7-1-2019

Does Prior Anterior Cruciate Ligament Reconstruction Affect Outcomes of Subsequent Total Knee Arthroplasty? A Systematic Review.

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Does Prior Anterior Cruciate Ligament Reconstruction Affect Outcomes of Subsequent Total Knee Arthroplasty?

A Systematic Review

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Background: Anterior cruciate ligament injury may accelerate knee osteoarthritis, and patients with a history of anterior cruciate ligament reconstruction (ACLR) tend to undergo total knee arthroplasty (TKA) at a greater rate than patients without a history of ACLR.

Purpose: To compare clinical outcomes of TKA in patients with and without a history of ACLR through a systematic review.

Study Design: Systematic review; Level of evidence, 3.

Methods: A comprehensive search of the PubMed (MEDLINE), Cochrane Central, and SPORTDiscus databases from inception through November 2018 was performed to identify studies directly comparing outcomes of TKA between patients with and without a history of ipsilateral ACLR. Eligible studies were included in this review if they reported at least 1 outcome measure.

Results: Included for review were 5 retrospective case-control studies collectively evaluating TKA outcomes in 318 patients (176 males, 142 females) with a history of ACLR and 455 matched controls. The mean age in the ACLR and control groups was 58.5 years and 60.9 years, respectively. The mean follow-up period after arthroplasty was 3.4 years in the ACLR group and 3.3 years in the control group. The mean time between ACLR and arthroplasty was 21.8 years. Three studies noted greater operative time in the ACLR group than in the control group. No differences in intraoperative blood loss were reported. Greater preoperative extension deficits were noted in the ACLR group in 2 studies. Two studies reported increased preoperative Knee Society Score function scores in the ACLR group, but no differences in postoperative subjective outcome scores were noted in any of the studies. One study reported increased incidence of periprosthetic joint infection and a higher total reoperation rate in the ACLR group, and another study reported an increased incidence of manipulation under anesthesia in the ACLR group.

Conclusion: Short- and midterm subjective scores and functional outcomes of TKA appear to be comparable in patients with and without a history of ACLR, although the risk for reoperation after TKA may be greater in patients with prior ACLR. Surgeons should anticipate increased operative time in patients with a history of ACLR. However, the findings of this review must be interpreted within the context of its limitations.

Keywords: anterior cruciate ligament reconstruction; total knee arthroplasty; outcomes

To date, various studies exploring the effects of previous knee surgery on subsequent total knee arthroplasty (TKA) have been published in the orthopaedic literature.[5,9,18,19,22,24] In particular, there has been a growing interest in the effects of prior ligamentous knee surgery on subsequent TKA outcomes. Anterior cruciate ligament (ACL) tears are a common orthopaedic injury, with an estimated annual incidence of 68.6 per 100,000 person-years in the United States.[20] ACL reconstruction (ACLR) is the treatment of choice in patients with ACL ruptures who are candidates for operative management, and over 100,000 ACLRs are performed annually in the United States alone.[4] However, there is evidence indicating that ACL injury and surgery may accelerate osteoarthritis in both the patellofemoral and tibiofemoral joints, particularly when associated with meniscal damage.[7,17]

Although ACLR produces favorable results in many patients, subsequent degenerative changes may arise from failure to fully restore the normal kinematics of the knee joint,

The Orthopaedic Journal of Sports Medicine, 7(7), 2325967119857551
DOI: 10.1177/2325967119857551

chondral damage from the initial trauma and pivot shift, or concomitant meniscal tears. Degenerative changes in the knee have been reported as early as 1 to 2 years following ACL injury regardless of whether patients had undergone ACLR or nonoperative management for their initial injury.[6,21] Thus, patients with a history of ACLR are at increased risk of undergoing ipsilateral TKA for the treatment of advanced knee osteoarthritis. Leroux et al[12] reported that the cumulative incidence of TKA among patients with a history of ACLR was 7 times greater at 15-year follow-up than in matched controls without a history of ACLR. In addition, Brophy et al[3] reported that patients with a history of knee surgery, especially those who have previously undergone knee ligament reconstruction, undergo ipsilateral TKA at a significantly younger age than patients without a history of knee surgery.

Because patients with a history of ACLR undergo TKA at a higher rate than patients without a history of ACLR, it is important to elucidate whether ACLR affects the outcome of subsequent TKA. The purpose of this study was to compare clinical outcomes of TKA in patients with and without a history of ACLR through a systematic review. We hypothesized that prior ACLR would lead to inferior clinical outcomes in patients undergoing subsequent TKA.

METHODS

Search Strategy

A systematic review was performed in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines.[16] Two reviewers (Z.S.C., H.S.S.) performed a comprehensive literature search of the PubMed (MEDLINE), Cochrane Central Register of Controlled Trials, and SPORTDiscus databases from inception through November 2018 using various combinations of the following key terms: “knee,” “arthroplasty,” “replacement,” “anterior cruciate ligament,” “ACL,” and “reconstruction.” Studies of evidence levels 1 to 3 that directly compared outcomes of TKA in patients with and without a history of ACLR on the ipsilateral knee were sought, and they were included in this review if at least 1 outcome measure was reported. To avoid excluding studies reporting intraoperative measures (eg, operative time, estimated blood loss) and perioperative outcomes, a minimum follow-up length was not established. Technique reports, case studies, review articles, and cadaveric or otherwise in vitro studies were excluded. In addition, studies that were not reported in English were excluded.

The reference lists for all articles that met the inclusion criteria were carefully screened to ensure that no relevant articles were missed in the database search. Any discrepancies between reviewers during the title/abstract and full-text screening phases were discussed with the senior author (S.H.), who made the final determination regarding inclusion.

Data Abstraction

Data abstraction was performed by 2 independent reviewers (Z.S.C., H.S.S.) who extracted data from all studies meeting the inclusion criteria. All data were recorded and stored in a standardized Microsoft Excel spreadsheet. Study characteristics, including study design, length of follow-up, time interval between ACLR and subsequent TKA, as well as patient demographics (eg, age, sex, body mass index [BMI]) were recorded. When reported, operative details for the prior ACLR (eg, technique, graft type, concomitant procedures) and operative details for the TKA (eg, technique, prosthesis, concomitant procedures) were also recorded. Any reported pre- and postoperative radiographic measures (eg, patella baja, hip-knee-ankle angle, Blackburne-Peel index, Insall-Salvati ratio, anterior tibial translation) were recorded, and intraoperative measures—including operative or tourniquet time, estimated blood loss, concomitant ACL hardware removal, and technical difficulty during the arthroplasty procedure—were recorded when available. Periprosthetic joint infection (PJI), postoperative stiffness, aseptic loosening, venous thromboembolism, and reoperation were recorded. Subjective outcome data included pre- and postoperative patient-reported outcome scores, such as the Knee Society Score (KSS), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) score, 12-Item Short Form Health Survey (SF-12) score, and patient satisfaction.

Quality Assessment

The Newcastle-Ottawa Scale (NOS) for case-control studies was used to assess the quality of the studies included in this review.[23] The NOS comprises 8 items that are organized into the following 3 categories: selection, comparability, and exposure. Studies are assigned a maximum of 1 point for each item, with the exception of the comparability category, which allows for the assignment of a maximum of 2 points. Final NOS scores range between 0 and 9, with a higher score indicating higher quality of study design and execution.

RESULTS

Study Characteristics

An initial search of the PubMed (MEDLINE), Cochrane Central, and SPORTDiscus databases yielded a total of 458 articles, and 5 studies met our inclusion criteria and

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One or more of the authors has declared the following potential conflict of interest or source of funding: S.H. has received research support from Arthrex, educational support from Arthrex and Liberty Surgical, and hospitality payments from Smith & Nephew. AOSSM checks author disclosures against the Open Payments Database (OPD). AOSSM has not conducted an independent investigation on the OPD and disclaims any liability or responsibility relating thereto.

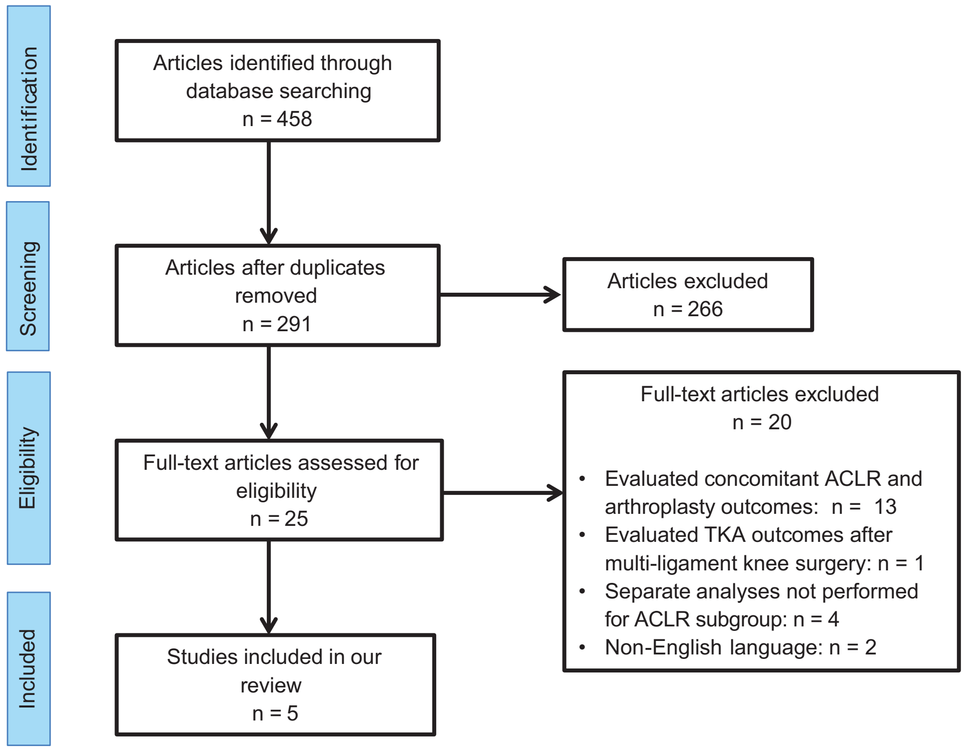

Figure 1. PRISMA (Preferred Reporting Items for Systematic Meta-Analyses) diagram. ACLR, anterior cruciate ligament reconstruction; TKA, total knee arthroplasty.

were therefore included for further analysis.[5,9,13,14,22] A PRISMA flow diagram delineating our literature search and rationale for exclusion is presented in Figure 1.

All of the included articles were retrospective case-control studies (level 3 evidence). In the study by Hoxie et al,[9] 5 of the 36 patients in the ACLR group had undergone open primary ACL repair, and their outcomes were reported in aggregate with the remaining patients who had undergone prior ACLR. Chong et al[5] performed additional subgroup analyses on the basis of intraoperative ACL hardware removal during the TKA procedure after dividing the ACLR group into the following 4 subgroups: no preexisting hardware removed (22 knees), preexisting hardware removed from the femur only (8 knees), preexisting hardware removed from the tibia only (45 knees), and preexisting hardware removed from both the femur and the tibia (26 knees).

The mean follow-up period for all 5 studies was 3.4 years in the ACLR group and 3.3 years in the control group. The mean time interval between ACLR and TKA was 21.8 years. A summary of the characteristics of each study, including assigned NOS quality assessment scores, is presented in Table 1.

Patient Demographics

Collectively, the 5 included studies evaluated TKA outcomes of 318 patients (176 male and 142 female patients) with a history of ACLR and 455 matched controls. The mean age in the ACLR and control groups was 58.5 years and 60.9 years, respectively. Hoxie et al[9] reported that the ACLR group in their study had a lower mean age (53 years) than the mean age for all patients undergoing TKA at their institution during the same period (67 years). Only 3 studies reported BMI for their patient populations.[5,13,14] The mean BMI in the ACLR and control groups ranged from 26 to 32.6 and from 28 to 32.5, respectively; no statistically significant differences between groups were reported. Matched controls were selected on the basis of age and sex in all 5 studies. Watters et al[22] and Chong et al[5] additionally matched patients on the basis of BMI, surgeon, and implant type. Hoxie et al also matched patients on the basis of surgeon and implant type. In the study by Lizaur-Utrilla et al,[13] patients were additionally matched for BMI and implant type. Magnussen et al[14] also matched patients according to length of follow-up.

ACLR Surgical Details

Only 3 of the included studies reported operative details for the prior ACLR.[9,13,14] Hoxie et al[9] reported that arthroscopic reconstruction was performed in 16 knees, open primary repair was performed in 5 knees, and the technique was unknown for 15 knees; the ACL graft types utilized in this study were bone–patellar tendon–bone (BPTB) autograft in 7 knees, hamstring autograft in 9 knees, and the graft type was unknown in 15 knees. Lizaur-Utrilla et al[13] reported that arthroscopic reconstruction was performed in 15 knees,

TABLE 1
Study Characteristics[a]

First Author (Year)[b]	NOS Score	ACLR Group; Control Group: Patients	Male:Female	Age, y	BMI, kg/m^2	Follow-up	Mean Interval: ACLR to Arthroplasty, y	Outcomes Reported
Hoxie (2008)[9]	9	36; 72	24:12; 48:24	53 (29-78); 57 (40-77)	NR	45 mo (2.0-239); 48 mo (1.5-186)	19.1 (1.2-39.4)	Pre- and postoperative Knee Society Score (knee and function), range of motion, technical difficulty during TKA, use of prosthetic augments or stems, PJI rate, revision surgery rate
Magnussen (2012)[14]	8	22; 22	7:15; 7:15	58.1 ± 10.2; 63.4 ± 9.4	26 ± 4; 28 ± 4	2.8 y (0.6-13); 3.3 y (0.6-10)	25.7 (14-44)	Pre- and postoperative Knee Society Score (knee and function), range of motion, tourniquet time during TKA, technical difficulty during TKA, use of prosthetic augments or stems, postoperative stiffness, PJI rate, revision surgery rate
Watters (2017)[22]	9	122; 122	67:55; 67:55	58; 58	NR[c]	3.3 y; 3.0 y	22 (2-46)	Pre- and postoperative Knee Society Score (pain and function), range of motion, intraoperative blood loss, operative time, PJI rate, reoperation rate
Chong (2018)[5]	9	101; 202	56:45; 112:90	54 ± 9; 56 ± 7	32.6 ± 6.5; 32.5 ± 6.0	10.4 mo ± 10.0; 11.3 mo ± 11.7	20 (3-38)	Operative time, intraoperative blood loss, rate of VTE and nerve injury, PJI rate, reoperation rate
Lizaur-Utrilla (2018)[13]	9	37; 37	22:15; 22:15	69.6 ± 7.3; 70.3 ± 8.2	29.5 ± 5.6; 31.2 ± 6.8	6.1 y (5-7.3); 5.3 y (5-6.2)	22.3 (18-27)	Pre- and postoperative Knee Society Score (knee and function), WOMAC (pain and function), SF-12 (physical and mental), range of motion, technical difficulty during TKA, use of prosthetic augments or stems, operative time, PJI rate, reoperation rate, aseptic loosening, VAS patient satisfaction

[a]Data are reported as absolute values or as mean ± SD (range). ACLR, anterior cruciate ligament reconstruction; BMI, body mass index; NOS, Newcastle-Ottawa Scale; NR, not reported; PJI, periprosthetic joint infection; SF-12, 12-Item Short Form Health Survey; TKA, total knee arthroplasty; VAS, visual analog scale; VTE, venous thromboembolism; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.
[b]All studies: design, retrospective case-control; level of evidence, 3.
[c]Patients matched within 3 kg/m^2.

open reconstruction in 22 knees, and extra-articular reconstruction in 1 knee; the ACL graft types used were BPTB in 21 knees (source unspecified), semitendinosus autograft in 10 knees, and synthetic ligament in 5 knees. Magnussen et al[14] reported that intra-articular reconstruction was performed in 4 knees, extra-articular reconstruction in 2 knees, combined reconstruction in 3 knees, and the technique was unknown for 13 knees; in their study, BPTB autograft was used in 1 knee, combined BPTB autograft and iliotibial band graft were used in 3 knees, iliotibial band graft alone was used in 2 knees, synthetic ligament was used in 3 knees, and the graft type was unknown in 13 knees. Only a single study reported concomitant procedures; Lizaur-Utrilla et al noted that 21 patients had also undergone meniscectomy at the time of their ACLR.

TKA Surgical Details and Intraoperative Measures

Operative details for the arthroplasty procedure were reported in all 5 studies. The TKA prosthesis, technique, and any concomitant procedures are presented in Table 2. Intraoperative measures included technical difficulty, operative time, and intraoperative blood loss during TKA.

Technical difficulty was reported in 3 studies.[9,13,14] Hoxie et al[9] noted that there were no references of technical difficulty or the need for augments or stems in the operative notes of patients with a history of ACLR. However, Lizaur-Utrilla et al[13] reported technical difficulty in 26 of 37 knees in the ACLR group, whereas technical difficulties were not reported in the control group; to obtain adequate ligament balance, additional medial collateral ligament release was required in 16 knees and posterior capsular release was required in 8 knees in the ACLR group, whereas no patients in the control group required additional releases, as exposure difficulties were not encountered in this group. Magnussen et al[14] reported increased difficulty with tibial exposure in 3 patients in the ACLR group, whereas exposure difficulties were not reported in any of the patients in the control group; additional medial or posterior release was performed in 12 patients (55%) in the ACLR group and 9 patients (41%) in the control group ($P = .54$).

The need for increased polyethylene insert thickness and tibial stems was reported in 2 studies.[13,14] In the study by Magnussen et al,[14] increased polyethylene insert thickness was required in 3 knees in the ACLR group and 2 knees in the control group; however, this difference was not statistically significant ($P \geq .99$). Moreover, 2 knees in the ACLR

TABLE 2
ACLR and TKA Operative Details[a]

	ACLR			TKA		
Study	Technique	Graft Type	Concomitant Procedures	Prosthesis	Technique	Concomitant Procedures
Hoxie (2008)[9]	Arthroscopic reconstruction (n = 16), open primary repair (n = 5), technique unknown (n = 15)	BPTB autograft (n = 7), hamstring autograft (n = 9), unknown (n = 15)	NR	24 cruciate sacrificing (posterior stabilized), 9 cruciate retaining, 3 constrained condylar designs; no stems or augments used	34 all components cemented, 1 components uncemented, 1 hybrid (cemented femoral component, uncemented tibial component); patella resurfaced in all cases	NR
Magnussen (2012)[14]	Intra-articular (n = 4), extra-articular (n = 2), combined (n = 3), NR (n = 13)	BPTB autograft (n = 1), BPTB autograft and ITB (n = 3), ITB (n = 2), synthetic ligament (n = 3), NR (n = 13)	NR	Posterior-stabilized tricompartmental TKA (Tornier); polyethylene insert thickness augmentation (ACLR: n = 3, control: n = 2); tibial stem 30 mm longer than standard (ACLR: n = 2, control: n = 0)	Medial parapatellar approach; patella resurfaced in all cases	ACLR hardware removal (n = 10), tibial tubercle osteotomy (ACLR: n = 3), medial or posterior release (ACLR: n = 12, control: n = 9), bony defect cementing/screw reinforcement (ACLR: n = 1)
Watters (2017)[22]	NR	NR	NR	Posterior-stabilized implant design	Patella resurfaced in all cases	ACLR hardware removal (n = 61)
Chong (2018)[5]	NR	NR	NR	Either cruciate-retaining or posterior-stabilized prosthesis designs	NR	ACLR femoral hardware removal only (n = 8), tibial hardware removal only (n = 45), femoral and tibial hardware removal (n = 26)
Lizaur-Utrilla (2018)[13]	Arthroscopic (n = 15), open (n = 21), extra-articular (n = 1)	BPTB graft (n = 21), semitendinosus autograft (n = 10), synthetic ligament (n = 5)	Meniscectomy (n = 21)	Posterior-stabilized Trekking modular system (Samo, Biomedica); polyethylene insert thickness augmentation (ACLR: n = 15, control: n = 2); tibial stem (ACLR: n = 5, control: n = 0)	Medial parapatellar approach; patella resurfaced in all cases	Medial collateral ligament release (ACLR: n = 16, control: n = 0), posterior capsular release (ACLR: n = 8, control: n = 0)

[a]ACLR, anterior cruciate ligament reconstruction; BPTB, bone–patellar tendon–bone; ITB, iliotibial band; NR, not reported; TKA, total knee arthroplasty.

group required the use of a 30-mm tibial stem, whereas no knees in the control group required tibial stems; this difference was also not statistically significant ($P = .49$). Lizaur-Utrilla et al[13] reported that increased polyethylene insert thickness was required in 15 knees and 2 knees in the ACLR and control groups, respectively; tibial stems were required in 5 knees in the ACLR group, whereas none of the knees in the control group required tibial stems. The significance of these differences is unknown, as Lizaur-Utrilla et al did not perform significance testing for these variables. The same authors also reported a partial patellar tendon avulsion that occurred intraoperatively in 1 patient in the ACLR group; this patient had previously undergone arthroscopic ACLR with synthetic ligament. Magnussen et al reported significant bone loss of the posteromedial tibia in 1 patient in the ACLR group at the time of TKA, which required drilling and cementing with screw reinforcement.

Operative time for the TKA procedure was reported in 4 studies.[5,13,14,22] Watters et al[22] found that the mean operative time was significantly longer in the ACLR group than in the control group (88 vs 73 minutes, $P < .001$); they noted that ACL hardware removal was required in 50% of the ACLR group at the time of arthroplasty. Lizaur-Utrilla et al[13] also reported increased operative time in the ACLR group as compared with the control group (82.4 vs 60.6 minutes, $P = .001$), as did Chong et al,[5] who reported that the mean ± SD operative time was greater in the ACLR group than in the control group (97 ± 29 vs 83 ± 24 minutes, $P < .05$). Moreover, Chong et al found that mean operative time was greater in the ACLR subgroup of patients requiring ACL hardware removal from both the tibia and the femur as compared with patients requiring ACL hardware removal from the tibia alone (74 ± 23 vs 64 ± 21 minutes, $P = .020$), whereas no differences were found between the other ACLR subgroups. However, Magnussen

TABLE 3
Range of Motion[a]

Study[b]	Extension Deficit		Flexion	
	Preoperative	Postoperative	Preoperative	Postoperative
Hoxie (2008)[9]				
ACLR	6 (0 to 15)	0.4 (–10 to 6)	101 (15 to 135)	105 (60 to 130)
Control	5 (0 to 30)	0.6 (–6 to 5)	105 (55 to 135)	104 (50 to 130)
Magnussen (2012)[14]				
ACLR	2.3 ± 4.5[c]	–1.1 ± 3.5	122 ± 12	119 ± 13
Control	–0.5 ± 3.7[c]	–2.5 ± 2.6	118 ± 21	118 ± 14
Watters (2017)[22]				
ACLR	4.11	0.17	119.05[c]	125.51
Control	3.92	0.25	123.16[c]	126.75
Lizaur-Utrilla (2018)[13]				
ACLR	6.9 ± 1.7[c]	3.4 ± 3.6	92.3 ± 11.1	109.4 ± 10.7
Control	5.3 ± 1.5[c]	3.6 ± 3.7	96.6 ± 12.4	110.2 ± 11.3

[a]Values are presented as degrees: mean ± SD (range). ACLR, anterior cruciate ligament reconstruction.
[b]Values not reported for Chong et al.[5]
[c]Statistically significant difference between groups, $P < .05$.

et al[14] did not find a significant difference in mean tourniquet time between groups despite 45% of patients in the ACLR group requiring ACL hardware removal at the time of arthroplasty (84 ± 21 minutes [ACLR] vs 75 ± 17 minutes [control], $P = .13$).

Intraoperative blood loss during TKA was reported in 2 studies.[5,22] Watters et al[22] reported no significant difference in estimated blood loss between groups (113 mL [ACLR] vs 111 mL [control], $P = .77$). Likewise, Chong et al[5] did not detect a significant difference in estimated blood loss between groups (94 ± 75 mL [ACLR] vs 87 ± 78 mL [control], $P > .05$).

Radiographic Findings

Three studies reported various radiographic measures, including patella baja, hip-knee-ankle angle, Blackburne-Peel index, Insall-Salvati ratio, and anterior tibial translation.[9,14,22] Hoxie et al[9] reported the presence of patella baja after TKA in 11% of patients in the ACLR group and 2.8% of patients in the control group, but this difference was not statistically significant ($P = .18$). Watters et al[22] reported a mean Insall-Salvati ratio of 1.05 in the ACLR group and 1.09 in the control group ($P = .05$); a ratio >1.2 is considered patella alta.[10] Magnussen et al[14] reported no significant between-group differences in hip-knee-ankle angle, Blackburne-Peel index, incidence of patella baja (defined as Blackburne-Peel index <0.6), femoral mechanical axis, or tibial mechanical axis after TKA. However, they did report significantly greater mean anterior tibial translation in the ACLR group as compared with the control group (5.7 ± 4.7 vs 1.2 ± 4.1 mm, $P = .0016$).

Range of Motion

Four studies reported data on pre- and postoperative knee range of motion.[9,13,14,22] Magnussen et al[14] and Lizaur-Utrilla et al[13] both reported greater preoperative knee extension deficits in the ACLR group as compared with the control group ($P < .05$); however, neither study noted significant between-group differences in postoperative range of motion following TKA. Lizaur-Utrilla et al reported 2 cases of postoperative stiffness that required manipulation under anesthesia (MUA) in the ACLR group, whereas there were no reports of postoperative stiffness in the control group. Magnussen et al reported that 6 patients in the ACLR group experienced postoperative stiffness; 5 of these patients underwent MUA as compared with none in the control group, and this difference was statistically significant ($P = .048$).

Watters et al[22] reported significantly decreased preoperative flexion in the ACLR group as compared with the control group ($P = .01$), but both groups demonstrated similar postoperative flexion following TKA; they noted postoperative stiffness in 3 patients in the ACLR group and in 1 patient in the control group, and all 4 patients underwent MUA. Hoxie et al[9] did not find any differences in pre- or postoperative range of motion between the ACLR and control groups. Although Chong et al[5] did not report range of motion data, they noted that 6 patients in the ACLR group underwent MUA, whereas 12 patients in the control group required MUA; moreover, scar tissue debridement was reported in 6 patients in the ACLR group and 13 patients in the control group. The reported values for pre- and postoperative range of motion are presented in Table 3.

Postoperative Complications and Reoperations

PJI was reported in 2 studies.[5,22] Watters et al[22] reported PJI in 4 patients in the ACLR group who subsequently underwent debridement with polyethylene exchange, compared with 0 patients in the control group ($P = .01$). However, Chong et al[5] noted PJI in 2 patients in the control group requiring reoperation and 0 patients in the ACLR

TABLE 4
Subjective Outcome Scores[a]

Study[b]	KSS: Knee		KSS: Function	
	Postoperative	Preoperative	Postoperative	Preoperative
Hoxie (2008)[9]				
ACLR	46 (6-85)	83 (30-99)	68 (40-94)[c]	85 (40-100)
Control	53 (18-94)	89 (35-100)	51 (22-94)[c]	80 (20-100)
Magnussen (2012)[14]				
ACLR	52 ± 16	93 ± 12	68 ± 14	95 ± 11
Control	50 ± 16	91 ± 9	65 ± 19	88 ± 17
Watters (2017)[22]				
ACLR	NR	NR	69.25[c]	93.12
Control	NR	NR	64.45[c]	90.04
Lizaur-Utrilla (2018)[13]				
ACLR	42.1 ± 13.8	87.9 ± 7.6	49.4 ± 14.1	86.7 ± 8.3
Control	46.9 ± 14.7	90.2 ± 8.1	53.2 ± 15.3	88.2 ± 9.4

[a]Values are presented as mean ± SD (range). ACLR, anterior cruciate ligament reconstruction; KSS, Knee Society Score; NR, not reported.
[b]Values not reported for Chong et al.[5]
[c]Statistically significant difference between groups, $P < .05$.

group, although this difference was not statistically significant ($P > .05$). The remaining 3 studies did not report PJI in the ACLR or control group.[9,13,14] Lizaur-Utrilla et al[13] reported 1 case of superficial wound infection in the control group, which resolved with antibiotics.

Chong et al[5] reported an overall complication rate of 18% in the ACLR group and 17% in the control group; this difference was not statistically significant ($P > .05$). Moreover, they reported 11 reoperations in the ACLR group as compared with 19 reoperations in the control group ($P = .693$). In addition to the 6 patients in the ACLR group who underwent scar tissue debridement, there were 4 cases of instability requiring revision surgery and 1 case requiring implant exchange to nickel-free hardware in the ACLR group. In the control group, in addition to the 13 patients who underwent scar tissue debridement and the 2 patients who underwent reoperation for PJI, 3 patients required implant exchange and 1 patient underwent tendon repair. These authors also reported 1 case of venous thromboembolism in the ACLR group and 1 case in the control group.

Hoxie et al[9] reported 2 revision operations in the ACLR group as well as in the control group. In the ACLR group, 1 patient underwent revision for instability at 6 months postoperatively, and another patient underwent revision owing to pain and osteolysis 13 years after the index TKA. In the control group, 1 patient underwent revision for polyethylene wear 10 years after the index TKA, and another patient underwent revision for aseptic loosening at 15 years postoperatively. Moreover, Hoxie et al reported that the risk for revision at 5 years (ACLR 3.7% vs control 0%) and 10 years (ACLR 3.7% vs control 8.3%) did not differ significantly between groups ($P = .74$).

Watters et al[22] reported a total of 11 reoperations in the ACLR group and 2 reoperations in the control group ($P = .01$). They reported symptomatic patellar crepitus requiring arthroscopic synovectomy in 3 patients in the ACLR group, and another patient in the ACLR group underwent revision arthroplasty 9 years after the index TKA owing to late instability, polyethylene wear, and patellar button failure; in the control group, 1 patient experienced early superficial wound dehiscence requiring closure.

Subjective Outcome Scores

Subjective outcome scores were reported by all studies with the exception of Chong et al.[5] Two studies reported increased preoperative KSS function scores in the ACLR group.[9,22] Watters et al[22] reported greater mean preoperative KSS function scores in the ACLR group (69.25 vs 64.45, $P = .04$), although KSS pain and total scores were similar between groups; however, no between-group differences were noted in any of the KSS components postoperatively. Hoxie et al[9] also reported greater mean preoperative KSS function scores in the ACLR group (68 vs 51, $P = .0001$), with no differences in any of the KSS components noted between groups following TKA. Moreover, none of the 4 studies reported significant differences in any of the KSS components postoperatively. The reported pre- and postoperative KSSs are summarized in Table 4.

Lizaur-Utrilla et al[13] also reported pre- and postoperative WOMAC scores (pain and function) and SF-12 scores (physical and mental). Preoperative WOMAC pain scores did not differ significantly between groups (ACLR 38.7 vs control 37.7, $P = .700$), and similar scores were noted between groups postoperatively (ACLR 44.5 vs control 45.9, $P = .536$). Similarly, no significant between-group differences in WOMAC function scores were noted preoperatively (ACLR 39.3 vs control 38.2, $P = .601$) or postoperatively (ACLR 45.1 vs control 47.9, $P = .232$). Moreover, no statistically significant between-group differences were noted in SF-12 physical component scores (preoperative: ACLR 34.4 vs control 36.7, $P = .139$; postoperative: ACLR 40.9 vs control 42.6, $P = .360$) or SF-12 mental component scores. In addition, Lizaur-Utrilla et al reported no significant differences between groups in patient satisfaction following TKA (ACLR 7.3 vs control 7.9, $P = .171$).

DISCUSSION

The results of this review, although limited, suggest that patients with a history of ACLR have similar postoperative subjective and functional outcomes as controls following TKA; however, differences in TKA operative time and the need for subsequent procedures were reported in several studies. Of the 4 studies that reported mean operative time,[5,13,14,22] 3 found significantly increased operative time in the ACLR group as compared with the control group.[5,13,22] Therefore, increased TKA operative time should be anticipated in this patient population. However, both studies reporting estimated intraoperative blood loss found no significant difference between the ACLR and control groups.[5,22]

Although most studies did not report between-group differences in the incidence of PJI, Watters et al[22] did note that the rate of PJI was higher in the ACLR group than in the control group, which contributed to the statistically higher total reoperation rate in the ACLR group that they reported. Another study reported a statistically higher rate of MUA in the ACLR group; it is worth noting that the ACLR group in this study also had a greater mean extension deficit preoperatively.[14] Lizaur-Utrilla et al[13] also reported a greater mean extension deficit preoperatively in the ACLR group, whereas Watters et al reported significantly decreased preoperative flexion in the ACLR group. It is important to note that no study found significant between-group differences in postoperative range of motion at final follow-up. Although better preoperative KSS function scores were noted in the ACLR group in 2 studies,[9,22] no between-group differences were reported in any subjective outcome scores postoperatively. The minimal clinically important difference for the KSS functional component in patients undergoing TKA is between 6.1 and 6.4[11]; however, only 1 of the studies that noted a statistical difference in preoperative KSS functional scores between groups met this threshold.[9]

Differences in intraoperative measures at the time of TKA have also been reported in patients with a history of ACL injury who were treated nonoperatively. Demey et al[8] compared intraoperative findings and outcomes of posterior-stabilized TKA in 54 patients with a remote history of ACL injury who were managed nonoperatively with a matched control group. Although no between-group differences were noted in postoperative range of motion, KSSs, or the presence of radiolucent lines on radiographs, bone loss and difficulties with tibial exposure were noted at the time of TKA in the ACL-deficient group, resulting in a partial patellar tendon avulsion and a femoral condylar fracture in this group. The authors concluded that, although patients with a history of ACL injury and chronic anterior instability have similar clinical and radiographic outcomes to controls following TKA, surgeons should anticipate difficulty obtaining tibial exposure and posteromedial tibial bone defects in this patient population. In our review, Lizaur-Utrilla et al[13] also reported a partial patellar tendon avulsion, which occurred intraoperatively in 1 patient with a history of prior arthroscopic ACLR with synthetic ligament. Moreover, Magnussen et al[14] reported significant bone loss of the posteromedial tibia in 1 patient with a history of ACLR.

ACLR techniques and postoperative rehabilitation protocols have evolved significantly over the past couple of decades, with arthroscopic procedures becoming increasingly popular given their minimally invasive nature. However, many patients with a history of ACLR who are currently undergoing TKA had their ACLs reconstructed 20 or more years ago, thus the procedures they underwent may have involved open arthrotomy and extensive dissection, which differ considerably from the ACLR techniques commonly used today.[15] Moreover, prolonged immobilization following ACLR had been a common practice that we now know has the deleterious effect of increasing the risk of arthrofibrosis.[2] Therefore, the differences noted in the included studies may not be evident in patients who have had ACLR with modern techniques.

Limitations

This systematic review is not without its limitations. First, only a small number of studies met the inclusion criteria. Second, although the included studies collectively reported outcomes of 318 patients who underwent TKA after ACLR and 455 matched controls, several of the studies had small sample sizes, and there was heterogeneity among studies in terms of the outcome measures evaluated. Therefore, the potential for β, or type II, error should be considered. Moreover, the use of power analyses was not reported in any of the included studies. Third, the mean follow-up duration for the included studies was 3.4 years and 3.3 years for the ACLR and control groups, respectively, which limited our ability to draw conclusions about long-term outcomes in this patient population. Fourth, there were differences both within and between studies in terms of ACLR techniques and graft types, and 2 studies did not report any operative details for the ACLR procedure. Given the heterogeneity in ACLR techniques and graft types, direct comparisons among these studies must be interpreted with caution. In addition, the studies provided limited data on the TKA techniques utilized, which may have affected both operative time and, potentially, reoperation rates. Last, none of the studies evaluated whether the time interval between ACLR and subsequent TKA affected outcomes. It is important to note that time-dependent differences in TKA outcomes have been reported in patients with a history of arthroscopic meniscectomy, with a shorter interval between procedures, particularly 6 months or less, being associated with increased risk for complications.[1,24] Given the retrospective nature of the included studies and therefore lower level of evidence, future studies with larger samples and prospective study designs are warranted.

CONCLUSION

The current literature review suggests that, although short- and midterm subjective scores and functional outcomes of TKA are comparable in patients with and without a history of ACLR, the risk for reoperation after TKA may be higher in patients with prior ACLR. Moreover, surgeons should anticipate increased TKA operative time in patients with a history of ACLR. However, given the limited number of studies and small sample sizes, the findings of this review must be interpreted within the context of its limitations. Nevertheless, our findings may be useful for orthopaedic surgeons evaluating TKA risks and prognoses in patients with a history of ACLR.

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