients undergoing primary PCLR demonstrated significantly better knee-related QoL compared to patients undergoing revision PCLR.

AUTHOR CONTRIBUTIONS

Philipp W. Winkler: Design of the study, data analysis and interpretation; drafting and revising the manuscript; final approval. **Bálint Zsidai**: Design of the study; drafting and revising the manuscript; final approval. **Eric Narup**: Design of the study; drafting and revising the manuscript; final approval. **Armin Runer**: Design of the study; data interpretation; revising the manuscript; final approval. **Martin Lind**: Acquisition and interpretation of data; revising the manuscript; final approval. **Gilbert Moatshe**: Acquisition and interpretation of data; revising the manuscript; final approval. **Eric Hamrin Senorski**: Design of the study, data interpretation; revising the manuscript, final approval. **Volker Musahl**: Design of the study; data interpretation; revising the manuscript; final approval. **Kristian Samuelsson**: Acquisition and interpretation of data; revising the manuscript; final approval. All authors agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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CONFLICT OF INTEREST STATEMENT

Philipp W. Winkler works as web editor for Knee Surgery, Sports Traumatology, Arthroscopy (KSSTA). VM reports educational grants, consulting fees, and speaking fees from Smith & Nephew plc, educational grants from Arthrex, is a board member of the International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine (ISAKOS), and deputy editor-in-chief of Knee Surgery, Sports Traumatology, Arthroscopy (KSSTA). Kristian Samuelsson is member of the Board of Directors of Getinge AB (publ) and medtech advisor to Carl Bennet AB. Gilbert Moatshe reports fellowship grants, consulting and speaking fees from Smith & Nephew Inc, is a committee member of the International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine (ISAKOS) and ESSKA, deputy editor of JBJS, editorial board of Arthroscopy. ML reports speaking fees from Smith & Nephew, Arthrex and Aneka.

DATA AVAILABILITY STATEMENT

Data are available from the corresponding author upon reasonable request.

ETHICS STATEMENT

This study was approved by the Swedish Ethical Review Authority (Dnr 2020-03559 and 2021-01002). The study was conducted in accordance with the Helsinki Declaration. Participation in the Swedish Knee Ligament Registry is voluntary for patients and surgeons. The registry complies with the Swedish legislation relating to data security. No written consent is necessary for national databases in Sweden. Investigators had access only to unidentifiable patient data. Registration in the Norwegian Knee Ligament Registry and Danish Knee Ligament Reconstruction Registry is mandatory for public and private hospitals.

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REFERENCES

1. Ahldén M, Samuelsson K, Sernert N, Forssblad M, Karlsson J, Kartus J. The Swedish National Anterior Cruciate Ligament Register: a report on baseline variables and outcomes of surgery for almost 18,000 patients. Am J Sports Med. 2012;40:2230–5.
2. Austin PC. Some methods of propensity-score matching had superior performance to others: results of an empirical investigation and Monte Carlo simulations. Biometrical J. 2009;51:171–84.
3. Beit Ner E, Nakamura N, Lattermann C, McNicholas MJ. Knee registries: state of the art. J ISAKOS. 2022;7:118–31.
4. Bohe O, Greve F, Höger S, Mehl J, Siebenlist S, Willinger L. Posteromedial corner injuries result in the same posterior

translation as posterolateral corner injuries in PCL ruptures. J Exp Orthop. 2024;11:e70118.
5. Briese T, Riemer R, Deichsel A, Peez C, Herbst E, Glasbrenner J, et al. Combined PCL instabilities cannot be identified using posterior stress radiographs in external or internal rotation: a cadaveric study. Knee Surg Sports Traumatol Arthrosc. 2025;33:1586–93.
6. Chen CH, Chen WJ, Shih CH. Arthroscopic reconstruction of the posterior cruciate ligament. Arthrosc J Arthrosc Rel Surg. 2002;18:603–12.
7. Chen YJ, Yang CP, Ho CS, Weng CJ, Chen ACY, Hsu WH, et al. Midterm outcomes after revision posterior cruciate ligament reconstruction with a single-bundle transtibial autograft. Orthop J Sports Med. 2022;10:23259671221115423.
8. Collins NJ, Misra D, Felson DT, Crossley KM, Roos EM. Measures of knee function: International Knee Documentation Committee (IKDC) subjective knee evaluation form, knee injury and osteoarthritis outcome score (KOOS), knee injury and osteoarthritis outcome score physical function short form (KOOS-PS), knee outcome survey activities of daily living scale (KOS-ADL), Lysholm knee scoring scale, Oxford knee score (OKS), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), activity rating scale (ARS), and tegner activity score (TAS). Arthritis Care Res (Hoboken). 2011; 63(Suppl 11):S208–28.
9. D'Ambrosi R, Carrozzo A, Di Feo F, Skopljak E, Kambhampati SBS, Attri M, et al. Posterior cruciate ligament revision surgery: outcomes, failure rates, and complications: a systematic review of the literature. J Knee Surg. 2025;38: 448–56.
10. D'Ambrosi R, Hallé A, Hardy A. Good clinical and radiological results following remnant-preserving posterior cruciate ligament reconstruction: a systematic review. Knee Surg Sports Traumatol Arthrosc. 2023;31:2418–32.
11. Gensior TJ, Mester B, Achtnich A, Winkler PW, Henkelmann R, Hepp P, et al. Anatomic repair and ligament bracing as an alternative treatment option for acute combined PCL injuries involving the posteromedial or posterolateral corner-results of a multicentre study. Arch Orthop Trauma Surg. 2023;143: 7123–32.
12. Granan LP, Bahr R, Steindal K, Furnes O, Engebretsen L. Development of a national cruciate ligament surgery registry: the Norwegian National Knee Ligament Registry. Am J Sports Med. 2008;36:308–15.
13. Granan LP, Baste V, Engebretsen L, Inacio MCS. Associations between inadequate knee function detected by KOOS and prospective graft failure in an anterior cruciate ligament-reconstructed knee. Knee Surg Sports Traumatol Arthrosc. 2015;23:1135–40.
14. Herman ZJ, Kaarre J, Grassi A, Senorski EH, Musahl V, Samuelsson K. Registry-based cohort study comparing percentages of patients reaching PASS for knee function outcomes after revision ACLR compared to primary ACLR. BMJ Open. 2024;14:e081688.
15. Kaarre J, Herman ZJ, Grassi A, Hamrin Senorski E, Musahl V, Samuelsson K. Comparison of improvement in patient-reported knee function after revision and multiple-revision ACL reconstruction compared with primary ACL reconstruction. Orthop J Sports Med. 2023;11:23259671231217725.
16. LaPrade RF, Cinque ME, Dornan GJ, DePhillipo NN, Geeslin AG, Moatshe G, et al. Double-bundle posterior cruciate ligament reconstruction in 100 patients at a mean 3 years' follow-up: outcomes were comparable to anterior cruciate ligament reconstructions. Am J Sports Med. 2018; 46:1809–18.
17. Lee DY, Park YJ, Kim DH, Kim HJ, Nam DC, Park JS, et al. The role of isolated posterior cruciate ligament reconstruction in knees with combined posterior cruciate ligament and posterolateral complex injury. Knee Surg Sports Traumatol Arthrosc. 2018;26:2669–78.
18. Lee SH, Jung YB, Lee HJ, Jung HJ, Kim SH. Revision posterior cruciate ligament reconstruction using a modified tibial-inlay double-bundle technique. J Bone Jt Surg. 2012;94:516–22.
19. Lind M, Menhert F, Pedersen AB. The first results from the Danish ACL reconstruction registry: epidemiologic and 2 year follow-up results from 5,818 knee ligament reconstructions. Knee Surg Sports Traumatol Arthrosc. 2009;17:117–24.
20. Lind M, Nielsen TG, Behrndtz K. Both isolated and multi-ligament posterior cruciate ligament reconstruction results in improved subjective outcome: results from the Danish Knee Ligament Reconstruction Registry. Knee Surg Sports Traumatol Arthrosc. 2018;26:1190–6.
21. Meena A, Farinelli L, Hoser C, Abermann E, Hepperger C, Patralekh MK, et al. Primary versus revision ACL reconstruction using quadriceps autograft: a matched-control cohort study. Orthop J Sports Med. 2024;12:23259671231224501.
22. Migliorini F, Maffulli N, Jeyaraman M, Schäfer L, Rath B, Huber T. Minimal clinically important difference (MCID), patient-acceptable symptom state (PASS), and substantial clinical benefit (SCB) following surgical knee ligament reconstruction: a systematic review. Euro J Trauma Emergency Surg. 2025;51:32.
23. Moatshe G, LaPrade CM, Fenstad AM, Persson A, LaPrade M, Martin RK, et al. Rates of subjective failure after both isolated and combined posterior cruciate ligament reconstruction: a study from the norwegian knee ligament registry 2004-2021. Am J Sports Med. 2024;52:1491–7.
24. Noyes FR, Barber-Westin SD. Posterior cruciate ligament revision reconstruction, part 1: causes of surgical failure in 52 consecutive operations. Am J Sports Med. 2005;33:646–54.
25. Noyes FR, Barber-Westin SD. Posterior cruciate ligament revision reconstruction, part 2: results of revision using a 2-strand quadriceps tendon-patellar bone autograft. Am J Sports Med. 2005;33:655–65.
26. Owesen C, Sivertsen EA, Engebretsen L, Granan LP, Årøen A. Patients with isolated PCL injuries improve from surgery as much as patients with ACL injuries after 2 years. Orthop J Sports Med. 2015;3:2325967115599539.
27. Rahr-Wagner L, Lind M. The Danish knee ligament reconstruction registry. Clin Epidemiol. 2016;8:531–5.
28. Scarcella MJ, Yalcin S, Scarcella NR, Saluan P, Farrow LD. Outcomes of pediatric posterior cruciate ligament reconstruction: a systematic review. Orthop J Sports Med. 2021;9:23259671211032539.
29. Thorolfsson B, Winkler PW, Piussi R, Snaebjörnsson T, Hamrin Senorski R, Karlsson J, et al. The chance to become an elite athlete after pediatric and adolescent anterior cruciate ligament reconstruction. Am J Sports Med. 2025;53:1027–33.
30. Vindfeld S, Persson A, Lindanger L, Fenstad AM, Visnes H, Inderhaug E. Revision anterior cruciate ligament reconstruction: surgeon-reported causes of failure from the norwegian knee ligament register. Am J Sports Med. 2025;53:801–8.
31. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. J Clin Epidemiol. 2008; 61:344–9.
32. Winkler PW, Thorolfsson B, Piussi R, Snaebjörnsson T, Hamrin Senorski R, Karlsson J, et al. Sport-specific concomitant injuries, return-to-sport rates and second anterior cruciate ligament (ACL) injuries in adolescents with ACL reconstruction. Br J Sports Med. 2025;59:931–40.
33. Winkler PW, Wagala NN, Carrozzi S, Nazzal EM, Fox MA, Hughes JD, et al. Low posterior tibial slope is associated with increased risk of PCL graft failure. Knee Surg Sports Traumatol Arthrosc. 2022;30:3277–86.

34. Winkler PW, Wagala NN, Hughes JD, Lesniak BP, Musahl V. A high tibial slope, allograft use, and poor patient-reported outcome scores are associated with multiple ACL graft failures. Knee Surg Sports Traumatol Arthrosc. 2022;30:139–48.
35. Winkler PW, Zsidai B, Narup E, Kaarre J, Horvath A, Sansone M, et al. Sports activity and quality of life improve after isolated ACL, isolated PCL, and combined ACL/PCL reconstruction. Knee Surg Sports Traumatol Arthrosc. 2022;31:1781–9.
36. Winkler PW, Zsidai B, Wagala NN, Hughes JD, Horvath A, Senorski EH, et al. Evolving evidence in the treatment of primary and recurrent posterior cruciate ligament injuries, part 1: anatomy, biomechanics and diagnostics. Knee Surg Sports Traumatol Arthrosc. 2021;29:672–81.
37. Winkler PW, Zsidai B, Wagala NN, Hughes JD, Horvath A, Senorski EH, et al. Evolving evidence in the treatment of primary and recurrent posterior cruciate ligament injuries, part 2: surgical techniques, outcomes and rehabilitation. Knee Surg Sports Traumatol Arthrosc. 2021;29:682–93.
38. Yoon KH, Lee JH, Kim SG, Park JY, Lee HS, Kim SJ, et al. Effect of posterior tibial slopes on graft survival rates at 10 years after primary single-bundle posterior cruciate ligament reconstruction. Am J Sports Med. 2023;51:1194–201.
39. Zsidai B, Piussi R, Winkler PW, Runer A, Diniz P, Cristiani R, et al. Deconstructing the age-washout phenomenon in ACL-R failure: a short survey of anatomical, physiological and genetic risk factors for ACL reinjury. Knee Surg Sports Traumatol Arthrosc. 2025;33:1943–7.
40. Zsidai B, Piussi R, Winkler PW, Runer A, Diniz P, Cristiani R, et al. Age is not a primary risk factor for anterior cruciate ligament injury—A comprehensive review of anterior cruciate ligament injury and reinjury risk factors confounded by young patient age. Knee Surg Sports Traumatol Arthrosc. 2025;34:17–33.

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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