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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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Background: Meniscal repair is commonly performed concurrently with anterior cruciate ligament reconstruction (ACLR) in the acutely injured knee. No large-scale, prospective multicenter studies have evaluated the long-term success and patient-oriented outcomes after combined ACLR and meniscal repair.

Purpose: To define the operative success and patient-oriented outcome scores 6 years after combined meniscal repair and ACLR.

Study Design: Cohort study; Level of evidence, 3.

Methods: All ipsilateral primary ACLR and meniscal 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 and then 2 and 6 years after the index procedure. Subsequent ipsilateral knee reoperations were confirmed by operative reports to evaluate for the failure of meniscal repairs.

Results: In total, 286 patients with 1440 primary ACLRs underwent concurrent meniscal repairs (298 meniscal repairs). Of these, 235 (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 one third of the meniscus (84%); patterns were typically longitudinal (84%) or displaced bucket-handle (10%), with a mean length of 16.5 ± 5.8 mm. 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 vs 3.7 years, respectively; $P = .01$). Significant improvements in outcome scores were sustained at 6-year follow-up. No differences in the suture number or type were detected between repair failures and successes. The rate of meniscal reoperations was higher in patients who underwent repair compared with those who did not have an identified meniscal injury at the time of ACLR ($P < .01$).

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

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

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Combined injuries to the meniscus 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 an ACL injury and ACL reconstruction (ACLR) with early posttraumatic osteoarthritis (PTOA) in young patients has been well established.^{6,21,37} There has been increased emphasis on meniscal repair over the past 3 decades, as the meniscus is essential in preventing osteoarthritis.^{10,34} In the United States, 500,000 procedures on medial and lateral menisci are undertaken annually, making abnormalities of the meniscus the most commonly treated knee disorders.¹⁸ As a result, investigations evaluating the efficacy of specific measures (ie, ACLR and meniscal repair) to

potentially mitigate PTOA and preserve global knee function are of high interest to the orthopaedic community.

Long-term results of isolated meniscal repair have been well described.¹⁷ Long-term outcomes after meniscal repair in patients undergoing concurrent ACLR are limited to small single-center case series, with failure rates ranging from 0% to 29% at a minimum 5-year follow-up.^{19,20,33} A recent systematic review calculated the failure rate of meniscal repair in ACL-reconstructed knees to be 26.9% at 5 years.²⁶ Significant deterioration in meniscal repairs has been demonstrated in 1 series between published 2- and 6-year follow-up time points.^{12,19} There have also been reports of meniscal repair failures occurring at more than 4 years.⁸ Therefore, long-term follow-up of combined ACLR and meniscal repair is warranted.

Given the 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 meniscal 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 the 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 meniscal repair. The initial multicenter study group's single-year cohort of ACLR and meniscal repair reported a 4% failure rate at 2 years.³⁶ The current literature describes clinical deterioration associated with long-term follow-up of combined ACLR and meniscal repair.¹⁹ The purpose of this study was to perform a 6-year follow-up inclusive of a previously reported cohort of patients³⁶ who underwent concurrent ACLR and meniscal repair and to expand this cohort to include an additional 2 years of enrollment. While meniscal repair in conjunction with ACLR has demonstrated good success at 2 years, we hypothesized that patient-centered outcome scores might deteriorate and ipsilateral reoperations might increase at 6-year follow-up; furthermore, we postulated that tears involving the center of the meniscus and tears of increased length would prove less durable over time.

MATERIALS AND METHODS

The Multicenter Orthopaedic Outcomes Network (MOON) is a prospective longitudinal cohort study following ACLRs performed at 7 centers (University of Iowa, Washington University in St Louis, Vanderbilt University, Cleveland Clinic, The Ohio State University, University of Colorado, and Hospital for Special Surgery) between 2002 and 2004. The study was funded by the National Institutes of Health. Institutional review board approval was obtained from all centers before 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 follow-up, 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 Score [KOOS],³⁰ Western Ontario and McMaster Universities Osteoarthritis Index [WOMAC], International Knee Documentation Committee [IKDC],² and Marx activity rating scores²³). Benchmarks to determine minimal clinically important differences (MCIDs) were determined as follows: 12% change from baseline scores for the WOMAC,³ a change of 8 points for all KOOS subscores,^{29,41} and a change of 11.5 points for IKDC scores.¹⁶ Marx scores²³ were calculated and trended versus time to assess for changes in activity levels.

After the index procedure, surgeons completed a detailed 49-page questionnaire. Data recorded included detailed examinations under general anesthesia, validated descriptions of meniscal injuries,¹³ 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, USA) and exported into a master database.

This master database was then queried for specific factors important in evaluating a cohort with combined ACLR and meniscal repair. This included left versus right knee, involvement of the medial versus lateral meniscus, 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 meniscal repair that were performed 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). Kaplan-Meier survival analysis was performed using SPSS software (IBM Corp).

RESULTS

Between 2002 and 2004, there were 1440 unilateral primary ACLRs performed as part of the MOON cohort. Of the 1440 patients enrolled during this time period, 955 had documented meniscus tears (66.3%). Of these subjects, 286 (29.9%) were treated with repair, 164 (17.2%) underwent no treatment, 7 (0.7%) were treated with abrasion and trephination, 2 (0.2%) were treated with meniscal transplant, and 496 (51.9%) were treated with excision.

There were 286 patients who underwent ACLR with concurrent meniscal repair (298 meniscal repairs). The

TABLE 1
Characteristics of Meniscal Tears in Patients
at 6-Year Follow-up^a

| | Values |
|-------------------------------------|----------------|
| Length, mean \pm SD, mm | 16.5 \pm 5.8 |
| Anterior-posterior location | |
| Anterior | 3 (1.2) |
| Anterior + posterior | 34 (13.9) |
| Posterior | 207 (84.8) |
| Coronal location | |
| Central + middle + peripheral third | 1 (0.4) |
| Central + middle third | 10 (4.1) |
| Central third | 6 (2.5) |
| Middle + peripheral third | 45 (18.4) |
| Middle third | 22 (9.0) |
| Peripheral third | 160 (65.6) |
| Tear type | |
| Bucket-handle (displaced) | 24 (9.8) |
| Complex | 3 (1.2) |
| Horizontal | 2 (0.8) |
| Longitudinal (vertical) | 204 (83.6) |
| Oblique | 9 (3.7) |
| Radial | 2 (0.8) |
| Degenerative characteristics | |
| Yes | 21 (8.6) |
| No | 223 (91.4) |

^aValues are expressed as n (%) unless otherwise indicated. There were 244 tears treated with repair in 235 patients.

median age of this cohort was 21 years (mean \pm standard deviation, 23.6 \pm 9.7 years; range, 11-63 years) at the time of the index procedure. Of these patients, 235 (82.2%) were available for follow-up at 6 years. There were 154 patients who underwent concurrent medial meniscal repair, 72 patients who underwent concurrent lateral meniscal repair, and 9 patients who underwent both lateral and medial meniscal repairs in conjunction with ACLR (244 total repairs in 235 patients) (Table 1).

There were 55 patients who underwent subsequent arthroscopic knee procedures (ipsilateral and contralateral), and operative reports were available for 51 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%), infections (1/235; 0.4%), or articular cartilage lesions (3/235; 1.3%) 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 Meniscal Repairs

We discovered 21 patients with documented failed medial meniscal 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 meniscal repair. In the medial meniscal repair group, 5 of 21 failures were addressed concurrently with revision ACL surgery. Two patients who underwent medial meniscal 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 failed medial meniscal repairs was 16.3 \pm 5.7 mm; the mean length of meniscal tears that did not require reoperations at 6 years was 16.2 \pm 5.9 mm. There was no difference between the 2 groups with regard to length ($P = .93$). There was no difference in tear type (vertical, bucket-handle, etc) or location (anterior-posterior or coronal) between medial meniscal repair failures and successes.

For medial repairs, there was no difference in the number of sutures used in repairs that failed and those that did not (2.3 \pm 1.5 sutures used for repair failures vs 2.5 \pm 1.3 sutures used for nonfailures; $P = .58$). No differences in types of sutures or devices used were detected between groups.

Of all medial repairs, 135 of 154 were repaired using all-inside techniques; of these, 19 (14.1%) failed at 6-year follow-up. Inside-out techniques were used in 12 of 154 medial meniscal repairs. Of the 12 repaired inside-out techniques, only 1 clinical failure was noted. Two patients underwent combined all-inside and inside-out techniques, and neither of these 2 patients had failed repairs. Five patients with medial meniscal tears were treated with outside-in techniques, and 1 demonstrated failure at 6 years (Figure 1).

Lateral Meniscal Repairs

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

The mean length of tears in failed lateral meniscal repairs was 19.6 \pm 5.5 mm; the mean length of lateral meniscal tears that did not require reoperations at 6 years was 16.7 \pm 5.8 mm. There was no difference between the 2 groups with regard to length ($P = .13$). All of the lateral repair failures were longitudinal (vertical); this was the most common tear type in successful lateral repairs in 51 of 62 (82%). There was no difference in location (anterior-posterior or coronal) between lateral meniscal repair failures and successes.

For lateral repairs, there was no difference in the number of sutures used in repairs that failed and those that did not (2.3 \pm 0.8 sutures used for repair failures vs 2.6 \pm 1.6 sutures used for nonfailures; $P = .58$). 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 meniscal repairs, 8.3% (6/72) of lateral meniscal tears were treated with inside-out techniques, and 1 patient (1.4%; 1/72) was treated with an outside-in technique. All lateral meniscal repair failures ($n = 10$) were treated with all-inside techniques at the index surgery. Therefore, 10 of the 65 lateral meniscal repairs treated with all-inside techniques (15.4%) failed at 6-year follow-up. None of the 7 cases

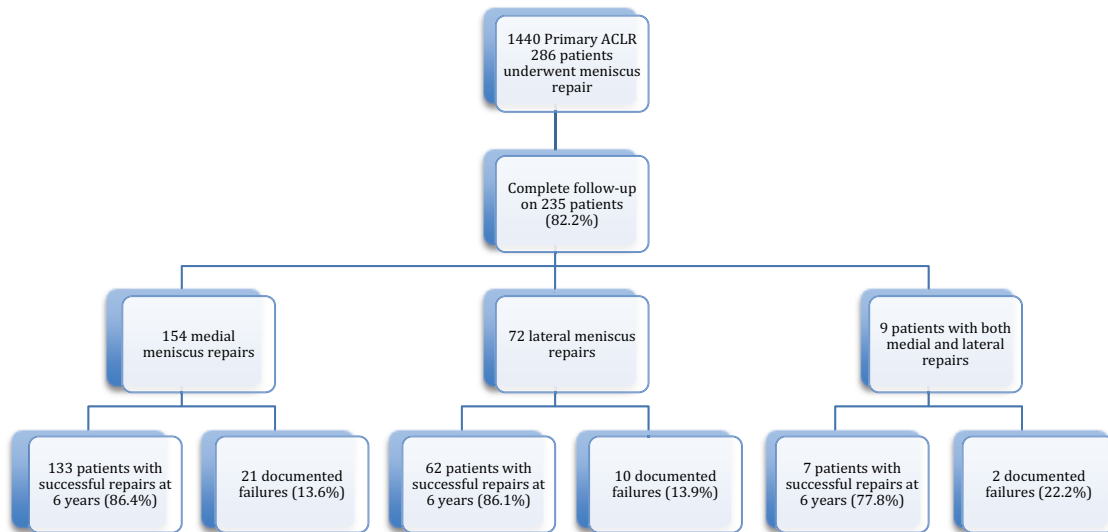


Figure 1. Surgical success of meniscal repairs evaluated by the medial/lateral meniscus. Similar rates of failures were noted in the medial and lateral repair groups. Patients who underwent bilateral meniscal repairs had an increased rate of repair failures.

treated with inside-out or outside-in techniques demonstrated clinical failure at 6 years.

Bilateral Meniscal Repairs

Nine patients in the present cohort underwent repair of both medial and lateral menisci during the index ACLR. Of these, there were 2 failures, resulting in a failure rate of 22.2%. Both of the failures in this group were medial meniscal 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 meniscal excisions or repairs (11/425; 2.6%). The rate of meniscal reoperations, therefore, was significantly higher in patients who underwent meniscal repair (14%) compared with those who did not have a meniscal injury at the time of the index ACLR (2.6%) ($P < .01$).

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 (9.6 mm) compared with the repair group (16.5 mm) ($P < .01$). Twelve patients underwent subsequent meniscal operations 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 ($P = .1$).

Timing of Repair Failure

Medial meniscal repairs failed at a mean of 2.1 ± 1.6 years (range, 0.4-6 years), while lateral meniscal repairs failed at a mean of 3.7 ± 1.3 years (range, 0.5-5.4 years). This was a statistically significant difference in the mean time to

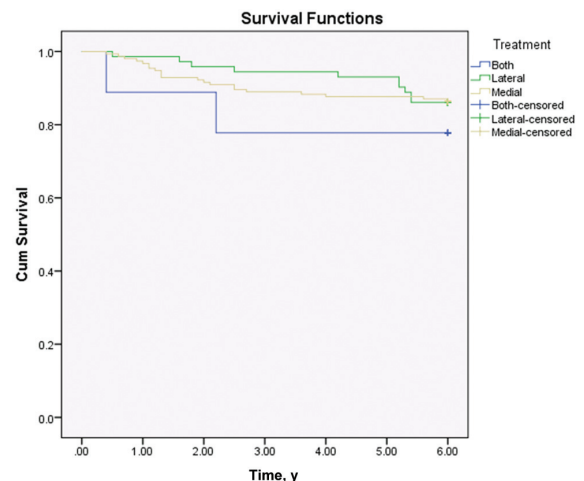


Figure 2. Kaplan-Meier survival analysis of meniscal repairs performed in combination with anterior cruciate ligament reconstruction. The vertical axis denotes cumulative survival, and the horizontal axis denotes time in years of survival of the meniscal repair. The survival plot of patients who underwent both lateral and medial meniscal repairs is in blue, the survival plot of patients who underwent lateral meniscal repairs is in green, and the survival plot of patients who underwent medial meniscal repairs is in tan. Note that medial repairs appeared to fail early (2.1 years), while lateral repair failures more commonly occurred late (3.7 years). Overall, similar survival rates were noted between medial and lateral repairs.

failure between medial and lateral repairs ($P = .01$). The Kaplan-Meier survival analysis for medial, lateral, and both meniscal repairs is displayed in Figure 2. While medial repairs appeared to fail earlier than lateral repairs, the overall survival rate was similar at 6 years.

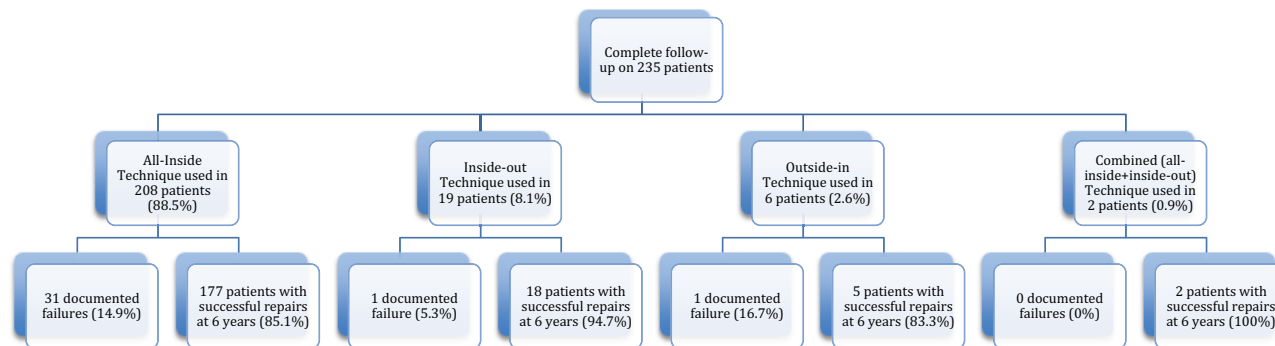


Figure 3. Evaluation of eligible patients segregated by repair technique. Failure rates were lowest in the inside-out technique group at 6-year follow-up. Given the low numbers in the open technique groups, it is difficult to accurately compare open techniques to the all-inside technique.

Repair Technique

Overall, all-inside techniques were performed in 208 of 235 patients (88.5%) available for follow-up. There were 31 failures with this technique, representing a 14.9% failure rate. There was 1 failure in the inside-out technique group (1/19; 5.3%) and 1 failure noted in the outside-in technique group (1/6; 16.7%) (Figure 3).

Patient-Oriented Outcome Scores

Knee Injury and Osteoarthritis Outcome Score. 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 the KOOS symptoms, pain, activities of daily living, or sports and recreation subscales between 2 and 6 years. With regard to the KOOS knee-related quality of life subscale, scores for lateral repair successes at 6-year follow-up were significantly superior to those of lateral repair failures (78.1 vs 68.8, respectively) (Table 2).

International Knee Documentation Committee. The median baseline IKDC score for all repairs was 47.1 (interquartile range [IQR], 35.6-60.9). Six years after ACLR and meniscal repair, the median IKDC score was 87.4 (IQR, 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 with those at 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 Activity Rating. With regard to all repairs, the median baseline Marx score was 12.0 (IQR, 8.0-16.0). At 2 and 6 years after ACLR and meniscal repair, the median Marx scores were 9.0 (IQR, 3.0-13.0) and 7.0 (IQR, 2.3-12.0), respectively; these significantly decreased over time. Marx activity scores were lowest in the bilateral repair groups (Table 2).

Western Ontario and McMaster Universities Osteoarthritis Index. The median baseline WOMAC stiffness score was 75.0 (IQR, 50.0-87.5). Six years after ACLR and meniscal repair, the median WOMAC stiffness score was 87.5 (IQR, 75.0-100.0). The median baseline WOMAC pain score was 85.0 (IQR, 70.0-95.0). The pain score 6 years after ACLR and meniscal repair was 100.0 (IQR, 90.0-100.0). The median baseline WOMAC activities of daily living score was 85.3 (IQR, 68.4-94.1), and the score was 98.5 (IQR, 94.1-100.0) at 6-year follow-up. No significant clinical differences were noted between 2- and 6-year follow-up with regard to WOMAC scores.

DISCUSSION

This study evaluated the incidence of repair failures and patient outcomes after ACLR and meniscal repair with a minimum 6-year follow-up. We determined the failure rate of meniscal repair with 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 (9/33; 27.3%) 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 the literature's established MCIDs at both 2- and 6-year follow-up. Overall, patients experienced operative success rates greater than 85%, and patients sustained such improvements in clinical outcomes between 2- to 6-year follow-up time points.

It is thought that 2-year rates of the combined procedures are associated with success in 90% to 96% of cases.^{36,39} Wasserstein et al³⁹ performed a population study in Ontario, Canada, between 2003 and 2008 using the Ontario Health Insurance Plan database; fee codes were queried, and the authors observed a 10% rate of reoperations within 2 years of ACLR and concomitant meniscal repair. In a prior multicenter study evaluating 2-year outcomes from the 2002 enrollment of our cohort, the success rate of meniscal repair performed concurrently with ACLR

TABLE 2
Median Scores at Baseline and 2- and 6-Year Follow-up^a

| | All Repairs (n = 235) | Successful Medial Repair (n = 133) | Failed Medial Repair (n = 21) | Successful Lateral Repair (n = 62) | Failed Lateral Repair (n = 10) | Successful Bilateral Repair (n = 7) | Failed Bilateral Repair (n = 2) |
|----------------------|--------------------------|--|-------------------------------------|--|--------------------------------------|---|---------------------------------------|
| KOOS symptoms | | | | | | | |
| Baseline | 67.9 | 67.9 | 67.9 | 67.9 | 75.0 | 67.9 | 55.4 |
| 2 years | 85.7 | 85.7 | 87.5 | 85.7 | 82.1 | 96.4 | 82.1 |
| 6 years | 85.7 | 89.3 | 82.1 | 88.4 | 83.9 | 85.7 | 89.3 |
| KOOS pain | | | | | | | |
| Baseline | 72.2 | 72.2 | 77.8 | 72.2 | 77.8 | 72.2 | 61.1 |
| 2 years | 91.7 | 91.7 | 97.2 | 91.7 | 88.2 | 100.0 | 86.1 |
| 6 years | 94.4 | 94.4 | 94.4 | 94.4 | 91.7 | 97.2 | 91.7 |
| KOOS ADL | | | | | | | |
| Baseline | 85.3 | 86.8 | 85.3 | 86.8 | 80.1 | 75.0 | 68.4 |
| 2 years | 98.5 | 98.5 | 98.5 | 98.5 | 95.5 | 100.0 | 91.2 |
| 6 years | 98.5 | 98.5 | 98.5 | 98.5 | 98.5 | 98.5 | 97.1 |
| KOOS Sports/Rec | | | | | | | |
| Baseline | 45.0 | 45.0 | 50.0 | 45.0 | 36.9 | 50.0 | 22.5 |
| 2 years | 85.0 | 85.0 | 85.0 | 90.0 | 80.0 | 95.0 | 85.0 |
| 6 years | 90.0 | 90.0 | 85.0 | 85.0 | 85.0 | 90.0 | 82.5 |
| KOOS KRQOL | | | | | | | |
| Baseline | 31.3 | 31.3 | 43.8 | 28.1 | 31.3 | 18.8 | 25.0 |
| 2 years | 75.0 | 75.0 | 78.1 | 75.0 | 68.8 | 87.5 | 46.9 |
| 6 years | 78.1 | 81.3 | 81.3 | 78.1 | 68.8 | 68.8 | 75.0 |
| Marx activity rating | | | | | | | |
| Baseline | 12.0 | 12.0 | 16.0 | 11.0 | 16.0 | 6.0 | 6.0 |
| 2 years | 9.0 | 9.0 | 9.5 | 8.0 | 9.5 | 8.0 | 8.0 |
| 6 years | 7.0 | 6.0 | 7.0 | 6.0 | 8.0 | 3.0 | 1.0 |
| IKDC | | | | | | | |
| Baseline | 47.1 | 47.1 | 51.7 | 44.9 | 48.3 | 48.3 | 38.8 |
| 2 years | 85.1 | 85.1 | 83.9 | 82.2 | 84.5 | 85.1 | 76.4 |
| 6 years | 87.4 | 87.4 | 85.1 | 87.4 | 80.5 | 85.1 | 88.4 |

^aGroups were analyzed by all cases undergoing meniscal repair, successful medial repair at 6 years, failed medial repair at 6 years, successful lateral repair at 6 years, failed lateral repair at 6 years, successful bilateral repair at 6 years, and failed bilateral repair at 6 years. Significantly decreased Marx activity scores were noted in failed bilateral repairs at 6-year follow-up. ADL, activities of daily living; KOOS, Knee Injury and Osteoarthritis Outcome Score; KRQOL, knee-related quality of life; Sports/Rec, sports and recreation.

was found to be 96%.³⁶ While early follow-up (2 years) is generally associated with high success rates, there are reports of deteriorating repairs with longer follow-up.¹⁹

In recent reports, long-term failure rates of combined ACLR and meniscal repair range from 0% to 29%^{19,20,33} at a minimum 5-year follow-up, with the 0% group representing a case series of 10 patients.³³ Lee and Diduch¹⁹ evaluated 28 patients 6.6 years after the index combined ACLR and meniscal 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 a minimum 5-year follow-up with ACLR in 35 athletes, although this number may be artificially low when compared with ours because the study excluded 7 meniscal failures associated with "traumatic events" including 2 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 a minimum 5 years. It should be recognized that our definition of meniscal repair failure (repeat

surgery on a repaired meniscus) may exclude clinically symptomatic patients.

In a single-center cohort study conducted over a 10-year period, Gallacher et al¹¹ reported a failure rate of 28% in ACLR and meniscal repair at a mean 5.5-year follow-up. Nepple et al,²⁶ in a recent systematic review, estimated the failure rate to be 27% at a minimum 5-year follow-up for combined ACLR and meniscal repair. Our study demonstrated a combined failure rate of 14% or just over half the rate of the similar ACLR and meniscal repair cohort (27%) from the study of Nepple et al²⁶ as well as other similar cohorts (27%-29%).^{11,19,20} This may be partially explained by the 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 and 1998.^{19,20,33}

Furthermore, there may be a protective effect associated with performing ACLRs along with meniscal repairs. In the Nepple et al²⁶ systematic review, inclusive of 566 cases with a minimum 5-year follow-up, the failure rate of all combined meniscal repairs was estimated to be 23%. This is significantly higher than our observed 14%

rate of failures in a similar follow-up period. There are a few studies in the literature that suggest concurrent ACLR, when necessary, may produce a protective effect of meniscal repair.^{4,27,31,35,39} In the population study by Wasserstein et al,³⁹ the rate of ipsilateral knee operations after ACLR and meniscal repair was observed to be 10%, while a matched cohort with meniscal 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 reported clinical failures in 9% of patients who underwent ACLR and meniscal repair versus a 25% failure rate in patients undergoing meniscal repair with an intact ACL. Current opinions in the field offer 3 possible explanations for the improved success of meniscal repair with concurrent ACLR; first, patients undergoing ACLR may be slower to rehabilitate after an injury, thereby producing a low-force environment for meniscal healing. Second, drilling of the tibial and femoral tunnels may produce a biologically advantaged environment to augment meniscal healing.³⁹ Third, meniscal 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 meniscal repair groups compared with meniscal repairs in stable (ACL-intact) knees.²⁶ The cases representing ACLR with concurrent meniscal repair within the systematic review were very limited in number and may not have been powered to detect differences between the groups.

Our study confirmed a current trend toward all-inside techniques, as these comprised 88.5% of the cases in our cohort. Short-term outcomes of all-inside techniques have proven reliable.¹ Our study detected 31 failures after meniscal repair utilizing all-inside techniques, representing a 14.9% failure rate. There was 1 failure in the inside-out technique group (1/19; 5.3%) and 1 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 the long-term clinical success of combined ACLR and meniscal repair. The IKDC is a validated assessment tool for knee ligament and meniscal injuries^{15,16}; the form is composed of 18 questions converted to a 0-to-100 scale. The MCID for IKDC scores has been demonstrated to be a change of at least 11.5 points.¹⁶ Logan et al²⁰ reported a mean IKDC score of 82.2 (range, 18-100) at a minimum 5.4-year follow-up after combined ACLR and meniscal repair. These data are representative of a heterogeneous cohort of 42 patients: 17% who underwent meniscal repair only and 83% who underwent meniscal repair and ACLR. No baseline IKDC scores were reported. Similarly, Melton

et al²⁵ determined the mean IKDC score to be 84.2 in 26 patients at a minimum of 7.7 years after combined meniscal repair and ACLR. These outcomes are similar to those in 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 and Diduch¹⁹ reported IKDC scores of successful meniscal 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.

Patients who underwent successful medial and lateral meniscal repairs had 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 ACLRs. Revision ACLR and the presence of meniscal injuries were found to predict worse outcomes. They determined that medial meniscal repairs predicted worse IKDC and KOOS scores but that lateral repairs did not. They also noted that grade 3 or 4 chondral lesions predicted significantly worse outcomes.

Differences in outcome scores greater than the established MCIDs 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 knee-related quality of life subscores 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 because of the high association with revision ACLR seen in the lateral failure group (4/10 meniscal repair failures associated with revision ACL procedures). Lower KOOS knee-related quality of life subscores in that group may therefore be a reflection of a second-hit injury phenomenon. Perhaps the 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 KOOS,³⁰ WOMAC, and Marx activity scores²³ for long-term follow-up of combined ACLR and meniscal repair. Our cohort demonstrated MCIDs 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 meniscal repair at 2 years, and there was no detectable deterioration in patient outcomes between 2- and 6-year follow-up. The median overall Marx activity scores were observed to decline from baseline (score = 12.0) to 2-year follow-up (score = 9.0) to 6-year follow-up (score = 7.0). Although there is no validated study to detect clinically important differences in Marx scores, a reduction of nearly 50%, as observed between median baseline and 6-year follow-up values, is generally considered a true change.

Lateral meniscal tears appeared to be longer in those who failed repair; however, the difference did not reach

statistical significance (medial repairs: $P = .93$; lateral repairs: $P = .13$). 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 amenable to repair may have been treated with excision or other modalities. While there were trends toward more sutures in successful repairs, the overall number and type of sutures were 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 were available for 235 patients, whereas the largest previous study of combined meniscal repair and ACLR at greater than 5-year follow-up comprised 35 patients.²⁰ The multicenter nature of our study provides generalizable data to multiple surgeon and patient populations. The study does have weaknesses. Although the follow-up was relatively high for a midterm 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 vs excision, amount and type of fixation). Our definition of surgical failure (repeat operation on the repaired meniscus) may exclude other subclinical failures. The gold standard would be for repeat arthroscopic surgery and/or magnetic resonance imaging at predetermined periods of follow-up; however, our cohort is so large that this would consume an incredible amount of financial resources. A repeat arthroscopic procedure, therefore, is the most common metric to evaluate surgical success in the current literature.²² Lastly, numerous factors contribute to outcomes after ACLR and meniscal treatment. A multivariate analysis of outcomes that takes into account all of these variables, including all possible statuses and interventions for the meniscus, is beyond the scope of this article.

CONCLUSION

The success rate of concurrent meniscal repair and ACLR is approximately 86% at 6-year follow-up. This success rate is higher than those of other studies in the literature and may reinforce an association of concurrent ACLR with improved meniscal 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, because of the low numbers of outside-in and inside-out techniques, the study is not adequately powered to detect differences in these latter 2 techniques. The rate of reoperations was higher in patients who underwent meniscal repair compared with those

without a detected meniscal injury. Patient-oriented outcome measures significantly increased between the time of the index procedure and 2 years; these increases were maintained between 2- and 6-year follow-up. Therefore, surgeons may expect good success with combined ACLR and meniscal repair at 6 years.

CONTRIBUTING AUTHORS

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