Subsequent Surgery After Revision Anterior Cruciate Ligament Reconstruction

Rates and Risk Factors From a Multicenter Cohort

The MARS Group*†
Investigation performed at the Department of Orthopaedic Surgery, University of California, San Francisco, San Francisco, California, USA

Background: While revision anterior cruciate ligament reconstruction (ACLR) can be performed to restore knee stability and improve patient activity levels, outcomes after this surgery are reported to be inferior to those after primary ACLR. Further reoperations after revision ACLR can have an even more profound effect on patient satisfaction and outcomes. However, there is a current lack of information regarding the rate and risk factors for subsequent surgery after revision ACLR.

Purpose: To report the rate of reoperations, procedures performed, and risk factors for a reoperation 2 years after revision ACLR.

Study Design: Case-control study; Level of evidence, 3.

Methods: A total of 1205 patients who underwent revision ACLR were enrolled in the Multicenter ACL Revision Study (MARS) between 2006 and 2011, composing the prospective cohort. Two-year questionnaire follow-up was obtained for 989 patients (82%), while telephone follow-up was obtained for 1112 patients (92%). If a patient reported having undergone subsequent surgery, operative reports detailing the subsequent procedure(s) were obtained and categorized. Multivariate regression analysis was performed to determine independent risk factors for a reoperation.

Results: Of the 1112 patients included in the analysis, 122 patients (11%) underwent a total of 172 subsequent procedures on the ipsilateral knee at 2-year follow-up. Of the reoperations, 27% were meniscal procedures (69% meniscectomy, 26% repair), 19% were subsequent revision ACLR, 17% were cartilage procedures (61% chondroplasty, 17% microfracture, 13% mosaicplasty), 11% were hardware removal, and 9% were procedures for arthrofibrosis. Multivariate analysis revealed that patients aged <20 years had twice the odds of patients aged 20 to 29 years to undergo a reoperation. The use of an allograft at the time of revision ACLR (odds ratio [OR], 1.79; P = .007) was a significant predictor for reoperations at 2 years, while staged revision (bone grafting of tunnels before revision ACLR) (OR, 1.93; P = .052) did not reach significance. Patients with grade 4 cartilage damage seen during revision ACLR were 78% less likely to undergo subsequent operations within 2 years. Sex, body mass index, smoking history, Marx activity score, technique for femoral tunnel placement, and meniscal tearing or meniscal treatment at the time of revision ACLR showed no significant effect on the reoperation rate.

Conclusion: There was a significant reoperation rate after revision ACLR at 2 years (11%), with meniscal procedures most commonly involved. Independent risk factors for subsequent surgery on the ipsilateral knee included age <20 years and the use of allograft tissue at the time of revision ACLR.

Keywords: revision anterior cruciate ligament reconstruction; subsequent surgery; reoperation; risk factors; outcomes

Anterior cruciate ligament (ACL) ruptures can be devastating injuries, leading to joint instability, meniscal tears,[33] and subsequent osteoarthritis.[12] Primary ACL reconstruction (ACLR) provides increased stability to the knee and aids in returning patients to sports and activity.[13] Recent studies have further demonstrated a significant overall increase in the diagnosis of ACL injuries and treatment with ACLR in both adult and pediatric populations.[14,19,30,32,34] As ACLR has become more widely utilized, there has been a concomitant increase in its failure, with estimated graft failure rates ranging from 1.8% to 10.4%.[9,10,18,37] In fact, a recent meta-analysis by Wiggins et al[34] estimated an overall graft failure rate of 7%, with rates upwards of 10% in a younger population (age <25 years).

*Address correspondence to David Y. Ding, MD, University of California, San Francisco, 1600 Owens Street, 2nd Floor, San Francisco, CA 94158, USA (email: daviddingmd@gmail.com).

†All authors are listed in the Authors section at the end of this article.

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The increased number of ACLR procedures has therefore amplified the need for revision ACLR, which may present a challenging dilemma for both the surgeon and the patient as several studies have shown inferior clinical outcomes after revision ACLR compared with primary ACLR.[4,11,13,26,35,36] Studies by Wright et al[35] and Spindler et al[26] showed that the Marx activity score, International Knee Documentation Committee (IKDC) score, and median Knee injury and Osteoarthritis Outcome Score (KOOS) knee-related quality of life subscore were significantly decreased in revision ACLR compared with primary ACLR at 2-year follow-up.

Reoperation rates after primary ACLR are reported as high as 27.6% and have a profound effect on patient outcomes and satisfaction.[29] Younger age at the time of index surgery, female sex, and the use of allografts have been reported as risk factors for subsequent surgery.[13,18,24] In fact, younger patients who undergo ACLR had significant increases in the incidence of concomitant meniscal and cartilage procedures, which can portend worse clinical outcomes.[32] Revision ACLR can be difficult and by definition involves a knee that already has had multiple traumatic episodes.

Currently, there is a lack of information concerning the rates and risk factors for further reoperations after revision ACLR. The development of the Multicenter ACL Revision Study (MARS) group led to a prospective longitudinal cohort of patients to evaluate these factors as well as outcomes of reoperations after revision ACLR. This is the first multicenter, prospective cohort study looking at revision ACLR and detailing the results and factors associated with reoperations. The purpose of this study was to report the rate of reoperations in this cohort, and the procedures performed, and identify potential risk factors for a reoperation 2 years after revision ACLR. Our null hypothesis was that no variable was a risk factor for reoperations.

METHODS

Setting and Study Population

The MARS group is an academic and private-practice multicenter consortium funded by the National Institutes of Health and sponsored by the AOSSM.[18] The prospective cohort consisted of 1205 patients enrolled between 2006 and 2011 who had undergone revision ACLR after previously failed primary ACLR. All enrolled patients signed informed consent forms and were required to complete a series of previously validated patient-reported outcome questionnaires both before surgery and then again at 2-year follow-up. Exclusion criteria were inability or unwillingness to complete a 2-year follow-up survey, graft failure secondary to prior intra-articular infections, arthrofibrosis, or complex regional pain syndrome.

All participating sites obtained local institutional review board approval before enrolling patients and complied with a standardized manual of operations. Participating surgeons were required to complete a training session that integrated articular cartilage and meniscus agreement studies, review of the study design, patient inclusion criteria, a practice intra-articular grading sheet, and a trial surgeon questionnaire. The surgeon questionnaire was completed at the time of surgery and included sections on the history of knee injuries and/or surgery on both knees, results of the general knee examination performed under anesthesia, recording of all previous and new intra-articular injuries and treatments to the meniscus and articular cartilage, and surgical technique used for revision ACLR.

Data Sources

Completed baseline data forms were mailed from the participating sites to the data-coordinating center. Data from both the patient and the surgeon questionnaires were subsequently scanned and read with TeleForm software (Cardiff Software Inc) using optical character recognition to avoid manual data entry, and the scanned data were then verified and exported to a master database. A series of logical error and quality control checks were subsequently performed before data analysis.

At 2-year follow-up, patients were mailed the same questionnaire that they had completed at baseline and were asked to complete it and send it back. At the same time, patients were also contacted by telephone and asked if any subsequent surgery had occurred on either knee since their revision ACLR. If they responded affirmatively, either on the questionnaire and/or by telephone, attempts were made to obtain the operative report. Operative reports were analyzed by a single MARS physician to ensure consistency, and all procedures were categorized and recorded along with the surgical date. If multiple procedures were performed during surgery, all procedures were recorded. Because one of our goals was to assess the effect of individual procedures on future outcomes in a multivariate analysis, all procedures were listed, not only whether the patient had undergone any subsequent surgery. Subsequent procedures encompassed hardware removal, arthroscopic scar debridement/synovectomy/manipulation, loose body removal, debridement for infections, articular cartilage procedures (chondroplasty, microfracture, autologous chondrocyte implantation, osteochondral autograft transplantation, and/or osteochondral allografts), meniscal procedures (meniscectomy, repair, and/or meniscal transplants), revision ACLR, and total knee arthroplasty.

Statistical Analysis

Assuming normal distribution of the data on the basis of the large sample size (n = 1112 with 2-year follow-up), we used the Pearson chi-squared test for analysis of categorical data and the independent-samples t test for continuous data. Multivariable binary logistic regression analysis was performed to determine factors associated with reoperations. Results were reported as odds ratios (ORs) with 95% CIs. Repeated-measures analysis of variance was used to assess for changes in patient-reported outcome scores comparing patients who had undergone subsequent surgery and those who did not. Statistical significance was set for all analyses to $P < .05$. SAS software (version 9.3; SAS Institute Inc) was used for statistical analyses and data modeling.

TABLE 1
Study Population Characteristics After Revision ACLR[a]

	No Reoperations	Reoperations	Lost to Follow-up	Total
All patients	990 (100)	122 (100)	93 (100)	1205 (100)
Sex				
Female	416 (42)	62 (51)	30 (32)	508 (42)
Male	574 (58)	60 (49)	63 (68)	697 (58)
Age group, y				
<20	235 (24)	43 (35)	14 (15)	292 (24)
20-29	363 (37)	33 (27)	55 (59)	451 (37)
30-39	240 (24)	33 (27)	14 (15)	287 (24)
40-49	120 (12)	9 (7)	9 (10)	138 (12)
≥50	32 (3)	4 (3)	1 (1)	37 (3)
Body mass index, kg/m^2				
Normal (18.5-24)	460 (46)	62 (51)	38 (41)	560 (46)
Overweight (25-29)	357 (36)	47 (39)	28 (30)	432 (36)
Obese (30-34)	129 (13)	9 (7)	22 (24)	160 (13)
Morbidly obese (≥35)	44 (4)	4 (3)	5 (5)	53 (4)
Smoking status				
Never	756 (76)	99 (81)	68 (73)	923 (77)
Quit	130 (13)	14 (12)	10 (11)	154 (13)
Current	89 (9)	8 (7)	12 (13)	109 (9)
Unknown	15 (2)	1 (1)	3 (3)	19 (2)
Baseline Marx activity score[b]				
0-4	264 (27)	35 (29)	37 (40)	336 (28)
5-8	121 (12)	11 (9)	10 (11)	142 (12)
9-12	226 (23)	24 (20)	20 (22)	270 (23)
13-16	379 (38)	51 (42)	26 (28)	449 (38)

[a]Values are expressed as n (%). ACLR, anterior cruciate ligament reconstruction.
[b]There were missing data for some of the patients.

RESULTS

A total of 1205 patients who underwent revision ACLR were enrolled from 2006 to 2011. Two-year questionnaire follow-up was obtained for 989 patients (82%), while telephone follow-up was obtained for 1112 patients (92%), which composed the study population (Table 1). One hundred twenty-two patients (11% of the cohort) underwent a total of 172 subsequent procedures on the ipsilateral knee at 2-year follow-up. Of the reoperations, 27% were meniscal procedures (69% meniscectomy, 26% repair, 5% meniscal transplant), 19% were subsequent revision ACLR, 17% were cartilage procedures (61% chondroplasty, 17% microfracture, 13% mosaicplasty, 9% cell-based cartilage restoration), 10% were hardware removal, and 9% were procedures for arthrofibrosis such as lysis of adhesions and synovectomy (Figure 1).

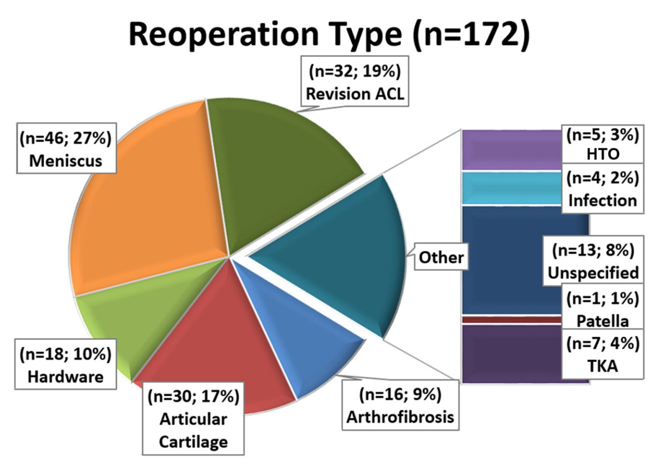

Figure 1. Types of reoperations that were performed within 2 years of revision anterior cruciate ligament (ACL) reconstruction. HTO, high tibial osteotomy; TKA, total knee replacement.

Of those who underwent reoperations, there were 62 female (51%) and 60 male (49%) patients. Reoperations occurred more frequently in patients aged <20 years compared with the overall cohort of patients aged ≥20 years (35% vs 24%, respectively). The majority of the reoperation group had a normal body mass index (BMI) (51%), with only 11% being defined as obese or morbidly obese. The overwhelming majority of the patients never smoked (99 patients, 81%), while only 8 (7%) of the patients were current smokers. Baseline surgical characteristics between the group that underwent subsequent reoperations and the group that did not also revealed some differences (Table 2). Staged revision (bone grafting of tunnels before revision ACLR) occurred more frequently in the reoperation group compared with the no-reoperation group (13% vs 7%, respectively). Allografts (58% vs 47%, respectively) and meniscal repair (25% vs 16%, respectively) were more common in the reoperation group compared with the no-reoperation group, while grade

TABLE 2
Knee Characteristics and Types of Procedures Performed at the Time of Revision ACLR[a]

	No Reoperations	Reoperations	Lost to Follow-up	Total
All patients	990 (100)	122 (100)	93 (100)	1205 (100)
No. of revisions				
1	879 (89)	102 (84)	74 (80)	1055 (88)
Multiple	111 (11)	20 (16)	19 (20)	150 (12)
No. of stages				
1	918 (93)	106 (87)	84 (90)	1108 (92)
2	72 (7)	16 (13)	9 (10)	97 (8)
Femoral tunnel technique[b]				
Transtibial drilling	3831 (36)	43 (35)	24 (26)	426 (36)
Anteromedial portal drilling	503 (347)	53 (43)	57 (61)	5565 (47)
2-incision outside-in drilling	185 (17)	26 (21)	12 (13)	211 (18)
Revision ACL graft type[b]				
Autograft: BTB	288 (29)	28 (23)	20 (22)	336 (28)
Autograft: soft tissue	205 (21)	17 (14)	22 (24)	244 (20)
Allograft: BTB	228 (23)	35 (29)	24 (26)	287 (24)
Allograft: soft tissue	238 (24)	36 (30)	24 (26)	298 (25)
Hybrid (autograft + allograft)	30 (3)	6 (5)	3 (3)	39 (3)
Meniscal tear				
Complete	443 (45)	56 (46)	46 (50)	545 (45)
Partial	173 (17)	25 (21)	14 (15)	212 (18)
None	374 (38)	41 (34)	33 (36)	448 (37)
Meniscal treatment[b]				
Normal meniscus	374 (38)	41 (34)	28 (30)	443 (37)
None	42 (4)	5 (4)	6 (6)	53 (4)
Repair	161 (16)	30 (25)	13 (14)	204 (17)
Meniscectomy	401 (41)	44 (36)	43 (46)	488 (40)
Other	12 (1)	2 (2)	2 (2)	16 (1)
Concomitant cartilage procedures				
None	603 (61)	75 (62)	53 (57)	731 (61)
Chondroplasty	311 (31)	37 (30)	27 (29)	375 (31)
Microfracture	69 (7)	10 (8)	11 (12)	90 (8)
Other (eg, OATS, ACI, osteochondral allograft)	7 (1)	0 (0)	2 (2)	9 (1)
Highest cartilage grade[b]				
1	284 (29)	38 (31)	23 (25)	345 (29)
2	316 (32)	48 (39)	36 (39)	400 (33)
3	98 (10)	20 (16)	12 (13)	130 (11)
4	292 (30)	16 (13)	21 (23)	329 (27)

[a]Values are expressed as n (%). ACI, autologous chondrocyte implantation; ACLR, anterior cruciate ligament reconstruction; BTB, bone-tendon-bone; OATS, osteochondral autograft transplantation.
[b]There were missing data for some of the patients.

4 articular cartilage lesions were much less common (13% vs 30%, respectively) (Table 2).

Multivariate analysis revealed that patients aged <20 years had an OR of 2.1 (95% CI, 1.2-3.7) for reoperations compared with patients aged 20 to 29 years (Table 3). The use of an allograft for the ACL during revision ACLR (OR, 1.79 [95% CI, 1.17-2.73]; P = .007) was a significant predictor for reoperations at 2 years. Staged revision (bone grafting of tunnels before revision ACLR) (OR, 1.93 [95% CI, 0.99-3.75]; P = .052) and the use of a hybrid auto-allograft (OR, 2.48 [95% CI, 0.92-6.65]; P = .071) did not reach significance. Patients with grade 4 cartilage damage seen during revision ACLR were 4.5 times (OR, 0.22 [95% CI, 0.09-0.53]; P = .001) less likely to undergo subsequent surgery within 2 years. Sex, BMI, smoking history, Marx activity score, technique for femoral tunnel placement (anteromedial vs transtibial drilling), number of previous revision procedures, and meniscal tearing or meniscal treatment at the time of revision ACLR showed no significant effect on the reoperation rate.

When analyzing the 989 patients who completed patient-reported outcome surveys, while patients in both the reoperation and no-reoperation groups improved from baseline, patients in the no-reoperation group showed significantly greater improvements in IKDC (P = .005), KOOS symptoms (P = .001), and KOOS pain (P = .034) scores compared with those in the reoperation group (Table 4). In addition, WOMAC stiffness scores (P = .020) improved more in the reoperation group as the baseline WOMAC stiffness scores were lower in the reoperation group (median, 62; interquartile range [IQR], 50-87) than in the no-reoperation group (median, 75; IQR, 50-87) (P = .01).

TABLE 3
Multivariate Regression Predicting Reoperations After Revision ACLR[a]

	Odds Ratio (95% CI)	*P* Value
Sex: male vs female	1.22 (0.79-1.88)	.380
Age (reference: <20), y		
20-29	**0.47 (0.27-0.82)**	**.008**
30-39	0.78 (0.43-1.43)	.422
40-49	0.58 (0.24-1.40)	.226
50-59	0.83 (0.24-2.89)	.770
Body mass index (reference: normal [17-24]), kg/m^2		
Overweight (25-29)	1.33 (0.84-2.10)	.222
Obese (30-34)	0.63 (0.29-1.38)	.249
Morbidly obese (35-40)	0.70 (0.22-2.19)	.543
Smoking history (reference: never)		
Current	0.81 (0.36-1.81)	.606
Quit	0.89 (0.47-1.68)	.712
Marx activity score (reference: 0-4)		
5-8	0.65 (0.31-1.38)	.262
9-12	0.88 (0.48-1.62)	.689
13-16	0.86 (0.50-1.50)	.604
No. of revisions (reference: 1)		
Multiple	1.45 (0.81-2.60)	.217
No. of stages (reference: 1)		
2 (bone grafting before revision)	1.93 (0.99-3.75)	.052
ACL graft type (reference: autograft)		
Allograft	**1.79 (1.17-2.73)**	**.007**
Hybrid (autograft + allograft)	2.48 (0.92-6.65)	.071
Highest cartilage grade (reference: 1)		
2	1.03 (0.61-1.73)	.916
3	1.24 (0.61-2.53)	.555
4	**0.22 (0.09-0.53)**	**.001**
Femoral tunnel technique (reference: transtibial drilling)		
Anteromedial portal drilling	0.96 (0.61-1.50)	.846
2-incision outside-in drilling	1.31 (0.75-2.29)	.337
Meniscal tear (reference: none)		
Partial	1.82 (0.07-48.4)	.720
Complete	1.52 (0.06-39.3)	.802
Meniscal treatment (reference: normal meniscus)		
None for partial tear	0.69 (0.02-19.9)	.827
Meniscectomy	0.73 (0.03-18.9)	.847
Repair	1.20 (0.05-31.7)	.912
Other (transplant)	1.28 (0.04-37.2)	.886

[a]Bolded values represent significant findings. ACLR, anterior cruciate ligament reconstruction.

DISCUSSION

Our results showed that after revision ACLR, the rate of reoperations at a short-term follow-up of 2 years was 11% overall, with 27% of reoperations consisting of meniscal procedures, 19% revision ACLR, and 17% articular cartilage procedures. These findings are consistent with those of previous studies reporting reoperations after primary ACLR. Lyman et al[15] reported a 6.5% reoperation rate on either knee after primary ACLR within 1 year using the New York SPARCS database. Dunn et al's[6] epidemiological study on US Army personnel reported a 12.7% rate of reoperations after ACLR, with 56% meniscal procedures and 35% articular cartilage procedures. Hettrich et al[10] and the MOON group reported an 18.9% rate of subsequent surgery on the ipsilateral knee at 6 years, of which there was a 7.7% rate of revision ACLR, a 13.3% rate of cartilage procedures, a 5.4% rate of arthrofibrosis procedures, and a 2.4% rate of procedures related to hardware.

Reoperations were associated with younger patients, as our patients aged <20 years had a 2.1 times higher risk of reoperations compared with the patients in their 20s. Paterno et al[21] showed an increased risk of repeat ACL tears after ACLR—up to 6 times more likely than a young, healthy cohort without ACLR. Additionally, Hettrich et al[10] found that after ACLR, a 17-year-old patient had an over 2-fold greater risk of reoperations compared with a 34-year-old patient. This has been reiterated by the literature, which has shown the rate of subsequent surgery to the ACL to be age dependent, with the risk decreasing approximately 10% with each successive year.[10,24] Similarly, Webster et al[31] found a 6-fold increase in ipsilateral ACL graft ruptures in patients aged <20 years at the time of surgery. This was correlated with our study, which showed that of the 32 revision ACLR procedures in the reoperation group, 20 (63%) were performed in patients aged <20 years. Possible causes include the following: younger patients who rupture their ACL may be likely to return to more aggressive cutting and pivoting sports, be less compliant with postoperative instructions, and/or have a genetic predisposition to collagen disruption, increasing their risk for ACL retears as well as meniscal and cartilage damage.[1,24,29] Additionally, in older patients, further surgery, especially procedures with a long recovery such as re-revision ACLR, may be discouraged by the surgeon.

In our analysis, the use of allografts was shown to be a significant risk factor for reoperations at 2 years. The risk of ACL graft ruptures with regard to graft choice has been extensively reported in the literature. The risk of ruptures with an allograft was up to 5 times greater compared with that of a bone-tendon-bone autograft.[10] Other authors have noted that the use of allografts significantly increases the risk for hardware removal reoperations.[3] In a previous work by the MARS group, an allograft was confirmed to have an increased incidence of reruptures and lower outcome measures.[17] In addition to showing that patients undergoing revision ACLR using autograft tissue were 2.78 times less likely to sustain a subsequent graft rupture compared with an allograft, the group demonstrated that the use of autografts resulted in improved IKDC scores, KOOS sports and recreation and quality of life subscores, and Marx activity scores.[17] While previous studies have reported better outcomes with bone-tendon-bone autografts,[16,23] in our analysis, the choice of a specific type of allograft or autograft (hamstring, bone-tendon-bone, or quadriceps tendon) was not a significant risk factor for reoperations. When allografts were taken as a whole, they showed a 1.8-times increase in reoperations compared with autografts. Additionally, while using a hybrid auto-allograft did not reach significance (P = .071), it showed a 2.5-times higher risk of reoperations compared with using an autograft. This was likely because of the low numbers of hybrid grafts (39 total, 6 requiring reoperations) despite our large database.

TABLE 4
Patient-Reported Outcome Scores Over Time[a]

	Total		No Reoperations		Reoperations		
	Baseline	2 y	Baseline	2 y	Baseline	2 y	*P* Value
IKDC	51 (37-63)	77 (60-86)	51 (37-63)	78 (63-87)	50 (38-64)	66 (48-81)	**.005**
KOOS							
Symptoms	67 (53-82)	78 (64-89)	67 (53-82)	82 (67-92)	64 (50-78)	71 (57-82)	**.001**
Pain	75 (58-86)	88 (75-94)	75 (58-86)	91 (77-97)	72 (58-86)	83 (69-91)	**.034**
ADL	86 (69-95)	97 (88-100)	86 (69-95)	97 (89-100)	83 (64-95)	94 (83-98)	.157
Sports	45 (25-65)	75 (55-90)	45 (25-65)	75 (55-90)	45 (25-65)	65 (37-80)	.063
QoL	31 (18-43)	56 (37-75)	31 (18-43)	62 (43-75)	37 (18-50)	50 (31-68)	.248
WOMAC							
Stiffness	75 (50-87)	75 (62-100)	75 (50-87)	75 (62-100)	62 (50-87)	75 (62-87)	**.020**
Pain	85 (70-95)	95 (80-100)	85 (70-95)	95 (80-100)	80 (70-95)	90 (75-95)	.089
ADL	86 (69-95)	97 (88-100)	86 (69-95)	97 (89-100)	83 (64-95)	94 (83-98)	.157
Marx activity	11 (4-16)	7 (2-12)	11 (4-16)	7 (2-12)	11 (4-16)	6 (3-12)	.529

[a]Values are expressed as median (interquartile range). The *P* value indicates the difference between no reoperations and reoperations using a repeated measures ANOVA. Bolded values represent significant differences. ADL, activities of daily living; IKDC, International Knee Documentation Committee; KOOS, Knee injury and Osteoarthritis Outcome Score; QoL, quality of life; WOMAC, Western Ontario and McMaster Universities Arthritis Index.

Two-stage revision (bone grafting of tunnels before revision ACLR) had an OR of 1.93 (95% CI, 0.99-3.75; *P* = .052) compared with 1-stage revision for reoperations at 2 years. In our data collection, the second stage of the revision procedure itself was not counted as a reoperation. The shortcomings of 2-stage revision (increased cost, morbidity, and rehabilitation) notwithstanding, the increase in reoperations at 2 years may be caused by increased Fairbanks changes that occur after a bone grafting procedure[7] and worsening meniscal lesions during the staged process. Typically, the time between bone grafting and revision ACLR is between 4 and 5 months, and during this time between procedures, it is possible that the patient may sustain additional meniscal and chondral damage from ambulation on an unstable knee or subtle microinstability. Additionally, various methods of bone grafting have been described,[2,7,27,28] and it is possible that despite our attempts to restore native bony anatomy to the knee, the previous tunnels remain a source of continued frailty for graft stability. While our numbers are low, 5 of the 97 patients (5%) who underwent 2-stage revision sustained another ACL rupture compared with only 25 of the 1108 patients (2%) who underwent 1-stage revision at 2 years. Further study is needed, however, as patients who underwent 2-stage revision might have fared even worse with 1-stage revision surgery. Presumably, these patients were bone grafted because one or both tunnels were very enlarged. Our findings emphasize the challenge of taking care of patients with failed ACLR and enlarged tunnels and the importance of studying this issue further to better define the optimal treatment protocol.

At the time of baseline revision ACLR, concomitant injuries such as meniscal tears and chondral damage were commonly present: 63% of the patients had meniscal tears noted during surgery, and 39% of patients had concomitant cartilage procedures performed. This is similar to the findings of Widener et al,[33] who reported a 74% rate of concomitant meniscal injuries at the time of revision ACLR. Our results demonstrated that grade 4 chondral damage noted at the time of initial surgery was associated with fewer reoperations within 2 years. This may be related to a decrease in activity with increasing chondral damage as patients develop more painful joints. These patients have lower IKDC scores and lower Marx activity scores proportional to their Outerbridge classification.[22] Furthermore, there may also be the added effect of the physician advising to decrease activity with severe cartilage loss after revision ACLR and a decreased proclivity of surgeons to recommend further procedures in these patients.

Interestingly, meniscal injuries and meniscal surgery (either repair or meniscectomy) at the time of revision ACLR did not portend future reoperations. Previous studies have shown mixed results: some have demonstrated a correlation with meniscal surgery and future reoperations,[3] while other studies have found no correlation.[18] This may be in part because of the philosophy of the operating surgeon with regard to meniscal injuries at the time of revision ACLR. Meniscal injuries, such as posterior-lateral meniscal tears[5,25] and small medial meniscal tears,[5] can be left in situ with very low rates of reoperations at greater than 6-year follow-up after ACLR.

Female sex also was not an independent predictor for future reoperations, which at first seems contradictory to previous studies that suggested that female patients are more prone to arthrofibrosis and stiffness-related reoperations.[3,20] However, our study focused on revision ACLR. Patients who have already undergone previous ACL surgery may be more knowledgeable and compliant with the postoperative rehabilitation protocols. As a result, these patients may be more vigilant for the prevention of arthrofibrosis compared with those undergoing primary ACLR. Alternatively, underlying biological differences that make patients more likely to undergo revision ACLR may make them less likely to develop scar tissue, arthrofibrosis, and stiffness.

In our study, several knee function scores were relatively lower in the reoperation group. These included the IKDC, KOOS symptoms, KOOS pain, and WOMAC stiffness scores. Similarly, Granan et al[8] found a correlation between lower KOOS scores and ACL graft failure. The median IKDC score of our patients who did not undergo reoperations was 78 at 2 years, while the median IKDC score of patients who underwent reoperations was significantly lower at 66. While our study is the first to note decreasing patient-reported outcomes with reoperations after revision ACLR, van Dijck et al[29] reported significantly lower Lysholm scores in patients who underwent reoperations after primary ACLR in comparison with patients who did not need additional surgery.

Our study has strengths as well as limitations. It consists of the largest prospective longitudinal cohort to analyze the outcomes of revision ACLR. The 50:50 mix of academic and private-practice surgeons makes the results generalizable to the sports medicine fellowship–trained community. The use of validated patient-reported outcome measures allowed us to compare this study with previous studies that have used these measures in other settings. The large number of patients enrolled allowed us to perform sophisticated statistical analyses, controlling for a large number of variables to understand the predictors of inferior outcomes noted in revision ACLR. Our study design is limited in that it currently precludes on-site follow-up, which may lead to recall bias, and has only a 2-year follow-up. It is also possible that important risk factors or confounders were not realized and not included in the multivariate regression. Long-term studies such as those by van Dijck et al[29] and Hanypsiak et al[9] show reoperation rates as high as 34% with greater than 7-year follow-up. Future follow-up studies, including a continued follow-up of our current cohort, may show a comparable incidence of reoperations.

CONCLUSION

There was a significant reoperation rate after revision ACLR at 2 years (11%). The most prevalent reoperations involved meniscal procedures. Independent risk factors for subsequent surgery on the ipsilateral knee included age <20 years and the use of allograft tissue at the time of revision ACLR. The knowledge of these facts will allow physicians to better counsel their patients appropriately before surgery.

AUTHORS

The MARS Group; David Y. Ding, MD, Alan L. Zhang, MD, Christina R. Allen, MD (University of California, San Francisco, San Francisco, California, USA); Allen F. Anderson, MD (Tennessee Orthopaedic Alliance, Nashville, Tennessee, USA); Daniel E. Cooper, MD (W.B. Carrell Memorial Clinic, Dallas, Texas, USA); Thomas M. DeBerardino, MD (The San Antonio Orthopaedic Group, San Antonio, Texas, USA); Warren R. Dunn, MD, MPH (Reedsburg Area Medical Center, Reedsburg, Wisconsin, USA); Amanda K. Haas, MA (Washington University in St. Louis, St. Louis, Missouri, USA); Laura J. Huston, MS (Vanderbilt University, Nashville, Tennessee, USA); Brett (Brick) A. Lantz, MD (Slocum Research and Education Foundation, Eugene, Oregon, USA); Barton Mann, PhD (deceased) (AOSSM, Rosemont, Illinois, USA); Kurt P. Spindler, MD (Cleveland Clinic, Cleveland, Ohio, USA); Michael J. Stuart, MD (Mayo Clinic, Rochester, Minnesota, USA); Rick W. Wright, MD (Washington University in St. Louis, St. Louis, Missouri, USA); John P. Albright, MD (University of Iowa Hospitals and Clinics, Iowa City, Iowa, USA); Annunziato (Ned) Amendola, MD (Duke University, Durham, North Carolina, USA); Jack T. Andrish, MD (Cleveland Clinic, Cleveland, Ohio, USA); Christopher C. Annunziata, MD (Commonwealth Orthopaedics & Rehabilitation, Arlington, Virginia, USA); Robert A. Arciero, MD (University of Connecticut Health Center, Farmington, Connecticut, USA); Bernard R. Bach Jr, MD (Rush University Medical Center, Chicago, Illinois, USA); Champ L. Baker III, MD (The Hughston Clinic, Columbus, Georgia, USA); Arthur R. Bartolozzi, MD (3B Orthopaedics, University of Pennsylvania Health System, Philadelphia, Pennsylvania, USA); Keith M. Baumgarten, MD (Orthopedic Institute, Sioux Falls, South Dakota, USA); Jeffery R. Bechler, MD (University Orthopaedic Associates LLC, Princeton, New Jersey, USA); Jeffrey H. Berg, MD (Town Center Orthopaedic Associates, Reston, Virginia, USA); Geoffrey A. Bernas, MD (State University of New York at Buffalo, Buffalo, New York, USA); Stephen F. Brockmeier, MD (University of Virginia, Charlottesville, Virginia, USA); Robert H. Brophy, MD (Washington University in St. Louis, St. Louis, Missouri, USA); Charles A. Bush-Joseph, MD (Rush University Medical Center, Chicago, Illinois, USA); J. Brad Butler V, MD (Orthopedic and Fracture Clinic, Portland, Oregon, USA); John D. Campbell, MD (Bridger Orthopedic and Sports Medicine, Bozeman, Montana, USA); James L. Carey, MD, MPH (University of Pennsylvania, Philadelphia, Pennsylvania, USA); James E. Carpenter, MD (University of Michigan, Ann Arbor, Michigan, USA); Brian J. Cole, MD (Rush University Medical Center, Chicago, Illinois, USA); Jonathan M. Cooper, DO (HealthPartners Specialty Center, St. Paul, Minnesota, USA); Charles L. Cox, MD, MPH (Vanderbilt University, Nashville, Tennessee, USA); R. Alexander Creighton, MD (University of North Carolina Medical Center, Chapel Hill, North Carolina, USA); Diane L. Dahm, MD (Mayo Clinic, Rochester, Minnesota, USA); Tal S. David, MD (Synergy Specialists Medical Group, San Diego, California, USA); David C. Flanigan, MD (The Ohio State University, Columbus, Ohio, USA); Robert W. Frederick, MD (The Rothman Institute/Thomas Jefferson University, Philadelphia, Pennsylvania, USA); Theodore J. Ganley, MD (Children's Hospital of Philadelphia, Philadelphia, Pennsylvania, USA); Elizabeth A. Garofoli, MD (Washington University in St. Louis, St. Louis, Missouri, USA); Charles J. Gatt Jr, MD (University Orthopaedic Associates LLC, Princeton, New Jersey, USA); Steven R. Gecha, MD (Princeton Orthopaedic Associates, Princeton, New Jersey, USA); James Robert Giffin, MD (Fowler Kennedy Sport Medicine Clinic, University of Western Ontario, London, Ontario, Canada); Sharon L. Hame, MD (David Geffen School of Medicine at UCLA, Los Angeles, California, USA); Jo A. Hannafin, MD, PhD (Hospital for Special Surgery, New York, New York, USA); Christopher D. Harner, MD (University of Texas Health Science Center, Houston, Texas, USA); Norman Lindsay Harris Jr, MD (Orthopaedic Associates of Aspen & Glenwood, Aspen, Colorado, USA); Keith S. Hechtman, MD (UHZ Sports Medicine Institute, Coral Gables, Florida, USA); Elliott B. Hershman, MD (Lenox Hill Hospital, New York, New York, USA); Rudolf G. Hoellrich, MD (Slocum Research and Education Foundation, Eugene, Oregon, USA); Timothy M. Hosea, MD (deceased) (University Orthopaedic Associates LLC, Princeton, New Jersey, USA); David C. Johnson, MD, Timothy S. Johnson, MD (National Sports

Medicine Institute, Leesburg, Virginia, USA); Morgan H. Jones, MD (Cleveland Clinic, Cleveland, Ohio, USA); Christopher C. Kaeding, MD (The Ohio State University, Columbus, Ohio, USA); Ganesh V. Kamath, MD (University of North Carolina Medical Center, Chapel Hill, North Carolina, USA); Thomas E. Klootwyk, MD (Methodist Sports Medicine, Indianapolis, Indiana, USA); Bruce A. Levy, MD (Mayo Clinic, Rochester, Minnesota, USA); C. Benjamin Ma, MD (University of California, San Francisco, San Francisco, California, USA); G. Peter Maiers II, MD (Methodist Sports Medicine, Indianapolis, Indiana, USA); Robert G. Marx, MD (Hospital for Special Surgery, New York, New York, USA); Matthew J. Matava, MD (Washington University in St. Louis, St. Louis, Missouri, USA); Gregory M. Mathien, MD (Knoxville Orthopaedic Clinic, Knoxville, Tennessee, USA); David R. McAllister, MD (David Geffen School of Medicine at UCLA, Los Angeles, California, USA); Eric C. McCarty, MD (University of Colorado Denver School of Medicine, Denver, Colorado, USA); Robert G. McCormack, MD (University of British Columbia, New Westminster, British Columbia, Canada); Bruce S. Miller, MD, MS (University of Michigan, Ann Arbor, Michigan, USA); Carl W. Nissen, MD (Connecticut Children's Medical Center, Hartford, Connecticut, USA); Daniel F. O'Neill, MD, EdD (Littleton Regional Healthcare, Littleton, New Hampshire, USA); Brett D. Owens, MD (Warren Alpert Medical School, Brown University, Providence, Rhode Island, USA); Richard D. Parker, MD (Cleveland Clinic, Cleveland, Ohio, USA); Mark L. Purnell, MD (Orthopaedic Associates of Aspen & Glenwood, Aspen, Colorado, USA); Arun J. Ramappa, MD (Beth Israel Deaconess Medical Center, Boston, Massachusetts, USA); Michael A. Rauh, MD (State University of New York at Buffalo, Buffalo, New York, USA); Arthur C. Rettig, MD (Methodist Sports Medicine, Indianapolis, Indiana, USA); Jon K. Sekiya, MD (University of Michigan, Ann Arbor, Michigan, USA); Kevin G. Shea, MD (Intermountain Orthopaedics, Boise, Idaho, USA); Orrin H. Sherman, MD (NYU Hospital for Joint Diseases, New York, New York, USA); James R. Slauterbeck, MD (Robert Larner College of Medicine, University of Vermont, Burlington, Vermont, USA); Matthew V. Smith, MD (Washington University in St. Louis, St. Louis, Missouri, USA); Jeffrey T. Spang, MD (University of North Carolina Medical Center, Chapel Hill, North Carolina, USA); LTC Steven J. Svoboda, MD (Keller Army Community Hospital, United States Military Academy, West Point, New York, USA); Timothy N. Taft, MD (University of North Carolina Medical Center, Chapel Hill, North Carolina, USA); Joachim J. Tenuta, MD (Albany Medical Center, Albany, New York, USA); Edwin M. Tingstad, MD (Inland Orthopaedic Surgery and Sports Medicine Clinic, Pullman, Washington, USA); Armando F. Vidal, MD (University of Colorado Denver School of Medicine, Denver, Colorado, USA); Darius G. Viskontas, MD (Royal Columbian Hospital, New Westminster, British Columbia, Canada); Richard A. White, MD (St. Mary's Hospital–Audrain, Mexico, Missouri, USA); James S. Williams Jr, MD (Cleveland Clinic, Euclid, Ohio, USA); Michelle L. Wolcott, MD (University of Colorado Denver School of Medicine, Denver, Colorado, USA); Brian R. Wolf, MD (University of Iowa Hospitals and Clinics, Iowa City, Iowa, USA); James J. York, MD (Chesapeake Orthopaedic & Sports Medicine Center, Glen Burnie, Maryland, USA).

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