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Meniscus Repair in the Setting of Revision ACL Reconstruction: Results from the MARS Cohort

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Abstract

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 meniscus repair in the setting of revision ACL reconstruction have not been documented.

Hypothesis/Purpose: The purpose of this study was to examine both the prevalence and 2-year operative success rate of meniscal repairs in the revision ACL setting.

Study Design: Cohort study

Methods: All revision ACL reconstruction with concomitant meniscal repair cases from a multicenter group between 2006 and 2011 were selected. Two-year follow-up was obtained by both phone and email to determine whether any subsequent surgery had occurred to either knee since their 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 vast 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 of the medial failures were treated in conjunction with a subsequent repeat revision ACL reconstruction.

Conclusions: Meniscus 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 less than 10% and consistent with primary ACL reconstruction meniscus repair success rates. Medial tears underwent reoperation for failure at a statistically significant higher rate than lateral tears ($p<0.001$).

Keywords

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

INTRODUCTION

The results of revision anterior cruciate ligament (ACL) reconstruction have been demonstrated to be worse than those typically obtained in primary ACL reconstruction.[9,15,36,37,39] The MARS group through its work the last several years has begun to elucidate contributing factors for these worse outcomes. These have included demonstrating graft choice, meniscal and chondral damage and surgical factors that contribute to outcome.[18,20–24] Meniscal preservation has been demonstrated to contribute to overall and long-term knee health. However, the results of meniscus repair in the setting of revision ACL reconstruction have not been documented.

Meniscus repair in the setting of ACL-intact and primary ACL reconstructed patients has been demonstrated to be a successful procedure in both the short and long-term. Previous studies have documented 84–96% success with 2-year follow-up of meniscus repair in the setting of primary ACL reconstruction.[10,14,16,31–35] At minimum 5-year follow-up, failures and reoperations have increased, but continued to be an overall successful procedure with reoperation and failures ranging from 11–24%.[1,27,28,35] Given the overall negative impact of loss of the meniscus these failure rates justify striving to repair as many menisci as possible. Our hypothesis for this study was that meniscus repair with revision ACL reconstruction would be less successful, as defined by lack of reoperation for meniscal symptoms, than with primary ACL reconstruction.

METHODS

Setting and Study Population

Our consortium was assembled with the aim of determining what impacts 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 (IRBs), this multicenter consortium began patient enrollment in 2006 and ended in 2011, during which time 1205 revision ACL reconstruction patients were enrolled in this prospective longitudinal cohort. The study enrolled patients undergoing revision of a previously failed ACL reconstruction who agreed to participate, signed an informed consent, and completed a series of patient-reported outcome instruments. Indications for the revision ACL reconstruction included functional instability, abnormal laxity testing or an MRI indicating graft tear. Multi-ligament reconstructions were excluded. Surgeon inclusion criteria included maintenance of an active IRB approval, completion of a training session that integrated articular cartilage and meniscus agreement studies, review of the study design and patient inclusion criteria, and a 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 (MTF) graft was utilized to standardize the allograft source and preparation.

Data Sources and Measurement

After obtaining informed consent, 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.[18,19] Within 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 Subjective form (IKDC) 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 etiology of the previous failure, physical exam findings, surgical technique utilized, and the intra-articular findings and surgical management of meniscal and chondral damage. Data regarding meniscus tears collected by the surgeon included tear location (medial versus lateral, anterior versus posterior), length, and tear location within the meniscus (central, middle, peripheral 1/3). Additionally, when menisci were repaired, the technique, devices and/or suture utilized was recorded.

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

Patient Follow-up

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

Statistical Analysis

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

RESULTS

A total of 235 meniscus repairs were performed in 218 patients at the time of ACL revision surgery, which represented 18% (218/1205) of the study cohort. There were 153 medial repairs, 48 lateral repairs, and 17 repairs of both medial and lateral meniscus tears in the same patient. For comparison, prior to revision, 362 had undergone previous medial meniscectomy and 195 previously underwent lateral meniscectomy. At the time of revision, 330 underwent medial meniscectomy and 313 underwent lateral meniscectomy. Two-year follow-up was obtained on 90.4% (197/218) of the repairs, including 92% (141/153) medial repairs, 90% (43/48) lateral repairs and 76% (13/17) combination repairs. Seventy-six percent (178/235) of the meniscal repairs were performed utilizing the all-inside technique.

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

Table 1 stratifies the patient and surgical characteristics between the meniscal failure and non-failure groups. No statistically significant difference was found in the ages of meniscus repair failures and the non-failure group (p=0.12), nor in the meniscal location, tear type, tear length, repair technique utilized, suture/implant type or number of sutures used between the two groups. Interestingly, the failure group did have a slightly lower BMI than the non-failure group (p=0.04).

Table 2 stratifies patient-reported outcome scores between the meniscal failure and non-failure groups. Although the meniscal failure group exhibited better KOOS pain and sports/recreation subscores at baseline, as compared to the non-failure group, no statistical differences were found in any outcome measure at 2 years follow-up.

DISCUSSION

Meniscus resection has been demonstrated to lead to osteoarthritis due to increased contact stress and decreased contact area.[6,30] Based on this, meniscus repair has been a treatment option advocated since the 1970's (open) and 1980's (arthroscopic).[7,11,12 -13] Many reparable tears occur in the setting of ACL reconstruction and previous studies have demonstrated the efficacy and success of this procedure.[31,34,35] To date no large prospective series has been published evaluating meniscal repair in the revision ACL reconstruction setting. While it might intuitively be thought that the procedure would have equal success in the revision ACL reconstruction setting as in the primary ACL reconstruction setting, overall results for outcomes have been shown to be worse for revision ACL reconstructions.[36,39,38] In addition, there is a much higher rate of chondral damage noted in revision ACL reconstructions, which might contribute to meniscal repair failure.[18] 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 fundamentally identical to the 18.3% reported in a

series of primary ACL reconstructions as described by Toman et al.[31] Their series with 2-year follow-up utilized similar descriptive methods and also reported failure as reoperation identical to this series. Those authors noted 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 higher failure rate that is twice as high (8.6%) as that noted by Toman et al. (4%), but was still over 90% success at a minimum 2-year follow-up.

The occurrence and type of meniscal tears may not be equivalent in primary and revision ACL reconstructions. In a comparison of primary and revision cohorts collected during the same time period using identical data collection tools, Borchers et al. noted similar medial meniscus tear rates, but a decreased risk of lateral tears in revisions (odds ratio of 0.54; $p<0.01$).[2] In a study analyzing the MARS cohort compared to the Norwegian Knee Ligament Registry (NKLR) and the Societe Francaise d'Arthroscopie (SFA) it was noted this current revision cohort had more meniscal repairs medially than either European group, but had a similar number of lateral repairs.[17]

In the current series there was noted to be a significantly higher failure rate of medial meniscus 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 were too small for this detailed analysis. The medial meniscus may see higher forces, but this would be true in any ACL reconstructed scenario and not necessarily more important in the revision ACL patient. These results are similar to the findings in a systematic review of meniscal surgery by Paxton et al. which reported higher failure rates of medial meniscus repairs than lateral meniscus repairs at short term (0–4 year follow-up) and intermediate (4–10 year follow-up).[29] It is not apparent in analysis why this might be occurring, and this finding has not been noted at this significance in prior studies. Nepple et al. in their systematic review of the 13 studies of meniscal repair with minimum 5-year follow-up did not note a difference in failure rates of medial or lateral tears (24.2% medial, 20.2% lateral).[28] The literature is evenly divided in regard to the incidence of medial versus lateral meniscal repair failures. It is interesting to note that Westermann et al. in a 6-year follow-up study of meniscus repair in the setting of primary ACL reconstruction described earlier medial repair failures vs. lateral repairs (2.1 vs. 3.7 years, $p<0.01$), Thus, there may be an equilibration of failure rates in this cohort with longer follow-up.[35]

Meniscus preservation has been previously demonstrated to be associated with a lower incidence of chondrosis pathology in this cohort. Brophy et al. found a significant decrease in chondrosis associated with previous meniscus repair vs. previous partial meniscectomy ($p=0.003$) at the time of revision reconstruction.[4] No significant difference was noted in knees without previous meniscal treatment and meniscus repair ($p=0.7$). 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]

Previous analysis of the MARS cohort by Chen et al. evaluating single vs. multiply revised patients found that in the first-time revision patient, medial meniscus repair rates were not significantly different (31% vs. 23% respectively) than in the multiply revised patient.

However, lateral meniscus repair rates were significantly greater in the multiply revised vs. the first-time revision patient (25% vs. 13%, p=0.01).[5]

The majority of the patients in this cohort underwent meniscus repair utilizing all-inside techniques, which has become the most common approach in the United States. Previous studies at short-term and mid-term with greater than 5-year follow-up have demonstrated 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 vs. 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 in this cohort allows 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 meniscus and chondral injuries. This fear is mitigated by our pre-study meetings to educate surgeons and studies that have been done that demonstrate that fellowship trained sports medicine surgeons can have good agreement on technical and diagnostic aspects of treating patients in this type of study.[8,25,26] An additional perceived weakness is utilizing reoperation as a determination of failure. However, in 2019 this remains our best surrogate for success. Reoperation may underestimate the number of failures, but it is impractical to obtain second look arthroscopy or MRI arthrograms in a cohort of this size after repair.

CONCLUSIONS

Meniscus 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 primary ACL reconstruction cohorts at 2 years, but greater than 90% success with no reoperation at 2 years justifies performing the procedure. We are unable to elucidate the reason 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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Clinical Relevance:

Knowledge from this study will allow surgeons to better counsel patients as to expected success after meniscal repair with concomitant revision ACL reconstruction.

What is known about the subject:

Meniscal repair results are well documented in the setting of a primary ACL reconstruction, but there is little prospective or high-level evidence regarding meniscal repair in revision ACL reconstructions.

What this study adds to existing knowledge:

It will establish expected outcomes of meniscal repair in the ACL revision setting.

Table 1.

Patient and Surgical Characteristics between the Meniscal Failures and Non-Failures

	Meniscal Failures (n=17)	Non-Failures (n=218)	P value*
Sex			0.56
• Males	53% (9)	60% (131)	
• Females	47% (8)	40% (87)	
Age, years	17 (16, 30)	22 (18, 29)	0.12
BMI	23.6 (22.1, 24.9)	25.0 (22.8, 27.7)	**0.04**
Smoking Status			0.06
• Non-smoker	100% (17)	81% (176)	
• Smoker (previous, current)	0	17% (38)	
• Blank/missing	0	2% (4)	
Activity Level			
• Baseline	12 (7, 16)	13 (8, 16)	0.78
• 2 years	4 (4, 10)	7 (3, 12)	0.56
Meniscal tear side			0.13
• Medial	88% (15)	71% (155)	
• Lateral	12% (2)	29% (63)	
Tear Severity			0.63
• Partial tear	24% (4)	19% (41)	
• Complete tear	76% (13)	81% (177)	
Meniscal Tear location (Anterior-Posterior)			0.36
• Anterior	0	1% (3)	
• Posterior	94% (16)	89% (193)	
• Anterior + Posterior	0	10% (22)	
• Blank/missing	6% (1)	0	
Meniscal Tear location (Central-Peripheral)			0.31
• Central 1/3	0	1% (3)	
• Middle 1/3	24% (4)	7% (16)	
• Peripheral 1/3	65% (11)	76% (166)	
• Central + middle 1/3	0	4% (8)	
• Middle + peripheral 1/3	6% (1)	6% (12)	
• Central + middle + peripheral 1/3	6% (1)	6% (12)	
• Blank/missing	0	<1% (1)	
Tear type			0.37
• 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)	

	Meniscal Failures (n=17)	Non-Failures (n=218)	P value*
Tear Length, mm	15 (14, 18)	15 (10, 20)	0.80
Repair technique			0.80
• 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			0.52
• Non-absorbable suture	65% (11)	52% (114)	
• Absorbable stint or implant	35% (6)	44% (95)	
• Absorbable suture	0	4% (8)	
• Blank/missing	0	<1% (1)	
Number of sutures	2 (2, 2)	2 (2, 4)	0.66

Key: continuous variables are listed as median (25% quartile, 75% quartile); categorical variables are listed as percentage (frequency).

*Wilcoxon tests were performed on the continuous variables; Pearson tests were performed on the categorical variables.

Table 2.

Baseline and 2-Year Patient Reported Outcome Scores between the Meniscal Failure and Non-Failure Groups

	Meniscal Failures (n=17)	Non-Failures (n=218)	P value*
Baseline KOOS			
• symptoms	61 79 82 (73±16)	57 68 82 (68±19)	0.41
• pain	75 86 97 (84±14)	64 78 89 (75±17)	**0.034**
• activities of daily living	82 96 99 (90±10)	75 90 97 (84±17)	0.12
• sports and recreation	45 60 80 (64±22)	30 50 75 (51±29)	**0.046**
• knee-related quality of life	31 44 56 (44±22)	19 31 44 (34±20)	0.06
2-Year KOOS			
• symptoms	64 79 86 (74±15)	67 82 90 (77±17)	0.21
• pain	86 92 97 (88±13)	81 92 97 (87±14)	0.90
• activities of daily living	97 99 100 (96±8)	93 97 100 (93±12)	0.15
• sports and recreation	69 78 85 (74±18)	60 75 90 (72±22)	0.96
• knee-related quality of life	38 56 69 (53±23)	38 59 75 (57±23)	0.41
Baseline IKDC	44 62 66 (57±16)	39 54 66 (54±17)	0.34
2-Year IKDC	66 70 79 (73±13)	66 78 85 (75±16)	0.08
Baseline Marx Activity Level	7 12 16 (10.7±6.1)	8 13 16 (11.3±5.3)	0.78
2-Year Marx Activity Level	4 4 10 (6.6±4.8)	3 7 12 (7.5±5.3)	0.56

Key: *a B c* represents the lower quartile *a*, the median *B*, and the upper quartile *c* for continuous variables. X±S represents the mean ± 1 standard deviation. Wilcoxon tests used for statistical analysis.