Meniscal Repair in the Setting of Revision Anterior Cruciate Ligament Reconstruction

Results From the MARS Cohort

MARS Group*†
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Background: Meniscal preservation has been demonstrated to contribute to long-term knee health. This has been a successful intervention in patients with isolated tears and tears associated with anterior cruciate ligament (ACL) reconstruction. However, the results of meniscal repair in the setting of revision ACL reconstruction have not been documented.

Purpose: To examine the prevalence and 2-year operative success rate of meniscal repairs in the revision ACL setting.

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

Methods: All cases of revision ACL reconstruction with concomitant meniscal repair from a multicenter group between 2006 and 2011 were selected. Two-year follow-up was obtained by phone and email to determine whether any subsequent surgery had occurred to either knee since the initial revision ACL reconstruction. If so, operative reports were obtained, whenever possible, to verify the pathologic condition and subsequent treatment.

Results: In total, 218 patients (18%) from 1205 revision ACL reconstructions underwent concurrent meniscal repairs. There were 235 repairs performed: 153 medial, 48 lateral, and 17 medial and lateral. The majority of these repairs (n = 178; 76%) were performed with all-inside techniques. Two-year surgical follow-up was obtained on 90% (197/218) of the cohort. Overall, the meniscal repair failure rate was 8.6% (17/197) at 2 years. Of the 17 failures, 15 were medial (13 all-inside, 2 inside-out) and 2 were lateral (both all-inside). Four medial failures were treated in conjunction with a subsequent repeat revision ACL reconstruction.

Conclusion: Meniscal repair in the revision ACL reconstruction setting does not have a high failure rate at 2-year follow-up. Failure rates for medial and lateral repairs were both <10% and consistent with success rates of primary ACL reconstruction meniscal repair. Medial tears underwent reoperation for failure at a significantly higher rate than lateral tears.

Keywords: meniscus; repair; failure; ACL reconstruction; revision; outcomes

The results of revision anterior cruciate ligament (ACL) reconstruction have been demonstrated to be worse than those typically obtained in primary ACL reconstruction.[9,15,36-38] The Multicenter ACL Revision Study (MARS) group, through its work over the past several years, has begun to elucidate contributing factors for these worse outcomes. Specifically, we have shown that graft choice, meniscal and chondral damage, and surgical factors all contribute to outcomes.[19-24] Meniscal preservation has been demonstrated to contribute to overall and long-term knee health. However, the results of meniscal repair in the setting of revision ACL reconstruction have not been documented.

Meniscal repair in the setting of ACL-intact and primary ACL-reconstructed knees has been shown to be a successful procedure in the short and long term. Previous studies documented 84% to 96% success with 2-year follow-up of meniscal repair in the setting of primary ACL reconstruction.[10,14,16,31-35] At minimum 5-year follow-up, however, failures and reoperations increase, but meniscal repair continues to be an

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overall successful procedure, with rates of reoperation and failure from 11% to 24%.[1,27,28,35] Given the overall negative effect of loss of the meniscus, these failure rates justify striving to repair as many menisci as possible. Our goal was to determine meniscal repair success in a prospective longitudinal cohort of revision ACL reconstructions. Our hypothesis for this study was that meniscal repair with revision ACL reconstruction would be less successful than primary ACL reconstruction, with success defined as the lack of need for reoperation for meniscal symptoms.

METHODS

Setting and Study Population

Our consortium was assembled with the aim of determining what affects outcome in an ACL revision setting and to identify potentially modifiable factors that could improve these outcomes. This collaboration consists of a group of 83 sports medicine fellowship–trained surgeons across 52 sites. Surgeons are a near equal mix of academic and private practitioners. After obtaining approval from respective institutional review boards, this multicenter consortium began patient enrollment in 2006 and ended it in 2011, during which time 1205 patients with revision ACL reconstruction were enrolled in this prospective longitudinal cohort. The study enrolled patients undergoing revision of a previously failed ACL reconstruction who agreed to participate, provided informed consent, and completed a series of patient-reported outcome instruments. Indications for the revision ACL reconstruction included functional instability, abnormal laxity testing, or magnetic resonance imaging indicating graft tear. Multiligament reconstructions were excluded. Surgeon inclusion criteria included maintenance of active institutional review board approval, completion of a training session that integrated articular cartilage and meniscal agreement studies, review of the study design and patient inclusion criteria, and review of the surgeon questionnaire. Surgeons performed the surgery as they desired. The only surgical stipulation was that, in allograft cases, a Musculoskeletal Transplant Foundation graft was used to standardize the allograft source and preparation.

Data Sources and Measurement

After informed consent was obtained, the patient filled out a 13-page questionnaire that included questions regarding demographics, sports participation, injury mechanism, comorbidities, and knee injury history, as previously described.[18,24] With this questionnaire, each participant also completed a series of validated general and knee-specific outcome instruments, including the Knee injury and Osteoarthritis Outcome Score (KOOS), the International Knee Documentation Committee (IKDC) subjective form, and the Marx Activity Rating Scale. Contained within the KOOS was the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC). Surgeons filled out a questionnaire that included the impression of the cause of the previous failure, the physical examination findings, the surgical technique used, and the intra-articular findings and surgical management of meniscal and chondral damage. Data regarding meniscal tears collected by the surgeon included tear location (medial vs lateral, anterior vs posterior), length, and tear location within the meniscus (central, middle, peripheral third). Additionally, when menisci were repaired, the technique, devices, and/or suture used were recorded.

Completed data forms were mailed from each participating site to the data coordinating center. Data from the patient and surgeon questionnaires were scanned with Teleform software (OpenText) and optical character recognition, and the scanned data were verified and exported to a master database. A series of logical error and quality control checks were subsequently performed before data analysis.

Patient Follow-up

Two-year patient follow-up was completed by mail with readministration of the same questionnaire as the one completed at baseline. Patients were also contacted by phone to determine whether any subsequent surgery had occurred to either knee since the initial revision ACL reconstruction. If so, operative reports were obtained, whenever possible, to verify pathology and treatment. The primary outcome measure for this study was meniscal reoperation.

Statistical Analysis

Descriptive statistics of variables were calculated. Baseline demographics and surgical variables were compared between patients who had a documented subsequent procedure for a failed meniscal repair and patients whose index meniscal repairs did not fail (as defined by not having undergone a subsequent meniscus-related surgical procedure). To examine evidence for unadjusted associations with meniscal failure status, Wilcoxon rank sum tests were used for continuous variables and Fisher exact tests for categorical variables. Statistical analysis was performed with open source R statistical software (www.cran.r-project.org).

RESULTS

A total of 235 meniscal repairs were performed in 218 patients at the time of ACL revision surgery, which represented 18% (218/1205) of the study cohort. Of the meniscal repairs, 76% (178/235) were performed via the all-inside technique. There were 153 medial repairs and 48 lateral repairs, and 17 patients had both menisci repaired at the time of ACL revision surgery (n = 34 repairs in 17 patients). For comparison, before the patient's index revision ACL reconstruction, 362 patients had undergone a previous medial meniscectomy, and 195 previously underwent a lateral meniscectomy. At the time of the index revision surgery, 330 patients underwent a concomitant medial meniscectomy, and 313 underwent a concomitant lateral meniscectomy.

Two-year follow-up was obtained on 90.4% (197/218) of the patients (89% of the repairs; 210/235), including 92% (141/153) of patients with medial repairs, 90% (43/48) with lateral repairs, and 76% (13/17) who had a combination repair.

Failure, defined as a reoperation for treatment of the meniscus, occurred in 8.6% (17/197) of the cohort. There were 14 of 153 medial meniscal repair failures (12 all-inside, 2 inside-out) and 2 of 48 lateral meniscal repair failures (both all-inside). One failure occurred in the combination repair group (medial-side failure only; all-inside). Four medial meniscal repair reoperations occurred in the context of 4 (independent) repeat revision ACL reconstructions.

Table 1 stratifies the patient and surgical characteristics between the meniscal failure and nonfailure groups. No statistically significant difference was found in the ages of patients in the meniscal repair failure group and the nonfailure group ($P = .12$) or in the meniscal tear location, tear type, tear length, repair technique, suture/implant type, or number of sutures used between the groups. The failure rate for medial meniscal repairs was 8.8% (15/170), while the failure rate for lateral meniscal repairs was 3.0% (2/65) but not statistically different ($P = .13$) (Table 1). Interestingly, the failure group did have a slightly lower body mass index (BMI) than the nonfailure group ($P = .04$).

Table 2 stratifies patient-reported outcome scores between the meniscal failure and nonfailure cases. Although the meniscal failure group exhibited better KOOS Pain and Sports and Recreation subscores at baseline as compared with the nonfailure group, no statistical differences were found in any outcome measure at 2-year follow-up.

DISCUSSION

Meniscal resection has been demonstrated to lead to osteoarthritis owing to increased contact stress and decreased contact area.[6,30] Based on this, meniscal repair has been a treatment option advocated since the 1970s (open) and 1980s (arthroscopic).[7,11-13] Many reparable tears occur in the setting of ACL reconstruction, and previous studies have shown the efficacy and success of this procedure.[31,34,35] To date, no large prospective series has been published evaluating meniscal repair in the setting of revision ACL reconstruction. While it might be intuitively thought that the procedure would have equal success in the revision ACL reconstruction setting compared with the primary ACL reconstruction setting, overall results for outcomes have been shown to be worse for revision ACL reconstructions.[36-38] In addition, there is a much higher rate of chondral damage in revision ACL reconstructions, which might contribute to meniscal repair failure.[24,39] For these reasons, this cohort offers the ability to address these issues.

In this cohort, 18% of the 1205 patients underwent revision ACL reconstruction and concurrent meniscal repair, which is a rate fundamentally identical to the 18.3% reported in a series of primary ACL reconstructions by Toman et al.[31] With 2-year follow-up, the authors used similar descriptive methods and reported failure as reoperation, identical to this series. Those authors also noted a 96% success rate in a series of medial and lateral tears repaired with a variety of techniques but predominantly all-inside implants. The current series has a failure rate that is twice as high (8.6%) as that noted by Toman et al (4%), but it was still >90% success at minimum 2-year follow-up.

The occurrence and type of meniscal tears may not be equivalent in primary and revision ACL reconstructions. In a study cohort of patients with primary ACL reconstruction who went on to revision ACL reconstructions, Wyatt et al[39] noted that the incidence of meniscal tears in revision ACL reconstructions was lower than that in primaries (43.7% vs 54.8%), with a 13% incidence of meniscal repairs in cases of revision. In another comparison of a cohort with primary ACL reconstruction going on to revision, Borchers et al[2] noted similar medial meniscal tear rates but a decreased risk of lateral tears in revisions (odds ratio, 0.54; $P < .01$). In a study analyzing the MARS cohort as compared with the Norwegian Knee Ligament Registry and the Societe Francaise d'Arthroscopie, it was noted that the current revision cohort had more meniscal repairs medially than either European group but a similar number of lateral repairs.[17]

The current series had a higher failure rate of medial meniscal tears (8.8%) than lateral tears (3.0%). The reasons for this finding are not clear. BMI, smoking, age, and activity may play a role, but the number of failures was too small for this detailed analysis. The medial meniscus may see higher forces, but this would be true in any ACL-reconstruction scenario and not necessarily more important in the revision ACL case. These results are similar to the findings in a systematic review of meniscal surgery by Paxton et al,[29] who reported higher failure rates of medial meniscal repairs than lateral meniscal repairs at short-term (0-4 years) and intermediate (4-10 years) follow-up. It is not apparent in analysis why this might be occurring, and this finding has not been noted at this significance in previous studies. In their systematic review of 13 studies of meniscal repair with a minimum 5-year follow-up, Nepple et al[28] did not note a difference in failure rates of medial or lateral tears (24.2% medial, 20.2% lateral). The literature is evenly divided in regard to the incidence of medial versus lateral meniscal repair failures. It is interesting that in a 6-year follow-up study of meniscal repair in the setting of primary ACL reconstruction, Westermann et al[35] described earlier medial repair failures versus lateral repairs (2.1 vs 3.7 years; $P < .01$). Thus, there may be an equilibration of failure rates in this cohort with longer follow-up.

Meniscal preservation was demonstrated to be associated with a lower incidence of chondrosis pathology in this cohort. Brophy et al[4] found a significant decrease in chondrosis associated with previous meniscal repair versus previous partial meniscectomy ($P = .003$) at the time of revision reconstruction. No significant difference was noted in knees without previous meniscal treatment and meniscal repair ($P = .7$). In a similar study, meniscal deficiency was associated with increased chondrosis in the affected compartment, while varus malalignment was associated with chondrosis in the medial compartment and elevated BMI was associated with chondrosis in the lateral compartment.[3]

TABLE 1
Baseline Patient and Surgical Characteristics Between the Meniscal Failure and Nonfailure Cases[a]

	Meniscal Failure (n = 17)	Nonfailure (n = 218)	*P* Value[b]
Sex			.56
Male	53 (9)	60 (131)	
Female	47 (8)	40 (87)	
Age, y	17 (16, 30)	22 (18, 29)	.12
Body mass index	23.6 (22.1, 24.9)	25.0 (22.8, 27.7)	**.04**
Smoking status			.06
Nonsmoker	100 (17)	81 (176)	
Smoker (previous, current)	0	17 (38)	
Blank/missing	0	2 (4)	
Activity level			
Baseline	12 (7, 16)	13 (8, 16)	.78
2 y	4 (4, 10)	7 (3, 12)	.56
Meniscal tear side			.13
Medial	88 (15)	71 (155)	
Lateral	12 (2)	29 (63)	
Tear severity			.63
Partial tear	24 (4)	19 (41)	
Complete tear	76 (13)	81 (177)	
Meniscal tear location (anterior-posterior)			.36
Anterior	0	1 (3)	
Posterior	94 (16)	89 (193)	
Anterior + posterior	0	10 (22)	
Blank/missing	6 (1)	0	
Meniscal tear location (central-peripheral)			.31
Central third	0	1 (3)	
Middle third	24 (4)	7 (16)	
Peripheral third	65 (11)	76 (166)	
Central + middle third	0	4 (8)	
Middle + peripheral third	6 (1)	6 (12)	
Central + middle + peripheral third	6 (1)	6 (12)	
Blank/missing	0	<1 (1)	
Tear type			.37
Radial	0	5 (10)	
Oblique	6 (1)	2 (4)	
Longitudinal (vertical)	88 (15)	76 (165)	
Bucket handle	0	12 (26)	
Horizontal	6 (1)	3 (6)	
Complex	0	3 (7)	
Tear length, mm	15 (14, 18)	15 (10, 20)	.80
Repair technique			.80
Inside-out	12 (2)	20 (43)	
Outside-in	0	3 (6)	
All-inside	88 (15)	75 (163)	
Both inside-out and all-in	0	1 (2)	
Other	0	1 (2)	
Blank/missing	0	1 (2)	
Type of suture/implant			.52
Nonabsorbable suture	65 (11)	52 (114)	
Absorbable stint or implant	35 (6)	44 (95)	
Absorbable suture	0	4 (8)	
Blank/missing	0	<1 (1)	
No. of sutures	2 (2, 2)	2 (2, 4)	.66
Lateral femoral condyle AC pathology			.50
Normal/grade 1	82 (14)	71 (155)	
Grade 2	12 (2)	20 (44)	
Grade 3	6 (1)	3 (6)	
Grade 4	0	6 (13)	

(continued)

TABLE 1
(continued)

	Meniscal Failure (n = 17)	Nonfailure (n = 218)	*P* Value[b]
Medial femoral condyle AC pathology			.43
Normal/grade 1	53 (9)	65 (142)	
Grade 2	35 (6)	22 (47)	
Grade 3	12 (2)	8 (18)	
Grade 4	0	5 (11)	
Lateral tibial plateau AC pathology			.17
Normal/grade 1	88 (15)	87 (189)	
Grade 2	6 (1)	12 (27)	
Grade 3	6 (1)	1 (2)	
Grade 4	0	0	
Medial tibial plateau AC pathology			.69
Normal/grade 1	100 (17)	96 (209)	
Grade 2	0	4 (8)	
Grade 3	0	<1 (1)	
Grade 4	0	0	
Patellar AC pathology			.33
Normal/grade 1	53 (9)	73 (159)	
Grade 2	35 (6)	19 (41)	
Grade 3	12 (2)	8 (17)	
Grade 4	0	<1 (1)	
Trochlear AC pathology			.34
Normal/grade 1	76 (13)	86 (188)	
Grade 2	18 (3)	6 (14)	
Grade 3	6 (1)	5 (11)	
Grade 4	0	2 (5)	

[a]Continuous variables are listed as median (25% quartile, 75% quartile); categorical variables are listed as percentage (frequency). AC, articular cartilage.

[b]Wilcoxon tests were performed on the continuous variables; Pearson tests were performed on the categorical variables. Bold values indicate statistical significance at the $P < .05$ level.

TABLE 2
Baseline and 2-Year Patient-Reported Outcome Scores Between the Meniscal Failure and Nonfailure Cases[a]

	Meniscal Failure[b]	Nonfailure[c]	*P* Value[d]
KOOS			
Baseline			
Symptoms	61, 79, 82 (73 ± 16)	57, 68, 82 (68 ± 19)	.41
Pain	75, 86, 97 (84 ± 14)	64, 78, 89 (75 ± 17)	**.034**
Activities of Daily Living	82, 96, 99 (90 ± 10)	75, 90, 97 (84 ± 17)	.12
Sports and Recreation	45, 60, 80 (64 ± 22)	30, 50, 75 (51 ± 29)	**.046**
Knee-related Quality of Life	31, 44, 56 (44 ± 22)	19, 31, 44 (34 ± 20)	.06
2 y			
Symptoms	64, 79, 86 (74 ± 15)	67, 82, 90 (77 ± 17)	.21
Pain	86, 92, 97 (88 ± 13)	81, 92, 97 (87 ± 14)	.90
Activities of Daily Living	97, 99, 100 (96 ± 8)	93, 97, 100 (93 ± 12)	.15
Sports and Recreation	69, 78, 85 (74 ± 18)	60, 75, 90 (72 ± 22)	.96
Knee-related Quality of Life	38, 56, 69 (53 ± 23)	38, 59, 75 (57 ± 23)	.41
IKDC			
Baseline	44, 62, 66 (57 ± 16)	39, 54, 66 (54 ± 17)	.34
2 y	66, 70, 79 (73 ± 13)	66, 78, 85 (75 ± 16)	.08
Marx activity level			
Baseline	7, 12, 16 (10.7 ± 6.1)	8, 13, 16 (11.3 ± 5.3)	.78
2 y	4, 4, 10 (6.6 ± 4.8)	3, 7, 12 (7.5 ± 5.3)	.56

[a]Data are presented as the lower quartile, the median quartile, and the upper quartile (mean ± SD). IKDC, International Knee Documentation Committee; KOOS, Knee injury and Osteoarthritis Outcome Score.

[b]n = 17 at baseline and 2-year follow-up.

[c]n = 218 at baseline; n = 193 at 2-year follow-up.

[d]Wilcoxon tests were used for statistical analysis. Bold values indicate statistical significance at the $P < .05$ level.

Previous analysis of the MARS cohort by Chen et al[5] evaluating single versus multiple revisions found that in cases of first-time revision, medial meniscal repair rates were not significantly different than in cases of multiple revisions (31% vs 23%, respectively) . However, lateral meniscal repair rates were significantly greater in multiple revisions versus first-time revisions (25% vs 13%; $P = .01$).

The majority of the patients in this cohort underwent meniscal repair based on an all-inside technique, which has become the most common approach in the United States. Previous studies at short and midterm with >5-year follow-up indicated similar success rates with the all-inside, open, outside-in, and inside-out techniques.[1,28] Our cohort did not demonstrate a difference in failure rates between all-inside and inside-out techniques.

This study has many strengths and a few weaknesses. The size of this prospectively collected cohort allows a variety of innovative analyses. The mix of practice locations and demographics also permits generalizability for the sports medicine practitioner. The large number of contributors could make one suspicious of our ability to be consistent in identifying and treating meniscal and chondral injuries. This fear is mitigated by our prestudy meetings to educate surgeons and by studies demonstrating that fellowship-trained sports medicine surgeons can have good agreement on the technical and diagnostic aspects of treating patients in this type of study.[8,25,26] An additional perceived weakness is using reoperation as a determination of failure. However, as of 2019, this remained our best surrogate for success. Reoperation may underestimate the number of failures, but it is impractical to obtain second-look arthroscopy or magnetic resonance imaging arthrograms in a cohort of this size after repair.

CONCLUSION

Meniscal repair is commonly performed in the revision setting, with the goal of articular cartilage preservation and prevention of arthritis. The success rate is slightly worse than that of primary ACL reconstruction cohorts at 2 years, but >90% success with no reoperation at 2 years justifies performing the procedure. We are unable to elucidate the reason why medial repairs failed at a higher rate than lateral repairs, and it will be interesting to follow this phenomenon and see if these findings are sustained over longer follow-up.

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