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Meniscal Repair with Concurrent Anterior Cruciate Ligament Reconstruction: Operative Success and Patient Outcomes at 6-Year Follow-up

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Abstract

BACKGROUND—Meniscus repairs are commonly performed concurrently with anterior cruciate ligament reconstruction (ACLR) in the acutely injured knee. No large-scale, prospective, multicenter studies have evaluated long-term success and patient-oriented outcomes after combined ACLR and meniscus repair.

PURPOSE—To define operative success and patient-oriented outcome scores 6 years after combined meniscus repair and ACLR.

STUDY DESIGN—Cohort study; Level of evidence, 3.

METHODS—All ipsilateral primary ACLR and meniscus repair cases from a multicenter study group between 2002 and 2004 were selected. Validated patient-oriented outcome instruments were completed at 3 time points: preoperatively, 2 years and 6 years following the index procedure. Subsequent ipsilateral knee re-operation was confirmed by operative reports to evaluate for failure of meniscal repairs.

RESULTS—In total, 286 patients of 1440 primary ACLR's underwent concurrent meniscus repair (298 meniscal repairs). 235/286 (82.2%) were available for follow-up at 6 years (154 medial, 72 lateral and 9 both lateral and medial meniscal repairs). Repaired menisci most commonly involved the peripheral 1/3 of the meniscus (84%); patterns were typically longitudinal (84%) or displaced bucket-handle (10%), with mean length of 16.5 ± 5.8mm. Overall, the meniscal repair failure rate was 14% (medial, 21/154; lateral, 10/72; both 2/9) at 6 years. Medial repairs failed earlier than lateral repairs (2.1 versus 3.7 years; $p=0.01$). Significant improvements in outcome instruments were sustained at 6-year follow-up. No differences in suture number or type were detected between repair failures and successes. Meniscal reoperation was higher in patients who underwent repair compared to those who did have an identified meniscal injury at the time of ACLR ($p<0.01$).

CONCLUSIONS—Concurrent meniscal repair with ACLR is associated with failure rates approximating 14% at 6-year follow-up. Improvements in patient-oriented outcome instruments were sustained at 6-year follow-up. Surgeons may expect good clinical outcomes 6 years after combined ACLR and meniscus repairs.

Keywords

meniscal repair; clinical medicine; anterior cruciate ligament (ACL) reconstruction, outcome

INTRODUCTION

Combined injuries to the menisci and anterior cruciate ligament (ACL) are frequently seen in the acutely injured knee^{28, 32, 38}. These represent severe injuries in young patient populations. The association of ACL injury and ACL reconstruction (ACLR) with early post-traumatic osteoarthritis (PTOA) in young patients has been well established^{6, 21, 37}. There has been increased emphasis on meniscus repair over the past 3 decades as this structure is essential in preventing osteoarthritis^{10, 34}. Five-hundred thousand procedures occur annually in the United States on medial and lateral menisci making disorders of the meniscus the most commonly treated knee disorder¹⁸. As a result, investigations evaluating efficacy of specific measures (i.e. ACLR and meniscus repair) to potentially mitigate PTOA and preserve global knee function are of high interest to the orthopaedic community.

Long-term results of isolated meniscus repair have been well described.¹⁷ Long-term outcomes after meniscal repair in patients undergoing concurrent ACL reconstructions are limited to small single-center case series with failure rates ranging from 0–29% at minimum 5-year follow-up^{19, 20, 33}. A recent systematic review calculated the failure rate of meniscus repair in ACL-reconstructed knees to be 26.9% at 5 years.²⁶ Significant deterioration in meniscal repairs has been demonstrated in one series between published 2 and 6-year follow-up time points^{12, 19}. There has also been reports of meniscal repair failures occurring at >4 years⁸. Therefore, long-term follow-up of combined ACLR and meniscus repair is warranted.

Given relatively low numbers in single center case series, perhaps the best way to study this clinical problem would be a multicenter prospective cohort that incorporates a variety of meniscus repair techniques. Multicenter studies may demonstrate results that are reproducible across different surgeon and patient populations. Also, collaborative efforts allow for a relatively larger patient cohort to be collected in a shorter period of time. Data generated from large multicenter cohorts could potentially improve decision-making for challenging problems such as optimal management for meniscal injuries associated with ACL disruptions.

No large-scale, prospective, multicenter studies have evaluated long-term patient-oriented outcomes after combined ACLR and meniscus repair. The initial multicenter study group's single-year cohort of ACLR and meniscal repairs reported a 4% failure rate at 2 years³⁶. Current literature describes clinical deterioration associated with long-term follow-up of combined ACLR and meniscus repairs¹⁹. The purpose of this study is to perform a 6-year follow-up inclusive of a previously reported cohort of patients³⁶ who underwent concurrent ACLR and meniscal repair and expand this cohort to be inclusive of an additional 2 years of enrollment. While meniscal repair in conjunction with ACLR has demonstrated good success at 2 years, we hypothesize that patient-centered outcome scores may deteriorate and ipsilateral reoperations may increase at 6-year follow-up; furthermore, we postulate tears

involving the center of the meniscus and tears of increased length will prove less durable over time.

MATERIALS AND METHODS

The Multicenter Orthopaedic Outcomes Network (MOON) is a prospective longitudinal cohort study following ACL reconstructions performed at 7 centers (University of Iowa, Washington University, Vanderbilt University, Cleveland Clinic, Ohio State University, University of Colorado and Hospital for Special Surgery) between 2002–2004.. The study is funded by the National Institutes of Health. Institutional review board (IRB) approval was obtained from all centers prior to enrollment and documented informed consent was obtained from each participant. The general methodology of the multicenter study group cohort has been previously described^{14, 36, 40}. Briefly, each patient completed a 13-page questionnaire at the time of (1) enrollment, (2) 2-year and (3) 6-year follow-up. This questionnaire included detailed patient-specific information regarding demographics, injury characteristics, health status, current therapies, comorbidities, prior surgeries and sports participation. It included validated patient-oriented outcome metrics (Knee Injury and Osteoarthritis Outcome Scores (KOOS)³⁰, Western Ontario and McMaster Universities (WOMAC) scores, International Knee Documentation Committee² (IKDC) scores, and Marx activity rating scores²³). Benchmarks to determine minimal clinically important differences (MCID) were determined as follows: 12% change from baseline scores for the WOMAC³, a change of 8 points for all KOOS scores^{29, 41} and a change of 11.5 points for IKDC scores¹⁶. Marx scores²³ were calculated and trended versus time to assess for changes in activity levels.

After the index procedure, the surgeons completed a detailed 49-page questionnaire. Data recorded included detailed examinations under general anesthesia, validated descriptions of meniscal injuries¹³, articular cartilage injuries and surgical techniques. Upon completion, both surgeon and patient forms were sent from each of the 7 centers to a central coordinating center. Forms were scanned using Teleform software (Cardiff Software Inc, Vista, California) and exported into a master database.

This master database was then queried for specific factors important in evaluating a cohort of combined ACLR and meniscus repairs. This included left versus right knee, medial versus lateral meniscus involvement, the status of the meniscus at the time of ACLR, meniscal tear characteristics (length, type and location of tear), repair versus excision techniques and sutures (type and number) used.

Inclusion criteria for our study were concurrent unilateral primary ACLR and meniscus repair that occurred in the MOON network between January 1, 2002 and December 31, 2004. Prospectively obtained 2- and 6-year follow-up questionnaires were required for inclusion. Patients were contacted by telephone to determine if any subsequent knee surgeries had been performed. Operative reports were obtained from any subsequent knee surgery (ipsilateral or contralateral); if the operative reports were not available the patients were excluded from this analysis.

Basic statistical analysis was performed using Microsoft Excel (Microsoft Inc, Redmond, Washington). Kaplan-Meier survival analysis was performed using IBM's SPSS software (IBM Corporation, Armonk, New York).

RESULTS

Between 2002 and 2004, 1440 unilateral primary ACLR's were performed as part of the MOON cohort. Of the 1440 patients enrolled during this time period, 953 had documented meniscus tears (66.2%). Of these subjects, 286/953 (30.0%) were treated with repair, 164/953 (17.2%) underwent no treatment, 7/953 (0.7%) were treated with abrasion and trephination, 2/953 (0.2%) were treated with meniscal transplant, and 496/953 (52.1%) were treated with excision.

286 subjects underwent concurrent meniscus repair (298 meniscal repairs). The median age of the ACLR with concurrent meniscus repair cohort was 21 (mean 23.6 ± 9.7 (range 11–63)) years at the time of the index procedure. Of these, 235/286 patients (82.2%) were available for follow-up at 6 years. There were 154 patients who underwent concurrent medial meniscus repairs, 72 patients who underwent concurrent lateral meniscal repairs, and 9 patients who underwent both lateral and medial meniscal repairs in conjunction with ACLR (244 total repairs in 235 patients). 55 patients underwent subsequent arthroscopic knee procedures (ipsilateral and contralateral), and operative reports were available for 51/55 cases. Of the 51 cases available for review, a total of 33 patients underwent procedures that addressed the meniscus repaired at the time of the index procedure (by debridement, excision or repeat repair) and these were considered failures. Procedures addressing only arthrofibrosis (11/235, 4.7%), infection (1/235, 0.4%), articular cartilage lesions were not included in the failure group. Revision ACL surgery on the ipsilateral knee was associated with 27.3% (9/33 overall, 5/21 medial, 4/10 lateral, 0/2 both) of the meniscal repair failures. Therefore, the overall failure rate of our ACLR and meniscal repair cohort was 14% (33/235) at 6 years. [Figure 1]

Medial Meniscus Repairs

We discovered 21 patients with documented failures of medial meniscus repairs in our cohort. Three operative reports were unavailable, and these patients were excluded. There was a 13.6% (21/154) failure rate after ACLR and combined medial meniscus repair. In the medial meniscus repair group, 5/21 failures were addressed concurrently with revision ACL surgery. Two patients who underwent medial meniscus repair at the time of ACLR subsequently underwent lateral meniscus-only procedures within the 6 year follow-up period.

The mean length of tears in medial meniscal repair failures was 16.3 ± 5.7 mm; the mean length of meniscal tears that did not require reoperation at 6 years was 16.2 ± 5.9 mm. There was no difference between the two groups with regard to length ($p=0.93$). There was no difference in tear type (vertical, bucket handle, etc) or location (anterior-posterior or coronal) between medial meniscus repair failures and successes.

For medial repairs, there was no difference in number of sutures used in repairs that failed and those that did not (2.3 ± 1.5 sutures used for repair failures versus 2.5 ± 1.3 sutures used for non-failures; $p=0.58$). No differences in types of sutures or devices used were detected between groups.

Of all medial repairs, 135/154 were repaired using all-inside techniques; of these, 19/135 (14.1%) failed at 6-year follow-up. Inside-out techniques were used in 12/154 medial meniscal repairs. Of the 12 repaired inside out techniques, only one 1/12 clinical failures was noted. Two patients underwent combined all-inside and inside-out techniques, and neither of these two patients had failure of repairs. Five patients with medial meniscal tears were treated with outside-in techniques, and 1/5 demonstrated failure at 6 years. [Figure 1]

Lateral Meniscus Repairs

We discovered 10 patients with documented failures of lateral meniscus repairs in the cohort. One operation note of repeat ipsilateral knee arthroscopy was unavailable. The overall failure rate in with lateral meniscus repairs was 13.9% (10/72). Of the 10 lateral meniscal failures, 4 were done in the setting of a revision ACL surgery.

The mean length of tears in lateral meniscal repair failures was 19.6 ± 5.5 mm; the mean length of lateral meniscal tears that did not require reoperation at 6 years was 16.7 ± 5.8 mm. There was no difference between the two groups with regard to length ($p=0.13$). All of the lateral repair failures were longitudinal (vertical); this was the most common tear type in successful lateral repairs representing 51/62 (82%). There was no difference in location (anterior-posterior or coronal) between lateral meniscus repair failures and successes.

For lateral repairs, there was no difference in number of sutures used in repairs that failed and those that did not (2.3 ± 0.8 sutures used for repair failures versus 2.6 ± 1.6 sutures used for non-failures; $p=0.58$). No differences in types of sutures or devices used were detected between groups.

Lateral menisci were commonly repaired with all-inside techniques; all-inside repairs represented 90.3% (65/72) of lateral meniscus repairs, 8.3% (6/72) of lateral meniscal tears were treated with inside-out techniques, and one patient (1.4%; 1/72) was treated with an outside-in technique. All lateral meniscus repair failures (10) were treated with all-inside techniques at the index surgery. Therefore, 10 of the 65 lateral meniscus all-inside repairs (15.4%) had failed at 6 year follow-up. None of the 7 cases treated with inside-out or outside-in techniques demonstrated clinical failure at 6 years.

Bilateral Meniscus Repairs

Nine patients in the present cohort underwent repair of both medial and lateral menisci during the index ACLR surgery. There were 2 failures (2/9) resulting in a failure rate of 22.2%. Both of the failures in this group were of the medial meniscus repairs.

Comparison Groups for Reoperation

Of the 487 patients who had intact menisci at the time of the index procedure, 425 were available for follow-up at 6 years. Eleven of these patients underwent subsequent ipsilateral

meniscus excisions or repairs (11/425, 2.6%). Meniscus reoperation, therefore, is significantly higher in patients who undergo meniscal repair (14%) compared to those who did not have meniscal injury at the time of the index ACLR (2.6%; $p<0.01$).

Of the 164 patients who did not undergo treatment for meniscal tears, 143 were available for follow-up. Meniscal tears were significantly smaller in the no treatment group (9.6mm) compared with the repair group (16.5mm; $p<0.01$). Twelve patients underwent meniscal reoperation in the no treatment group (8.4%). While this rate is lower than reoperation rates in the repair group (14%), the difference is not statistically significant ($p=0.1$).

Timing of Repair Failure

Medial meniscal repairs failed at an average of 2.1 ± 1.6 years (range 0.4 to 6 years), while lateral meniscus repairs failed at an average of 3.7 ± 1.3 years (range 0.5 to 5.4 years). This was a statistically significant difference in mean time to failure between medial and lateral repairs ($p=0.01$). The Kaplan-Meier survival analysis for medial, lateral and both meniscal repairs is displayed in Figure 3. While medial repairs appeared to fail earlier than lateral repairs, overall survival was similar at 6 years.

Repair Technique

Overall, all-inside techniques were performed in 208/235 patients (88.5%) available for follow-up. There were 31 failures with this technique representing a 14.9% (31/208) failure rate. There was one failure in the inside-out technique group (1/19, 5.3%), and one failure noted in the outside-in technique group (1/6, 16.7%). [Figure 2]

Patient-Oriented Outcome Scores

KOOS—There was significant improvement from baseline to 6-year follow-up with respect to all groups; outcome scores appeared to be preserved between 2 and 6-year follow-up [Table 2]. There were no clinically significant differences in outcomes (defined as a change of 8 points^{29, 30}) with regard to KOOS Symptom, Pain, ADL, or Sports Rec subscales between 2 years and 6 years. With regards to the KOOS KRQOL subscale, lateral repair success scores at 6-year follow-up were significantly superior to lateral repair failures (78.1 versus 68.8) [Table 2].

IKDC—The baseline median IKDC scores for all repairs (interquartile range) was 47.1 (35.6–60.9). Six years status post ACLR and meniscus repair the median IKDC score was 87.4 (74.7–95.4). No significant clinical differences were noted in IKDC scores between 2 and 6-year follow-up. Significant improvements were noted in all groups when baseline scores were compared to 2 and 6-year follow-up [Table 2]. No significant differences in IKDC scores were noted between meniscal repair successes and failures at 2 or 6-year follow-up.

Marx—With regard to all repairs, baseline median Marx score (interquartile range) was 12 (8–16). At 2 and 6- years status post ACLR and meniscus repair the median Marx score were 9 (3–13) and 7 (2.3–12), respectively; these significantly decreased over time. Marx activity scores were lowest in the bilateral repair groups [Table 2].

WOMAC—The baseline median WOMAC Stiffness score (interquartile range) was 75.0 (50.0–87.5). Six years status post ACLR and meniscus repair the median WOMAC Stiffness score was 87.5 (75.0–100). The baseline median WOMAC pain score (interquartile range) was 85.0 (70.0–95.0). Six years status post ACLR and meniscus repair the median WOMAC pain score was 100 (90.0–100). The baseline median WOMAC ADL score (interquartile range) was 85.3 (68.4–94.1). Six years status post ACLR and meniscus repair the median WOMAC ADL score 98.5 (94.1–100). No significant clinical differences were noted between 2 and 6-year follow-up with regard to WOMAC scores.

DISCUSSION

This study evaluated incidence of repair failure and patient outcomes after ACLR and meniscus repair with minimum 6-year follow-up. We determined the failure rate of meniscal repairs during concurrent ACLR to be 14% at 6 years. Failure rates were similar in repairs of the medial (13.6%) and lateral (13.9%) menisci. A large proportion of the meniscal failures (27.3%, 9/33) were associated with ACLR graft failure. Tear length, type or location did not appear to be associated with repair failure. Patient-oriented outcome metrics demonstrated significantly improved results according to literature established MCID's at both 2- and 6-year follow-up. Overall, patients experienced operative success rates greater than 85%, and patients sustained such improvements in clinical outcome between 2 to 6-year follow-up time points.

It is thought that 2-year success rates of the combined procedures are associated with success in 90–96% of cases^{36, 39}. Wasserstein et al³⁹ performed a population study in Ontario, Canada between 2003–2008 utilizing the Ontario Health Insurance Plan database; fee codes were queried and the authors observed a 10% rate of reoperation within 2 years of ACL reconstruction and concomitant meniscus repair. In a prior multicenter study evaluating 2-year outcomes from the 2002 enrollment of our cohort, success rates of meniscal repair done concurrently with ACLR was found to be 96%.³⁶ While early follow-up (2 years) is generally associated with high success rates, there are several reports of deteriorating repairs with longer follow-up¹⁹.

Recent reports of long-term failure of combined ACLR and meniscal repair range from 0% to 29%^{19, 20, 33} at minimum 5 year follow-up, with the “0%” group representing a case series of 10 patients³³. Lee et al¹⁹ evaluated 28 patients 6.6 years after index combined ACLR and meniscus repair with arthroscopy and demonstrated a 28.6% failure rate. The failure rate of our cohort of all-inside techniques is approximately half of this; this may be partially explained by advances in all-inside repair with new techniques. Logan et al²⁰ reported a 26.7% meniscal repair failure rate with minimum 5-year follow-up with ACL reconstruction in 35 athletes, although this number may be artificially low when compared to ours because the study excluded 7 meniscal failures associated with ‘traumatic events’ including two ACL graft ruptures. If failure rates were calculated inclusive of these traumatic events, the study's true failure rate would lie between 31% and 43% at minimum 5 years. It should be recognized that our definition of meniscus repair failure (repeat surgery on repaired meniscus) may exclude clinically symptomatic patients.

Gallacher et al¹¹ in a single-center cohort study collected over a 10-year period reported a failure rate of 28% in ACLR and meniscus repair at mean 5.5 year follow-up. Nepple et al, in a recent systematic review, estimated failure rate to be 27% at minimum 5-year follow-up for combined ACLR and meniscus repair.²⁶ Our study demonstrated a combined failure rate of 14% or just over half the rate of Nepple et al's similar ACLR and meniscus repair cohort (27%) and other similar cohorts (27–29%)^{11, 19, 20}. This may be partially explained by improvement in operative techniques over time, as the index procedures in our cohort took place between 2002 and 2004, while the comparative studies took place between 1985–1998^{19, 20, 33}.

Furthermore, there may be a protective effect associated with performing ACL reconstructions along with meniscal repairs. In the Nepple et al systematic review inclusive of 566 cases with a minimum 5-year follow-up²⁶, the failure rate of all combined meniscus repairs was estimated to be 23%. This is significantly higher than our observed 14% rate of failure in a similar follow-up period. There are a few studies in the literature that suggest concurrent ACL reconstruction, when necessary, may produce a protective effect of meniscal repair.^{4, 27, 31, 35, 39} In Wasserstein et al's³⁹ population study, ipsilateral knee operation after ACLR and meniscus repair was observed to be 10% while a matched cohort of meniscus repair only demonstrated a 17% ipsilateral knee operation rate within 2 years of the index procedure. In a prospective cohort study of 26 patients, Noyes and Barber-Westin²⁷ report clinical failure in 9% of patients who underwent ACLR and meniscus repair, versus a 25% failure rate in patients undergoing meniscus repair with an intact ACL. Current opinions in the field offer three possible explanations behind improved success of meniscal repairs with concurrent ACLR; first, patients undergoing ACLR may be slower to rehab after injury therefore producing a low-force environment for meniscal healing. Secondly, the drilling of the tibial and femoral tunnels may produce a biologically advantaged environment to augment meniscal healing³⁹. Third, meniscus injury patterns that accompany acute ACL disruptions may be more amendable to repair^{5, 26} while meniscal injuries in ACL-intact knees are more commonly degenerative in nature^{9, 24}. This finding is controversial, as a recent systematic review demonstrated increased failures in combined ACLR and meniscus repair groups compared to meniscus repairs in stable (ACL intact) knees.²⁶ The studies representing ACLR with concurrent meniscus repairs within the systematic review was very limited in number, and may not have been powered to detect differences between the groups.

Our study confirmed a current trend towards all-inside techniques as these comprised 88.5% of the cases in our cohort. Short-term outcomes of all-inside techniques have proven reliable¹. Our study detected 31 failures following meniscal repair utilizing all-inside techniques representing a 14.9% failure rate. There was one failure in the inside-out technique group (1/19, 5.3%), and one failure noted in the outside-in technique group (1/6, 16.7%). Because of the limited numbers in the outside-in and inside-out repair groups, it is not possible to draw conclusions from the differences in failure rates between the repair technique groups. With regard to all-inside techniques, our 14.9% failure rate is lower than Lee and Diduch's¹⁹ 28.6% failure rate with the meniscus arrow (minimum 5.4 year follow-up). This may be partially explained by second-generation all-inside repairs in our cohort.

Few studies report validated patient-oriented outcome measures when evaluating long-term clinical success of combined ACLR and meniscus repair. The IKDC is a validated assessment tool for knee ligament and meniscus injuries^{15, 16}; the form is comprised of 18 questions converted to a 0–100 scale. The minimal clinically important differences (MCID) for IKDC scores has been demonstrated to be a change of at least 11.5 points¹⁶. Logan et al reported mean IKDC scores of 82.2 (range 18–100) at minimum 5.4 years follow-up after combined ACLR and meniscus repair. This data is representative of a heterogeneous cohort of 42 patients: 17% who underwent meniscal repair only, and 83% underwent meniscal repair and ACLR. No baseline IKDC scores were reported. Similarly, Melton et al²⁵ determined mean IKDC scores to be 84.2 in 26 patients at a minimum of 7.7 years after combined meniscus repair and ACLR. These outcome scores are similar to our present study at 6-year follow-up. Median IKDC scores for all meniscal repair patients in our study were 47.1 at baseline, 85.1 at 2 years and 87.4 at 6 years. Lee et al reported IKDC scores of successful meniscus repairs only at 5-year follow-up for combined meniscal repair and ACLR. Of the 20 patients with successful clinical outcomes, 11 were reported as “normal” and 9 as “near-normal”. No numerical value of outcome scores was reported.¹⁹

Patients undergoing successful medial and lateral meniscal repairs have identical median IKDC scores (87.4) in our study. There are several factors that influence outcomes in an ACL-injured knee. Cox et al⁷ used a multivariable regression model to associate independent risk factors with outcomes in a MOON cohort inclusive of both primary and revision ACL reconstructions. Revision ACLR and the presence of meniscal injury were found to predict worse outcomes. They determined that medial meniscus repairs predicted worse IKDC and KOOS scores but lateral repairs did not. They also noted that grade 3 or 4 chondral lesions predicted significantly worse outcomes.

Differences in outcome scores greater than established MCID’s were noted between baseline IKDC and 2 year outcome scores in our study; this improvement was well maintained at 6-year follow-up indicating preserved clinical success at long-term follow-up in our cohort of meniscal repairs. Interestingly, with the exception of KOOS KRQOL scores at 6 years for lateral repair failures and successes, no other significant clinical differences were noted in outcome scores between groups with successful meniscal repairs, and those who underwent subsequent ipsilateral meniscal procedures at 6 years. This may be due to the high association with revision ACL reconstruction seen in the lateral failure group (4/10 meniscal repair failures associated with revision ACL procedures). Lower KOOS KRQOL scores in that group may therefore be a reflection of a second-hit injury phenomenon. Perhaps 6-year follow-up time is too soon to detect differences in outcome scores between successful repairs and failures.

To our knowledge, this is the first study to report KOOS³⁰, WOMAC, and Marx activity scores²³ for long-term follow-up of combined ACLR and meniscus repairs. Our cohort demonstrated MCID from baseline scores to 2 and 6-year follow-up with regard to WOMAC³ and KOOS scores^{29, 41}. This indicates that patients experienced successful outcomes as a result of concurrent ACLR and meniscus repair at two years, and there was no detectable deterioration in patient outcomes between 2 and 6-year follow-up. The overall median Marx activity scores were observed to decline from baseline (12) to 2-year follow-

up (9) to 6-year follow-up (7). Although there is no validated study to detect clinically important differences in Marx scores, a reduction of nearly 50%, as observed between baseline and 6-year follow-up median values, is generally considered a true change.

Lateral meniscal tears appeared to be longer in those that failed repair, however the difference did not reach statistical significance (medial repairs $p=0.93$, lateral repairs $p=0.13$). Tear location was no different in repairs that failed and those that did not. This may potentially be explained by surgical decision making as tears that were less amendable to repair may have been treated with excision or other modalities. While there were trends towards more sutures in successful repairs, the overall number and type of sutures was no different between groups.

The present study has several strengths. It is the first prospective multicenter study to report comprehensive validated patient-oriented outcome measures at long-term follow-up for meniscal repair with ACLR. Also, this cohort is relatively large. Complete follow-up data was available for 235 patients, whereas the largest previous study of combined meniscus repair and ACLR at greater than 5-year follow-up was 35 patients²⁰. The multicenter nature of our study provides generalizable data to multiple surgeon and patient populations. The study does have weaknesses. Although follow-up was relatively high for a mid- to long-term study, we were unable to obtain operative reports on 4 patients (4/286) who underwent subsequent ipsilateral knee operations; these patients otherwise had full 6-year follow-up data. They were therefore excluded. Furthermore, a relatively small portion of patients underwent repair with inside-out and outside-in techniques, making comparisons to all-inside techniques difficult. Additionally, several factors were non-randomized and left to the surgeon's discretion (repair techniques, repair versus excision, amount and type of fixation). Our definition of surgical failure (repeat operation on repaired meniscus) may exclude other subclinical failures. The gold standard would be for repeat arthroscopy and/or MRI scans at predetermined periods of follow-up, however our cohort is so large this would consume an incredible amount of financial resources. A repeat arthroscopic procedure, therefore, is the most common metric to evaluate surgical success in current literature²². Lastly, numerous factors contribute to outcomes following ACLR and meniscus treatment. A multivariate analysis of outcomes that takes into account all of these variables, including all possible status' and interventions for the meniscus, is beyond the scope of this paper.

CONCLUSIONS

The success rate of concurrent meniscus repair and ACLR is approximately 86% at 6-year follow-up. This success rate is higher than other studies in the literature, and may re-enforce an association of concurrent ACLR with improved meniscus repair success. While medial repairs appeared to fail earlier than lateral repairs, no significant differences were noted in overall failure rates between sides. Although more failures occurred with the use of all-inside techniques, due to the low numbers of outside-in and inside-out techniques, the study is not adequately powered to detect differences in these latter two techniques. Reoperation was higher in patients who underwent meniscal repair compared to those without detected meniscal injury. Patient-oriented outcome measures significantly increase between the time of the index procedure and two years; these increases are maintained between 2- and 6-year

follow-up. Therefore, surgeons may expect good success with combined ACLR and meniscal repairs at 6 years.

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What is known about this subject

Reports of meniscal repair success at the time of ACLR vary; it is recognized that most outcomes are good at 2 years. Data regarding meniscal repair success with concurrent ACLR is limited beyond 5–6 year follow-up.

What this study adds to existing knowledge

This is the first prospective multicenter study to report comprehensive validated patient-oriented outcome measures at long-term follow-up for meniscal repair with ACLR. Furthermore, this study provides initial data regarding the long-term success of second-generation meniscal repair techniques.

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Figure 1.

Surgical success of meniscus repairs evaluated by medial/lateral meniscus. Similar rates of failures were noted in medial and lateral repair groups. Patients who underwent bilateral meniscal repairs had an increased rate of repair failure.

Figure 2.

Evaluation of eligible patients segregated by repair technique. Failure rates were lowest in the inside-out technique group at 6-year follow-up. Given low numbers in open technique groups, it is difficult to accurately compare open techniques to all-inside.

Figure 3.

Kaplan-Meier survival analysis of meniscal repairs performed in combination with ACL reconstruction. The vertical axis denotes cumulative survival, and the horizontal axis denotes time in years of survival of meniscal repair. The survival plot of patients who underwent both lateral and medial meniscal repairs is in blue; the survival plot of patients who underwent lateral meniscal repairs is in green; the survival plot of patients who underwent medial meniscal repairs is in tan. Note, medial repairs appeared to fail early (2.1 years), while lateral repair failures more commonly occurred late (3.7 years). Overall, similar survivals were noted between medial and lateral repairs.

Table 1

Characteristics of meniscus tears in patients present for 6 year follow-up. The group includes 244 tears treated with repair in 235 patients.

Anterior - Posterior Location	n	%
anterior	3	1.23
anterior + posterior	34	13.93
posterior	207	84.84
Coronal Location	n	%
central + middle + peripheral 1/3	1	0.41
central + middle 1/3	10	4.10
central 1/3	6	2.46
middle + peripheral 1/3	45	18.44
middle 1/3	22	9.02
peripheral 1/3	160	65.57
Tear Type	n	%
bucket handle - displaced	24	9.84
complex	3	1.23
horizontal	2	0.82
longitudinal - (vertical)	204	83.61
oblique	9	3.69
radial	2	0.82
Length	mm	
Mean	16.46	
St. Dev.	5.76	
Degenerative Characteristics	n	%
Yes	21	8.61
No	223	91.39

Table 2

Median scores at baseline, 2-year and 6-year follow-up. Groups were analyzed by all cases undergoing meniscal repair, successful medial repairs at 6 years, meniscal repair failures at 6 years, successful lateral repairs at 6 years, lateral repair failures at 6 years, bilateral successful repairs at 6 years, and bilateral repair failures at 6 years. Significantly decreased Marx activity scores were noted in bilateral repair failures at 6 year follow-up.

	All Repairs	Medial Repair Success	Medial Repair Failures	Lateral Repair Success	Lateral Repair Failures	Bilateral Repair Success	Bilateral Repair Failures
Total Number (<i>n</i>)	235	135	21	62	10	7	2
KOOS Symptoms							
Baseline KOOS Symptoms	67.9	67.9	67.9	67.9	75.0	67.9	55.4
KOOS Symptoms at 2 y	85.7	85.7	87.5	85.7	82.1	96.4	82.1
KOOS Symptoms at 6 y	85.7	89.3	82.1	88.4	83.9	85.7	89.3
KOOS Pain							
Baseline KOOS Pain	72.2	72.2	77.8	72.2	77.8	72.2	61.1
KOOS Pain at 2 y	91.7	91.7	97.2	91.7	88.2	100.0	86.1
KOOS Pain at 6 y	94.4	94.4	94.4	94.4	91.7	97.2	91.7
KOOS ADL							
Baseline KOOS ADL	85.3	86.8	85.3	86.8	80.1	75.0	68.4
KOOS ADL at 2 y	98.5	98.5	98.5	98.5	95.5	100.0	91.2
KOOS ADL at 6 y	98.5	98.5	98.5	98.5	98.5	98.5	97.1
KOOS SptRec							
Baseline KOOS SptRec	45.0	45.0	50.0	45.0	36.9	50.0	22.5
KOOS SptRec at 2 y	85.0	85.0	85.0	90.0	80.0	95.0	85.0
KOOS SptRec at 6 y	90.0	90.0	85.0	85.0	85.0	90.0	82.5
KOOS KRQOL							
Baseline KOOS KRQOL	31.3	31.3	43.8	28.1	31.3	18.8	25.0
KOOS KRQOL at 2 y	75.0	75.0	78.1	75.0	68.8	87.5	46.9
KOOS KRQOL at 6 y	78.1	81.3	81.3	78.1	68.8	68.8	75.0
Marx activity score							
Baseline Marx	12.0	12.0	16.0	11.0	16.0	6.0	6.0
Marx at 2 y	9.0	9.0	9.5	8.0	9.5	8.0	8.0

	All Repairs	Medial Repair Success	Medial Repair Failures	Lateral Repair Success	Lateral Repair Failures	Bilateral Repair Success	Bilateral Repair Failures
Marx at 6 y	7.0	6.0	7.0	6.0	8.0	3.0	1.0
IKDC							
Baseline IKDC	47.1	47.1	51.7	44.9	48.3	48.3	38.8
IKDC score at 2	85.1	85.1	83.9	82.2	84.5	85.1	76.4
IKDC score at 6	87.4	87.4	85.1	87.4	80.5	85.1	88.4