Systematic Review

Outcomes and Risk Factors of Rerevision Anterior Cruciate Ligament Reconstruction: A Systematic Review

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Purpose: The purpose of this study was to systematically review the literature on rerevision anterior cruciate ligament (ACL) reconstruction, focusing on patient outcomes. The secondary aims of this study were to (1) identify risk factors that contribute to multiple ACL reconstruction failures (defined as a complete tear of a revision ACL graft with knee instability) and (2) assess concomitant knee injuries, such as articular cartilage and menisci lesions. **Methods:** A systematic review of the literature was performed. Inclusion criteria were as follows: outcomes of rerevision ACL reconstruction, English language, minimum of 2 years of follow-up, and human studies. We excluded cadaveric studies, animal studies, basic science articles, editorial articles, surgical technique descriptions, surveys, and rerevision ACL articles in which rerevision reconstruction subgroups were not reported independently of first-time ACL revision groups. **Results:** Six studies met the inclusion criteria and were considered for review. One was a case-control study (Level III evidence), and 5 studies were case series (Level IV evidence). Compared with preoperative scores, patient outcomes improved after rerevision ACL reconstruction. However, more meniscal and cartilage pathologies were present in rerevision cases compared with after primary and revision ACL reconstruction. **Conclusions:** Although rerevision ACL reconstruction can restore stability and improve functional outcomes compared with the preoperative state, outcomes remained inferior when compared with primary ACL reconstructions, particularly regarding a patient's ability to return to his or her preinjury level of activity. Additional factors that place increased stress on the ACL graft, such as increased posterior tibial sagittal plane slope or undiagnosed concomitant ligament injuries, should be investigated, especially in atraumatic failures. If present, operative treatment of these factors should be considered. **Level of Evidence:** Level IV, systematic review of Level III and IV studies.

Anterior cruciate ligament (ACL) reconstruction is one of the most common knee procedures performed today, with an estimated 200,000 cases occurring in the United States annually, and the incidence continuing to rise.[1] While the procedure is largely successful in restoring knee stability, recent studies have reported a considerable incidence of revision surgery, with revision rates of 4.1%[2] to 13%.[3] Due to the increasing number of ACL reconstructions performed both nationwide and throughout the world, revision and rerevision procedures after graft failure have become more prevalent.

Revision ACL reconstruction presents a challenging problem to the orthopaedic surgeon because graft choice options and positioning of bone tunnels are more limited than with primary ACL reconstruction, sometimes requiring staged procedures to restore stability.[4] Additionally, studies have reported an increased incidence of chondral lesions and decreased patient-reported outcome scores with revision ACL reconstruction compared with primary ACL reconstruction.[5,6] Therefore, it is reasonable to assume that these difficulties and concerns may increase with subsequent revision surgeries.

Rerevision ACL reconstructions have not been well studied. While younger age and early return to sport have been shown to be risk factors for primary ACL reconstruction failure, the patient group treated with multiple revisions is particularly interesting because risk factors that increase the likelihood of multiple failures

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have not yet been determined.[7] With the emergence of large multicenter cohorts, an increasing body of literature regarding multiple ACL reconstructions is now available for review.[8,9]

The purpose of this study was to systematically review the current literature on rerevision ACL reconstruction, focusing specifically on clinical outcomes including activity level, pain, and knee stability. The secondary aims of this study were to (1) identify risk factors that contribute to multiple ACL reconstruction failures (defined as a complete tear of the ACL graft with knee instability) and (2) assess secondary structures for concomitant injuries such as articular cartilage and menisci lesions after rerevision procedures.

Methods

Article Identification and Selection

This study was conducted in accordance with the 2009 Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) statement.[10] A systematic review of the literature regarding the existing evidence for outcomes of rerevision ACL reconstruction was performed using the Cochrane Database of Systematic Reviews, the Cochrane Central Register of Controlled Trials, PubMed (1980 to 2014), and MEDLINE (1980 to 2014). The queries were performed in November 2015.

The literature search strategy included the following: Search: ("anterior"[All Fields] AND "cruciate"[All Fields] AND "ligament"[All Fields]) OR "anterior cruciate ligament"[All Fields] OR "acl"[All Fields] AND revision[All Fields].

Inclusion criteria were as follows: outcomes of rerevision ACL reconstruction, English language, minimum of 2 years of follow-up, and human studies. We excluded cadaveric studies, animal studies, basic science articles, editorial articles, surgical technique descriptions, surveys, and rerevision ACL articles in which rerevision reconstruction subgroups were not reported independently of first-time ACL revision groups.

Two investigators (D.J.L. and J.J.M.) independently reviewed the abstracts from all identified articles. Full-text articles were obtained for review if necessary to allow for further assessment of inclusion and exclusion criteria. Additionally, all references from the included studies were reviewed and reconciled to verify that no relevant articles were missing from the systematic review.

Data Collection

The level of evidence of the studies was assigned according to the classification as specified by Wright et al.[11] In the included studies, subjective patient outcomes scores were collected as our primary objective. Additionally, our secondary objective data were collected, including graft used, procedure performed, subjective and objective knee stability, and radiographic findings (e.g., posterior tibial slope). Patient demographics, follow-up, objective, and subjective clinical outcomes were extracted and recorded. For continuous variables (e.g., age, timing, follow-up, outcome scores), the mean and range were collected if reported. Data were recorded into a custom Microsoft Excel spreadsheet (Microsoft Corp., Redmond, WA) using a modified information extraction table.

Bias

Studies classified as level of evidence III or IV can potentially be affected by selection and performance bias because of the lack of randomization and prospective comparative control groups (level IV), especially in populations characterized by heterogeneity of injuries. Therefore, selected studies were reviewed by 2 authors (D.J.L. and J.J.M.), and data were extracted individually. Extracted data were then compared and discussed for accuracy to ensure that authors minimized bias while recognizing the constraints present with such studies. If necessary, additional authors were included to reconcile study inclusion discrepancies.

Results

Study Selection

The systematic search performed using the previously mentioned keywords identified 537 studies from the MEDLINE database and 34 studies from the Cochrane Clinical Trials Database. After duplicates were removed, 553 articles were screened and 6 articles fit the inclusion criteria. One study was Level III evidence, and 5 studies were Level IV evidence. Figure 1 is a PRISMA flowchart that demonstrates the selection criteria of the studies found with the given search criteria.

Demographics

All studies were performed retrospectively and included a total of 214 patients with reported mean ages that ranged from 24 to 30.3 years, with a mean follow-up of 2.6 to 5 years. Five studies reported on a total of 50 males and 13 females,[12-16] with the remaining study of 151 patients composed of 60% males.[8] Two studies reported an average body mass index of 26.5 (n = 151)[8] and 27.3 (n = 15), respectively.[14] In the Multicenter ACL Revision Study (MARS) cohort, Chen et al.[8] reported the rerevision ACL patients to be significantly younger than the first-time revision ACL cohort. Two studies reported a time from primary ACL reconstruction to rerevision of 4.8 years[13] to 9.8 years,[16] and 2 studies reported time from revision ACL reconstruction to rerevision of 2.8 years[13] to 4.4 years[16] (Table 1).

Cartilage and Meniscus Status

Chen et al.[8] demonstrated significantly more chondral injuries in the medial compartment with rerevision

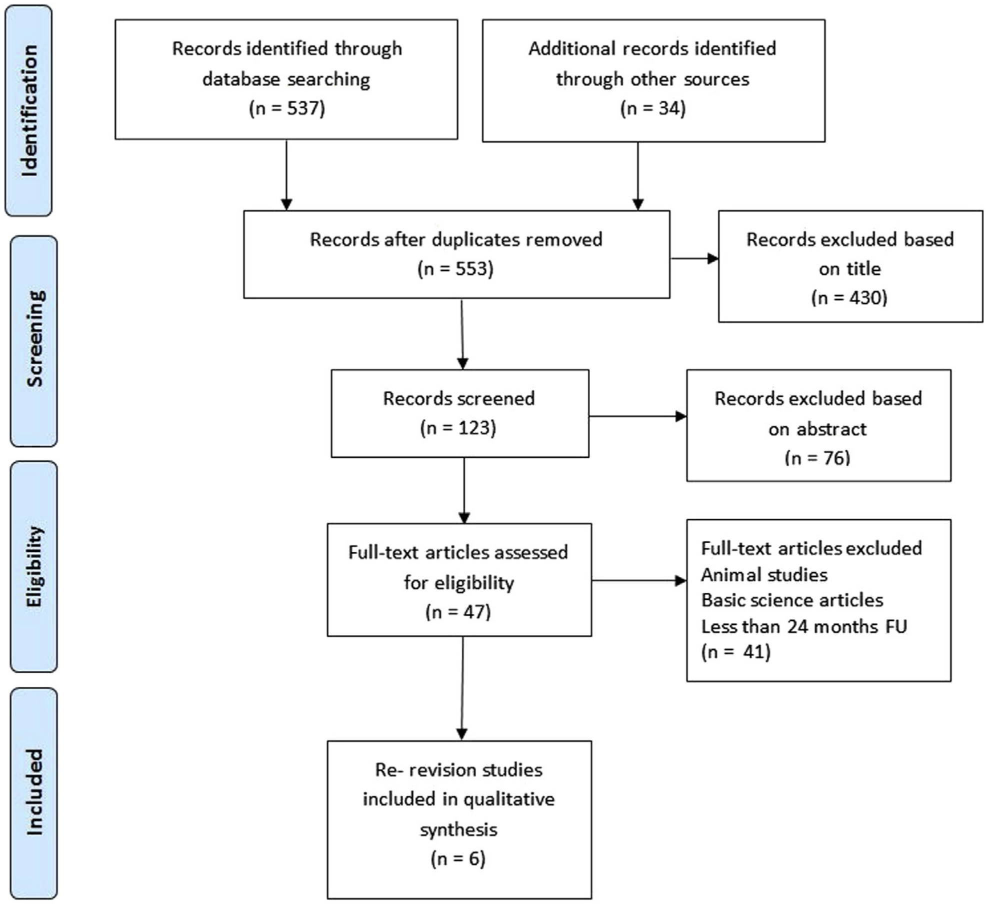

Fig 1. PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analysis) flowchart that demonstrates the selection criteria of the studies found with the given search criteria. (FU, follow-up.)

ACL reconstruction when compared with both primary and initial revision subjects. Of note, subsequent revisions resulted in greater chondral injury, and the location of the chondral damage tended to shift to the patellofemoral joint.[8] Of the 24 patients included in their study, Buda et al.[12] reported diffuse cartilage lesions in 8 cases (International Cartilage Repair Society [ICRS] grade I [8], II [4], III [2]) and focal osteochondral lesions in 4 cases (III [2]. IV [2]). Signs of focal chondral damage were further reported to be between 50%[12] and 67%[14] for evaluated subjects. Moreover, cartilage damage correlated with meniscal damage or injury. All studies included in this review reported on the presence of meniscal damage at time of rerevision procedure and are summarized in Table 1. Chen et al. and Griffith et al. reported a prevalence of meniscal pathology to be 70% and 73%, respectively, with the medial meniscus being the most commonly affected.[8,14]

Operative Data and Rehabilitation

Graft choice was heterogeneous, with a notable preference for autografts over allografts. Three of the included studies used autografts exclusively.[13,15,16] Intraarticular procedures performed are summarized in Table 2, with partial meniscectomy being the most common. In addition to intraarticular procedures performed, 2 studies performed anterior closing wedge proximal tibial osteotomy for correction of excessive tibial slope.[13,15] Two studies reported the use of staged procedures with bone grafting of the prior tunnels.[8,14] Griffith et al.[14] performed a 2-stage procedure in 2 patients due to tunnel widening. Chen et al.[8] reported on the incidence of tibial (3%) and femoral (3%) tunnel widening requiring bone grafting in rerevision procedures. Tibial and femoral bone grafting procedures were performed in 2 stages in 25% and 23% of cases, respectively. Buda et al.[12] reported the use of an over-the-top reconstruction technique with extra-articular plasty.

Three studies reported details of postoperative rehabilitation protocols, which were variable in regards to timing for weight bearing and return-to-sport.[12,13,15] In all studies that reported on rehabilitation protocols, passive and active motion was started in the immediate postoperative period. Patients were made full weight bearing between 1 and 3 months[12,15] and allowed to return to sport between 6 months[13] and 1 year,[15] which was also sport specific. Sonnery-Cottet et al.[15] allowed for return to nonpivoting sports at 5 months, pivoting noncontact sports at 9 months, and full-contact sports at 1 year.

Table 1. Patient Characteristics for Rerevision Anterior Cruciate Ligament Reconstruction

Authors	Year	Level of Evidence	Study Design	Patients (Male, Female)	Age, yr	Follow-up, yr	Time From Primary, yr	Time From Revision, yr	Meniscal Tears	Kellgren-Lawrence Osteoarthritis Score
Dejour et al.	2015	IV	Retrospective case series	9 (6, 3)	30	4.0	4.8	2.8	2 meniscal repairs, 2 meniscectomies	
Sonnery-Cottet et al.	2014	IV	Case series	5 (4, 1)	24	2.6			1 meniscectomy 1 repair	Preoperative: 1 (4), 2 (1); postoperative: 1 (1), 2 (3), 3 (1)
Buda et al.	2013	IV	Case series	24 (24, 0)	30	3.3			13 cases (10 medial, 3 lateral)	
Chen et al.	2013	III	Case-control	151 (60% male)	30				41% medial and 29% lateral tears	
Griffith et al.	2013	IV	Case series	15 (8, 7)	27	5 (range, 2-10)			11 (73%)	
Wegrzyn et al.	2009	IV	Case series	10 (8, 2)	30	3.2	9.8	4.4	11 meniscal tears (8 meniscectomy and 3 trephination). Increased after second revision (P = .016, .0098, and .0197, respectively).	
Total				214						

Tibial Slope

Two of the 6 included studies reported on preoperative and postoperative sagittal tibial slope modification.[13,15] In both studies, patients underwent proximal tibial osteotomy in combination with rerevision ACL reconstruction for correction of a mean preoperative tibial slope that was found to be 13.2° in the study by Dejour et al. and 13.6° in the study by Sonnery-Cottet et al.[13,15] Dejour et al. measured tibial slope using a goniometer to measure the angle between the perpendicular to the tibial diaphyseal axis and the tangent to the most superior points of the anterior and posterior edges of the medial tibial plateau. Sonnery-Cottet et al. measured tibial slope by measuring the angle between the tangent to the medial tibial plateau and the lateral mechanical axis of the leg. Postoperatively, the average tibial slope in the study by Dejour et al. was reduced to 4.4° at a minimum follow-up of 2 years and 9.2° at a mean follow-up of 31.6 months in the Sonnery-Cottet et al. study.[13,15]

Patient-Reported Outcomes

Subjective patient outcomes measures are summarized in Table 3. Outcomes scores collected in the included studies were the Lysholm Knee Scoring Scale, Tegner Activity Scale, International Knee Documentation Committee (IKDC) subjective and objective scores, and Marx activity level. Two of 6 studies reported significant improvements in Lysholm scores compared with preoperative scores. Three studies did not report Lysholm scores. One study collected Lysholm and IKDC subjective and objective scores, but due to small sample size did not perform statistical analysis between pre- and postoperative scores.[13] Three studies reported significant improvements in subjective IKDC scores compared with preoperative scores.[12,14,15] Four studies collected IKDC objective scores, all of which showed improvement compared with preoperative scores.[12,13,15,16] Buda et al.[12] reported significantly improved subjective and objective IKDC scores and a higher return to sport in traumatic failures compared with atraumatic failures. Likewise, in Griffith et al.[14] 8 of 9 patients with traumatic rerupture went on to have good or excellent IKDC scores, while only 1 of 6 patients with atraumatic rerupture reported a good or excellent IKDC score. All patients included in the Sonnery-Cottet et al.[15] study had traumatic ACL graft ruptures. The other 3 studies did not differentiate outcomes based on whether the graft ruptures were traumatic or atraumatic. Wegrzyn et al.[16] reported that severe articular cartilage degeneration (ICRS III and IV lesions) strongly correlated with poor outcomes (IKDC C or D). One study did not report IKDC scores,[8] and one study reported only the A to D IKDC classification score.[16] Further, Chen et al.[8] reported that patients with rerevision reconstruction were more likely to have nontraumatic graft failure.

Two studies reported a decrease in Tegner activity scale scores at final follow-up (range, 2.6 to 5 years postoperative) when compared with prefailure or after

Table 2. Surgical Related Features

Authors	Graft Choice				Posterior Tibialis	Comments	Associated Extraarticular Procedures	Associated Intraarticular Procedures	Staged
	BPTB	Hamstring	Quad	Achilles					
Dejour et al.[13]		1 (auto) (IL)	8 (auto) (IL)				Anterior tibial osteotomy		No
Sonnery-Cottet et al.[15]	1 (CL)		4 (3 IL/1 CL)				Anterior tibial osteotomy	1 partial meniscectomy 1 meniscal repair	No
Buda et al.[12]				9 (allo)	15 (allo)		OTT+ Extraarticular plasty	13 meniscectomy 8 chondral debridement 3 microfracture 2 lateral release 1 bone marrow−derived cell transplantation	No
Chen et al.[8]	88	57	1	5		36% (allo)	6 MCL reconstruction 2 FCL reconstruction	67 partial meniscectomy 25 meniscal repair 3 meniscal trasplant	3% bone grafting for femoral tunnel widening (22% staged), 3% bone grafting for tibial tunnel widening (25% staged)
Griffith et al.[14]	12 (allo) (1 IL)	2 (auto) (1IL/1CL)					1 MCL reconstruction (allo)	10 partial meniscectomy 9 chondroplasty 2 microfracture 1 subtotal meniscectomy 1 meniscal repair	13%
Wegrzyn et al.[16]	9 (auto) (4 IL/5 CL)		1 (auto) (IL)				2 lateral extraarticular reconstructions with gracilis (auto)	9 partial meniscectomy 2 meniscal trephination 4 microfracture	No

allo, allograft; auto, autograft; BPTB, bone−patellar tendon−bone; CL, contralateral; FCL, fibular collateral ligament; IL, ipsilateral; MCL, medial collateral ligament; OTT, “over-the-top” technique.

Table 3. Patient-Reported Outcomes of Rerevision Anterior Cruciate Ligament Reconstruction

Authors	Lysholm Preop	Lysholm Postop	Tegner Prefailure	Tegner Postop	Marx Postop	IKDC SKF Preop	IKDC SKF Postop	Return to Previous Level of Sports Activity, % (n)	Commentaries
Dejour et al.[13]	38.4	73.8				44.1	71.6		Small sample size without statistical analysis
Sonnery-Cottet et al.[15]	46.2	87.8	7.4	7.2		39.5	79.1	80 (4)	Subjective and objective IKDC and Lysholm had statistically significant improvement.
Buda et al.[12]						40.8	81.3	71 (17)	Significant better subjective and objective IKDC scores in traumatic failures and also the return to sports activities.
Chen et al.[8]					6.74				Marx activity levels were significantly higher in the primary-revision group compared with those patients with multiple revisions
Griffith et al.[14]	60	82	6	4.5		59	80	27 (4)	Subjective IKDC, and Lysholm had statistically significant improvement.
Wegrzyn et al.[16]						5 A, 2 B, 3 C, 0 D*	3 A, 2 B, 3 C, 0 D	20 (2)	Severe articular cartilage degeneration (ICRS III and IV lesions) in patients with bad outcomes (IKDC C or D)

IKDC, International Knee Documentation Committee; Preop, preoperative; Postop, postoperative; SKF, Subjective Knee Form.
*Assessed 6 months after first revision.

first-time ACL revision reconstruction.[14,15] Chen et al.[8] also found that Marx activity levels were significantly lower in the rerevision cohort compared with patients with primary revisions. Four studies reported on patients' ability to return to prior level of athletic activity and found high variability ranging from 20%[16] to 80%[15] return to sport.[12,14] Dejour et al.[13] provided some explanation on why 2 patients had postoperative pain during activities. Both of these patients had medial meniscectomies at their primary ACL reconstruction and went on to developed radiographic evidence of osteoarthritis (one from stage 0 → stage 1 and another from stage 0 → stage 2). Griffith et al.[14] reported that most of their patients elected to restrict their activities after repeat revision surgery, which may account for the low level of return to sport (27%). Wegrzyn et al.[16] reported that none of the patients who had prior meniscectomies or ICRS grades III or IV cartilage lesions returned to preinjury level of sports activity.

Restoration of Stability

Objective knee stability improved in all reported studies compared with preoperative values. Two studies evaluated stability with the Lachman test.[14,16] Both studies revealed 100% positive laxity preoperatively, and both studies also showed 20% positive laxity postoperatively.[14,16] Three studies evaluated stability with the pivot shift test, which were all 100% positive preoperatively and ranged from 11% to 27% positive postoperatively.[14-16] Additionally, one study reported a negative Lachman test in 100% of patients and a negative pivot shift in 89% of patients at final

Table 4. Objective Outcomes of Rerevision Anterior Cruciate Ligament Reconstruction

Authors	(+) Lachman Preop	(+) Lachman Postop	(+) Pivot Shift Preop	(+) Pivot Shift Postop	Tibial Slope Preop	Tibial Slope Postop	IKDC Ob Preop	IKDC Ob Postop
Dejour et al.[13]		0/9		1/9	13.2°	4.4°	5 D, 4 C	2 C, 7 B
Sonnery-Cottet et al.[15]			5/5	1/5	13.6°	9.2°	3 C, 2 D	1 A, 4 B
Buda et al.[12]		7 "normal" 15 "nearly normal"					All C/D	4 A, 16 B, 2 C, 2 D
Chen et al.[8]								
Griffith et al.[14]	15/15	3/15	15/15	4/15				
Wegrzyn et al.[16]	10/10	2/10	10/10	0/10			3 A, 5 B, 2 C	2 A, 5 B, 2 C, 1 D

IKDC, International Knee Documentation Committee; Ob, objective; Preop, preoperative; postop, postoperative.

follow-up.[13] Buda et al.[12] reported that 92% patients had a "normal" or "nearly normal" Lachman test at a mean 3.3 year follow-up. One study quantified anteroposterior laxity with a KT-1000 arthrometer, which improved from the preoperative state (6.6 mm) to final follow-up (1.3 mm).[16] Objective data are summarized in Table 4.

Complications and Failures

Of the 6 included studies, 4 reported no complications,[12,13,15,16] and the 2 remaining studies did not report on complications.[8,14] Griffith et al. reported 2 failures. One of these patients was a 35-year-old male who experienced rerupture of the graft at 36 months after rerevision, while the other patient was a 30-year-old male who sustained a retear at 55 months postoperatively. Two failures were also reported by Buda et al.[12] in which the patients had IKDC objective grade D and objective instability. Of note, the study by Chen et al. (MARS group) was not included in the total failures because only patients who had failed primary and revision ACL reconstruction procedures were included in this study.

Discussion

The most important finding of this systematic review was that although rerevision ACL reconstruction can restore stability and improve functional outcomes compared with the preoperative state, outcomes remained inferior when compared with primary ACL reconstructions, particularly regarding a patient's ability to return to his or her preinjury level of activity. The studies reviewed were considerably heterogeneous in the procedures performed, postoperative rehabilitation, and reported outcomes. Further, most studies did not perform objective qualification or quantification of anterior-posterior or rotational stability of the knee. Additionally, failure rates were reported in only 2 studies having an incidence of 8%[12] to 13%.[14] Although these numbers are slightly higher than those reported for primary ACL reconstruction, no conclusion can be drawn owing to the limited number of patients.[2]

Further, most of the studies did not have control groups and were nonrandomized, resulting in the inclusion of only level III and level IV studies. As a result of the heterogeneity among the studies, and the limited data set, no treatment strategy was clearly superior to another. Pain and stability, both subjectively and objectively, improved across all studies when comparing preoperative values with those at time of final follow-up.

Regarding physical examination, in studies that did report physical exam findings, approximately 20% of patients were noted to have a positive Lachman examination, and approximately 20% had a persistent pivot shift. These percentages likely represent an underreporting, as one study reported a mean >3 mm Lachman examination (which would be considered as abnormal in a native ACL situation) as a "normal" or "nearly normal" finding.

The time frame from the primary revision ACL surgery to rerevision reconstruction was 2.8[13] to 4.4[16] years, with an average follow-up among all studies of 2.6 to 5 years. This may introduce bias because this timeframe was likely not long enough to ensure survivorship of the rerevision procedure. Interestingly, there was a predominance of males across all studies, including one study that consisted entirely of male athletes.[12] A study by Wright et al.[17] from the Multicenter Orthopaedic Outcomes Network cohort supports this finding, reporting that men were more likely to rupture their ACL graft in the first 2 years postoperatively, while women were more likely to tear the contralateral native ACL. The difference, however, in tearing the graft versus the tearing the contralateral ACL between genders or graft type was not found to be statistically significant. This is likely due to the limited number of patients in their cohort, and further studies with larger cohorts may better identify a gender risk.

Return to index activity level was variable throughout the included studies, with 27%[14] to 80%[15] of patients able to return to their previous level of activity. Additionally, Tegner activity scores decreased compared with before the most recent ACL reconstruction failure. The cause of the lower levels of activity after rerevision ACL reconstruction was multifactorial, but the status of articular surface of the knee likely played a major role.

All studies reported a progression of degenerative changes in both the menisci and articular cartilage in rerevisions. Wegrzyn et al. reported a higher incidence of meniscal tears and articular cartilage lesions in rerevision ACL reconstructions and found significantly lower IKDC functional assessment scores in patients with severe degenerative lesions (IKDC C or D). As expected, Wegrzyn et al. found a strong correlation with the severity of cartilage lesions and patients' ability to return to activity. Increased contact stresses in an unstable ACL-deficient knee and, subsequently, the possibility for later degenerative changes should not be underestimated.[18,19] Therefore, patients undergoing rerevision procedures should be appropriately counseled for the increased possibility of these degenerative changes.

One potential way to improve outcomes is to identify risk factors that contribute to repeat ACL graft failure. This may be particularly true of biomechanical factors, because 2 studies in this review reported that rupture of ACL grafts were more likely the result of an atraumatic failure compared with primary ACL rupture, and patients who failed nontraumatically reported worse functional outcomes.[8,12] The use of allograft has been reported to have higher failure rates than bone−patellar tendon−bone autografts, and it is now believed that the use of allograft may contribute to nontraumatic ACL graft failures (most likely due to the increased graft incorporation time).[20-22]

Increased posterior tibial sagittal plane slope may also contribute to repeated ACL graft failures. Two studies reported on patients with rerevision ACL reconstruction who had increased posterior tibial slope with preoperative slopes in the studies of 13.2° and 13.6°.[13,15] Historically, Dejour and Bonnin demonstrated that for every 10° increase in posterior tibial slope, 6 mm of anterior tibial translation occurs.[23] More recently, several studies have investigated increased tibial slope as a risk factor for both primary ACL injury as well as graft failure in ACL reconstruction.[24,25] Specifically, a meta-analysis demonstrated increased posterior tibial slope in patients with ACL injury compared with uninjured knees.[26] Christensen et al.[27] compared patients with early ACL graft failure with a control group of patients with successful ACL reconstruction and also found significantly increased slope in patients who had failed (8.4° *v* 6.5°).

Posterior tibial slope is a risk factor for initial ACL injury and ACL reconstruction graft failure, and therefore it constitutes a risk factor for rerevision ACL reconstruction. This is supported by Chen et al.[8] who reported that patients with rerevision reconstruction were more likely to have nontraumatic graft failure. Therefore, patients who have failed primary and revision ACL reconstructions are a challenging group. Biomechanical factors, including posterior tibial slope, which may have contributed to graft failure, should be thoroughly evaluated. Of note, no study included in this review commented on the status and role of secondary restraints of the knee including the medial collateral ligament (MCL), the medial meniscus, and the posterolateral structures.[28] However, Chen et al.[8] did note a higher rate of MCL reconstructions in the rerevision group than in first-time revisions. We strongly recommend that further studies address the status of these structures in rerevision patients as a potential source of failure.

Limitations

The authors recognize that this systematic review has limitations. First, there was little uniformity in reporting subjective and objective outcomes after rerevision ACL reconstruction. All of the included studies had additional procedures performed, and thus isolation of the results of the rerevision ACL was difficult. Additionally, the lack of control groups makes comparative analysis difficult. The relatively short follow-up reported in most of the studies impedes the assessment of true outcomes of this procedure in the long term. As with any systematic review, it is possible that relevant articles or patient subgroups were not identified with our search terms and literature review.

Conclusion

Although rerevision ACL reconstruction can restore stability and improve functional outcomes compared with the preoperative state, outcomes remained inferior when compared with primary ACL reconstructions, particularly regarding a patient's ability to return to his or her preinjury level of activity. Additional factors that place increased stress on the ACL graft, such as increased posterior tibial sagittal plane slope or undiagnosed concomitant ligament injuries, should be investigated, especially in atraumatic failures. If present, operative treatment of these factors should be considered.

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