

Adverse Events After Isolated Posterior Cruciate Ligament Reconstruction

A National Database Study

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Background: Optimal management after posterior cruciate ligament (PCL) injury remains an active area of research, as reconstruction is technically challenging and poses unique risks in the posterior knee. Studies have reported variable rates of complications.

Purpose: To describe the rates of readmission, emergency department (ED) visits, and postoperative complications within 90 days of isolated PCL reconstruction (PCLR) in a large, national cohort to better understand the perioperative variables that influence a practitioner's decision of whether to pursue operative versus nonoperative management.

Study Design: Descriptive epidemiology study.

Methods: PCLRs from January 1, 2010, through August 31, 2020, were identified in PearlDiver, a national administrative database. Patients with concomitant ligament surgery and those with fewer than 90 days of postoperative database activity were excluded. Deep vein thromboses, pulmonary embolisms, surgical site infections, compartment syndrome, and vascular events within 90 days of surgery were identified, as were 90-day readmissions and ED visits. Logistic regression models were built in PearlDiver to calculate odds ratios (ORs) for ED utilization.

Results: The final cohort consisted of 1154 patients with isolated PCLR (mean age, 34 ± 16 years; 62% male). Most patients were located in the Southern United States (n = 417; 36.1%), and most had commercial insurance (n = 992; 86%). The 90-day rates of adverse events were as follows: deep vein thrombosis (13; 1.1%), pulmonary embolism (19; 1.6%), surgical site infection (<11; <1%), compartment syndrome (<11; <1%), vascular event (<11; <1%), readmission (13, 1.1%), and ED utilization (99; 8.6%). The majority of emergency department visits (52%) occurred in the first 2 weeks postoperatively. Predictive factors for ED utilization included Elixhauser Comorbidity Index score (OR = 1.31 per 2-point increase) and Medicaid insurance (OR = 2.03 relative to commercial insurance).

Conclusion: The current study reported rates of adverse events after isolated PCLR in a large, national cohort. The results provide important context for decisions about optimal management of PCL injury.

Keywords: posterior cruciate ligament reconstruction, adverse events, PearlDiver, ED utilization

Accounting for 2% to 5% of all ligamentous knee injuries, posterior cruciate ligament (PCL) injuries, particularly in isolation, occur less commonly than other ligamentous knee injuries.^{3,11,21,23,28} Limited high-quality evidence exists regarding the optimal management of isolated PCL

injuries, and PCL reconstruction (PCLR) remains an area of active research. PCLR is technically challenging, and surgery around the posterior knee poses unique risks, particularly related to the posterior vascular structures.²⁴ The decision to pursue nonsurgical versus surgical management requires accurately identifying those patients who are likely to obtain functional benefits from isolated PCLR. An accurate appreciation of the postoperative course and likelihood of complications better informs this decision-making.

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Understanding the rates of postoperative adverse events, such as complications, readmission, and emergency department (ED) visits, is critical for understanding the effects of a procedure on patients and the health care system.^{5,26,30} Complications described in the PCLR literature include venous thromboembolism (VTE), surgical site infection (SSI), compartment syndrome, vascular injury, hematoma, reflex sympathetic dystrophy syndrome, heterotopic ossification, and motion loss, but these studies have high variability in rates of complications, with some reporting rates as high as 20.1% and others reporting no complications.^{4,27} Such discrepancies make postoperative management and patient education challenging. In addition, the authors are unaware of any analysis of readmissions and ED utilization in the PCLR literature. These present a potentially avoidable cost to the health care system and have been associated with lower patient satisfaction in other orthopaedic literature.^{14,16} As such, a baseline understanding of these events and their etiology is warranted.

Large, publicly available, datasets are powerful tools for conducting epidemiological research, particularly for rare events such as isolated PCLR. The present study utilized PearlDiver, a national administrative claims database, to analyze complications, readmissions, and ED utilization within 90 days of isolated PCLR. The primary objective of this study was to better understand the perioperative variables that influence a practitioner's decision to pursue operative versus nonoperative management.

METHODS

The current study analyzed PearlDiver's M91Ortho dataset, which contains administrative claims data on more than 90 million orthopaedic patients across the United States. The study protocol was exempt from institutional review board approval because all output from the PearlDiver database is deidentified and aggregated.

The study cohort was defined using Current Procedural Terminology (CPT) codes. Patients who underwent PCLR from January 1, 2010, through August 31, 2020, were identified using CPT-29889. Of note, this CPT code can also include PCL repairs. Data captured both inpatient and outpatient procedures, including those done at ambulatory surgery centers. Patients with concomitant anterior cruciate ligament reconstruction (CPT 29888), extra-articular ligament reconstruction (CPT 27427), or collateral ligament/knee capsule repair (CPT 27405) were excluded. Patients were also excluded if they were not active in the database for at least 90 days after surgery. For the final

cohort, patient age, sex, region of the country (US Census Bureau definitions of West, Midwest, South, Northeast), insurance plan, and Elixhauser Comorbidity Index (ECI) score were extracted. ECI is a measure of categorizing comorbidity based on 30 diseases and their International Classification of Diseases (ICD) codes found in administrative data.⁹ Each disease with which patients are diagnosed adds a point to their ECI.

ICD codes were used to determine 90-day rates of deep vein thrombosis (DVT), pulmonary embolism (PE), SSI (which included both superficial and deep infections), and compartment syndrome. ICD and CPT codes were both used to determine the 90-day incidence of adverse vascular events (diagnosis of vascular injury or surgery involving a vessel). Readmissions were identified by the presence of any inpatient code within 90 days of surgery; 90-day ED visits were identified using CPT codes that correspond to varying levels of care in the ED (CPT 99281, CPT 99282, CPT 99283, CPT 99284, CPT 99285), and the timing and risk factors for ED visits were determined. Some results are reported as <11 because PearlDiver does not provide specific numbers for cohorts below this size unless they are 0; thus, low numbers of readmissions prohibit detailed data capture whether or not the ED visits were related to the surgery.

PearlDiver's built-in statistical software was used for all analyses, with significance defined as $P < .05$. Continuous variables (eg, age, ECI score) were compared using t tests, and categorical variables (eg, sex, region, insurance coverage) were compared using chi-square tests. Multivariate logistic regression including age, sex, ECI score, region, and insurance plan was used to determine independent risk factors for ED utilization and to generate odds ratios (ORs).

RESULTS

Figure 1 shows the selection process of the study cohort, which consisted of 1154 patients with isolated PCLR. Patient characteristics are shown in Table 1. The mean age of the cohort was 33.9 ± 15.5 years, with more men (62.2%) than women and an ECI score of 1.7 ± 2.1 . Most of the patients were located in the Southern United States ($n = 417$; 36.1%), and most had commercial insurance ($n = 992$; 86%).

Table 2 shows 90-day adverse events. These included DVT for 13 patients (1.1%) and PE for 19 patients (1.6%). Fewer than 11 patients (<1%) experienced SSI, compartment syndrome, or a vascular event. Readmissions were

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Ethical approval was not sought for the present study.

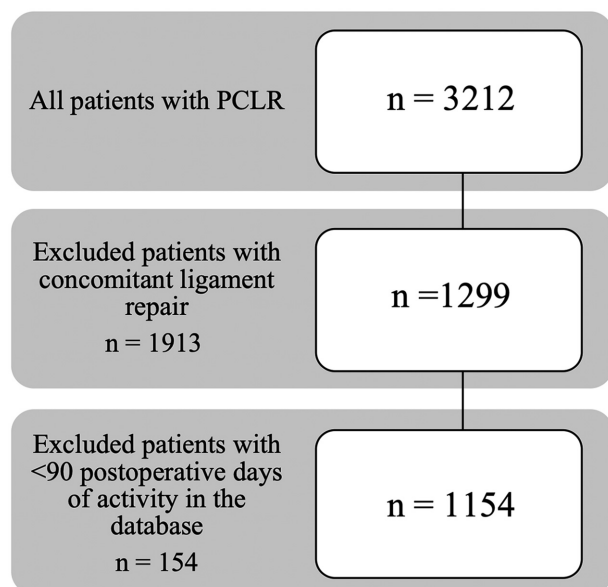


Figure 1. Flowchart showing selection of final study cohort. PCLR, posterior cruciate ligament reconstruction.

TABLE 1
Characteristics of Study Patients (N = 1154)^a

Characteristic	Value
Age, y	33.9 ± 15.5
Sex	
Male	718 (62.2)
Female	436 (37.9)
ECI	1.7 ± 2.1
Region	
South	417 (36.1)
Midwest	274 (23.7)
Northeast	253 (21.9)
West	210 (18.2)
Insurance	
Commercial	992 (86.0)
Medicaid	116 (10.0)
Medicare	46 (4.0)

^aData are reported as mean ± SD or n (%). ECI, Elixhauser Comorbidity Index.

TABLE 2
Distribution of 90-Day Adverse Events^a

Adverse Event	Value
DVT	13 (1.1)
Pulmonary embolism	19 (1.6)
SSI	<11 (<1)
Compartment syndrome	<11 (<1)
Vascular event	<11 (<1)
Readmission	13 (1.1)
ED visit	99 (8.6)

^aData are reported as n (%). DVT, deep vein thrombosis; ED, emergency department; SSI, surgical site infection.

identified for 13 (1.1%) patients, and ED visits were identified for 99 (8.6%).

On further analysis of ED visits, it was found that more than one-third (38%) of visits occurred in the first week after surgery, and two-thirds (67%) occurred by the end of week 4 (Figure 2). Most patients (n = 73) visited the ED once, 17 visited twice, and 9 visited 3 times (Figure 2).

Univariate analysis showed statistically significant differences in ECI score and insurance coverage between patients who did and did not visit the ED (Table 3). On multivariate analysis (Table 4), independent risk factors for 90-day ED utilization included greater ECI score (OR = 1.31 per 2-point increase, P = .004) and Medicaid insurance (OR = 2.03 relative to commercial, P = .017).

DISCUSSION

The present study evaluated the rates of adverse events after isolated PCLR. This information is important for understanding the burden of the surgery on patients and the health care system and optimizing decision-making for treatment of PCL injury.^{5,30} Some literature suggests PCLR may be associated with higher complication rates than other knee surgeries.⁶ A 2014 review of the American Board of Orthopaedic Surgery database for orthopaedic surgeons showed PCLR to have the highest complication rate of arthroscopic knee surgeries among novice surgeons sitting for their certification.²⁷ The high complication rate reported rate speaks to the relative difficulty and learning curve associated with the procedure. However, limited information exists regarding the frequency of complications after PCLR in the broader literature. For example, Chahla et al⁴ performed a systematic review and meta-analysis of PCLR techniques with at least 24 months of follow-up and identified 441 patients from 11 studies; of these, fewer than half of the studies published data related to complications. DVT, PE, SSI, compartment syndrome, and vascular injury are among the specific complications identified.^{20,22,31}

DVT and PE, collectively known as VTEs, can be devastating complications; however, arthroscopic surgeries are generally considered to be safe enough that the American College of Chest Physicians does not recommend routine DVT chemoprophylaxis.¹⁰ The incidence of VTE after anterior cruciate ligament reconstruction is estimated to be 0.44% to 1.22%.^{12,15,18} In the current study, 1% to 2% of patients experienced DVT or PE, suggesting that isolated PCLR does not present a substantially greater risk than other arthroscopic procedures. Smaller prospective studies of VTE after PCLR, however, report rates of symptomatic DVT to be 5.8% to 8.2% without prophylaxis.^{6,34} In addition, Dong et al⁸ compared isolated PCLR and isolated anterior cruciate ligament reconstruction and found a significantly greater rate of DVT after PCLR. Notably, the aforementioned studies had color Doppler ultrasound performed on all patients, so their DVT rates are likely to be higher based on asymptomatic DVTs, and our DVT rates

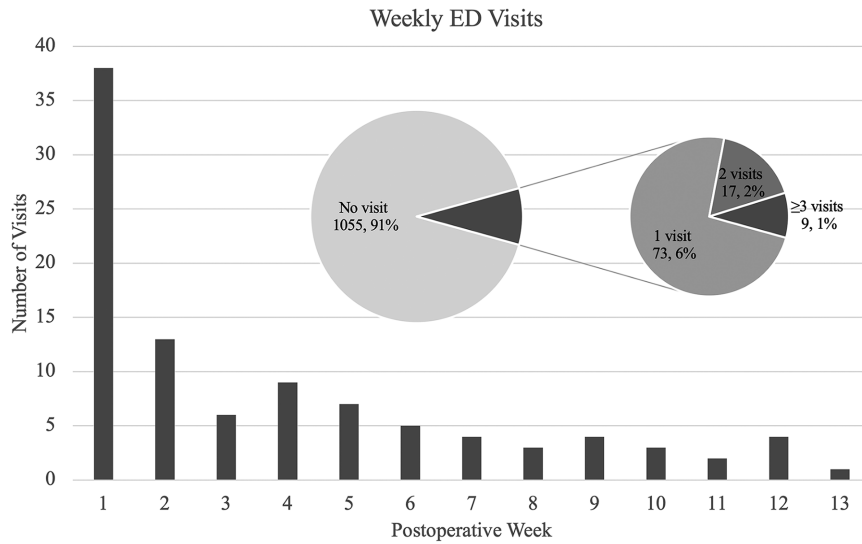


Figure 2. Number of patients with 90-day ED utilization (pie charts) and number of postoperative ED visits per week (bar graph). Multiple ED visits from the same patient (eg, visited in week 1, visited again in week 4) are represented separately. ED, emergency department.

TABLE 3
Univariate Analysis of Patient Characteristics by ED Utilization^a

Characteristic	No ED Visit (n = 1055)	ED Visit (n = 99)	P
Age, y	34.0 ± 15.6	32.4 ± 13.1	.237
Sex			>.99
Male	656 (62.2)	62 (62.6)	
Female	399 (37.8)	37 (37.4)	
ECI	1.7 ± 2.1	2.7 ± 2.5	<.001
Region			.166
South	390 (37.0)	27 (27.3)	
Midwest	251 (24.0)	24 (24.2)	
Northeast	228 (21.6)	24 (24.2)	
West	186 (17.6)	24 (24.2)	
Insurance			.001
Commercial	910 (86.3)	77 (77.8)	
Medicaid	96 (9.1)	20 (20.2)	
Medicare	44 (4.2)	2 (2.0)	

^aData are reported as mean ± SD or n (%). Boldface P values indicate statistically significant difference between groups (P < .05).

may be lower due to coding errors and omission of outpatient visit claims.

Of the 1154 patients identified in the present study, the rate of SSI was <1%. Infection has been noted to be a leading complication after knee arthroscopy, with rates reported from 0.15% to 0.84%.^{2,27,33} Less than 1% of patients in the current study experienced compartment syndrome or a vascular injury after isolated PCLR. These are feared complications mentioned in review articles and case reports, but little is published with regard to their

TABLE 4
Multivariate Analysis of Predictive Factors for ED Utilization^a

Factor	OR (95% CI)	P
ECI score (per 2-point increase)	1.31 (1.08-1.57)	.004
Insurance		
Commercial (reference)	-	-
Medicare	0.86 (0.20-2.62)	.819
Medicaid	2.03 (1.10-3.55)	.017

^aBoldface P values indicate statistical significance (P < .05). CI, confidence interval; ECI, Elixhauser Comorbidity Index; ED, emergency department.

incidence.^{17,29} Although care should be taken to prevent these complications, the current study suggests they may not represent as large a danger as suspected.

Postoperative acute care utilization can have a large impact on patients and the health care system. In the current study, 1.1% of patients were readmitted and 8.6% visited the ED within 90 days of surgery. The authors are unaware of previous studies reporting either of these metrics. The difference between ED utilization and hospital readmission emphasizes the utility of evaluating ED encounters in understanding postoperative burden and where to focus resources.

Although readmissions were not analyzed further because the sample was small, further analysis of ED visits showed the greatest incidence in the first week after surgery, with 38% of visits occurring in the first 7 days. ED utilization declines over the remainder of the 90-day study period, but, by the end of the fourth week, two-thirds of all ED visits have taken place. This decline indicates that

preventive measures aimed at reducing ED burden should focus on this early postoperative period.

Predictive factors for ED visits were increasing comorbidity burden, represented by the ECI, and Medicaid insurance.⁹ Studies of orthopaedic procedures, including anterior cruciate ligament reconstruction, total joint arthroplasty, and hand surgery, have shown a similar trend.^{5,19,30} The association of comorbidity burden and acute care utilization makes sense, as health outcomes are heavily influenced by patient comorbidities and increasing numbers of comorbidities have been associated with lower quality of life, increased disability, and greater use of health care services.^{13,25} Regarding payor type, it is well-known that Medicaid insurance is associated with greater ED use. This is likely associated with socioeconomic factors, and the literature has demonstrated that Medicaid patients have inferior access to orthopaedic surgery care than patients with Medicare or private insurance.³² As a result, it may be possible that Medicaid patients were more likely to present to the ED for a health issue instead of visiting a primary care doctor.

Limitations

Limitations to this study include the fact that it relied on a retrospective database, and therefore, diagnoses cannot be verified. The accuracy of this study assumes correct coding, but due to the large sample size and dichotomous nature of the data (the code for visit, readmission, or complication happened or did not), any associated error should be small. Furthermore, the CPT code we used also included PCL repairs, which may involve a concomitant avulsion fracture and occur more acutely from time to injury compared with reconstruction, which typically happens 2 to 3 weeks afterward.⁷ In addition, the majority of patients were from the Southern United States, which has the highest burden of comorbidities.¹ Regarding the incidence of readmissions, low numbers of readmissions and ED visits precluded detailed data capture regarding the etiology of these events and we were unable to determine whether they were related to the surgery. Because this study evaluated events within 90 days postoperatively, events outside of that window were excluded. While this study reported on VTE, infections, and vascular complications, other complications such as graft failure, loss of range of motion, and pain at the donor site were less likely to be captured by ICD coding and thus escaped accurate estimation.

CONCLUSION

The current study adds to our understanding of the challenges expected in the immediate postoperative course after isolated PCLR using a large, national cohort. Knowledge of postoperative adverse events aids in counseling patients, guiding management, improving outcomes, and anticipating health care systems costs. Importantly, this report suggests that PCLR has similar rates of adverse events compared with other arthroscopic knee surgeries despite the challenges posed during PCLR.

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