Outcomes of Inside-out Meniscal Repair in the Setting of Multiligament Reconstruction in the Knee

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Background: Limited evidence exists for meniscal repair outcomes in a multiligament reconstruction setting.

Purpose/Hypothesis: The purpose of this study was to assess outcomes and failure rates of meniscal repair in patients who underwent multiligament reconstruction compared with patients who underwent multiligament reconstruction but lacked meniscal tears. The authors hypothesized that the outcomes of meniscal repair associated with concomitant multiligament reconstruction would significantly improve from preoperatively to postoperatively at a minimum of 2 years after the index surgery. Secondarily, they hypothesized that this cohort would demonstrate similar outcomes and failure rates compared with the cohort that did not have meniscal lesions at the time of multiligament reconstruction.

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

Methods: Inclusion criteria for the study included radiographically confirmed skeletally mature patients of at least 16 years of age who underwent multiligamentous reconstruction of the knee without previous ipsilateral osteotomy, intra-articular infections, or intra-articular fractures. Patients were included in the experimental group if they underwent inside-out meniscal suture repair with concurrent multiligament reconstruction. Those included in the control group (multiligament reconstruction without a meniscal tear) underwent multiligament reconstruction but did not undergo any type of meniscal surgery. Lysholm, Western Ontario and McMaster Universities Osteoarthritis Index, Short Form–12 physical component summary and mental component summary, Tegner activity scale, and patient satisfaction scores were recorded preoperatively and postoperatively. The failure of meniscal repair was defined as a retear of the meniscus that was confirmed arthroscopically.

Results: There were 43 patients (16 female, 27 male) in the meniscal repair group and 62 patients (25 female, 37 male) in the control group. Follow-up was obtained in 93% of patients with a mean of 3.0 years (range, 2.0-4.7 years). There was a significant improvement between all preoperative and postoperative outcome scores ($P < .05$) for both groups. The meniscal repair group had significantly lower preoperative Lysholm and Tegner scores ($P = .009$ and $P = .02$, respectively). There were no significant differences between any other outcome scores preoperatively. The failure rate of the meniscal repair group was 2.7%, consisting of 1 symptomatic meniscal retear. There was no significant difference in any postoperative outcome score at a minimum 2-year follow-up between the 2 groups.

Conclusion: Good to excellent patient-reported outcomes were reported for both groups with no significant differences in outcomes between the cohorts. Additionally, the failure rate for inside-out meniscal repair with concomitant multiligament reconstruction was low, regardless of meniscus laterality and tear characteristics. The use of multiple vertical mattress sutures and the biological augmentation resulting from intra-articular cruciate ligament reconstruction tunnel reaming may be partially responsible for the stability of the meniscal repair construct and thereby contribute to the overall improved outcomes and the low failure rate of meniscal repair, despite lower preoperative Lysholm and Tegner scores in the meniscal repair group.

Keywords: meniscal repair; vertical mattress suture; inside-out technique; multiple ligament reconstruction; multiligament

Meniscal repair procedures are increasingly being performed because of an improved understanding of the long-term deleterious effects that can result from the loss of meniscal tissue.[25] Although meniscal repair has a higher reoperation rate than meniscectomy, a recent systematic review reported that repairing the meniscus resulted in improved long-term outcomes.[25] The failure to restore the main meniscal function of load bearing and force distribution can predispose the joint to early degenerative changes.[12]

Improved outcomes have been reported for meniscal tears that were repaired at the time of anterior cruciate ligament (ACL) reconstruction or after tibial plateau fractures as compared with those repaired in isolation.[13] This

The American Journal of Sports Medicine, Vol. XX, No. X
DOI: 10.1177/0363546517698944

has been postulated to be related to the biological augmentation of the repair from factors in the bone marrow released within the joint.[5,9,13] However, to our knowledge, there is no literature on meniscal repair outcomes and failure rates in the setting of patients with multiligament knee injuries. Multiple ligament–injured knees are often the result of high-energy mechanisms and produce extensive soft tissue damage to the knee. These injuries may therefore predispose patients to diminished outcomes and increased failure rates after meniscal repair performed concomitantly with multiple ligament surgery as compared with isolated meniscal repair or repair with single-ligament reconstruction. While this is theoretically plausible, the intra-articular tunnels drilled for central ligament reconstruction in the multiligament reconstruction setting may provide the biological augmentation of the repair to allow for similar rates of healing when compared with meniscal repair performed concomitantly with ACL reconstruction.

The purpose of this study was to assess outcomes and failure rates of meniscal repair in patients who underwent multiligament reconstruction compared with patients who underwent multiligament reconstruction but not meniscal repair. We hypothesized that the outcomes of meniscal repair associated with concomitant multiligament reconstruction would significantly improve from preoperatively to postoperatively at a minimum of 2 years after the index surgery. Secondarily, we hypothesized that this cohort would demonstrate similar outcomes compared with the cohort that did not have meniscal lesions at the time of multiligament reconstruction.

METHODS

This study was approved by our institutional review board. This study was a retrospective analysis of prospectively collected data from 2010 to 2014. Inclusion criteria were skeletally mature patients with closed physes confirmed on radiography of at least 16 years of age who underwent inside-out meniscal suture repair and concurrent multiple ligament reconstruction of the ipsilateral knee. Patients who underwent multiligament reconstruction with no meniscal tears constituted the control group. Patients were excluded from this study if they had undergone prior ipsilateral meniscus or knee ligament surgery or osteotomy procedures or had intra-articular infections or fractures. Ligament repair (solely consisting of cruciate ligament avulsion fractures) was excluded from this study because of the differing nature of treatment and rehabilitation protocols as compared with reconstruction techniques. Detailed operative data and intraoperative findings were documented at the time of surgery. For the purpose of this study, multiligament reconstruction was defined as reconstruction of at least 1 cruciate ligament (ACL, posterior cruciate ligament [PCL]) and 1 of the collateral ligaments (superficial medial collateral ligament [sMCL] or fibular collateral ligament [FCL]). Failure was defined as a retear of the meniscus that was confirmed arthroscopically or reoperation performed because of complications after the index surgery.

At a minimum of 2 years after the index surgery, patients were administered a subjective questionnaire, which included the following clinical outcome measures: Lysholm score, Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), Short Form–12 (SF-12) physical component summary (PCS) and mental component summary (MCS), Tegner activity scale, and patient satisfaction with outcomes. Patient satisfaction was measured on a 1-to-10 scale, with a score of 10 being very satisfied and a score of 1 being very unsatisfied. Demographic characteristics were also recorded, such as age, sex (male or female), body mass index (BMI), previous surgery, tear zone (red-red, red-white, and white-white), and meniscus (medial or lateral).

Surgical Technique

All patients included in the study group underwent inside-out meniscal repair with vertical mattress sutures when possible. In cases where it was not feasible, horizontal mattress sutures were used. Before attempting the repair, a complete evaluation of the lesion was performed including stability, state of the meniscus, and type and zone of the lesion. For each ligament tear pattern, the corresponding ligament reconstruction was performed using previously described techniques and approaches.[2,3,10,22] The extra-articular portions of each reconstruction were performed before intra-articular procedures to allow for ease of dissection and to avoid fluid extravasation around the injured structures during arthroscopic surgery. On the basis of each case, the ligament grafts were fixed in the following order: the PCL, the FCL/posterolateral corner, the ACL, and finally the sMCL. All the extra-articular work was performed initially to identify the injured structures before fluid extravasation from the arthroscopic procedure.

For the purposes of meniscal repair, a posterolateral or posteromedial approach was used according to a previously reported technique depending on whether the tear was on the lateral or medial meniscus.[4] A self-delivery device fitted with a cannula (Ivy Sports Medicine) was used to pass double-loaded nonabsorbable No. 2-0 sutures into the meniscus. To pass the sutures, the knee was positioned in 20° of flexion, and the meniscal needle was advanced approximately 1 cm through the superior or inferior aspect of the meniscus; then, the knee was flexed to 70° to 90°, while the needle was further advanced to help the assistant retrieve the needle through the previously made incision. The same process was repeated adjacent to the previous suture with the second needle penetrating the

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One or more of the authors has declared the following potential conflict of interest or source of funding: R.F.L. is a consultant and receives royalties from Arthrex, Ossur, and Smith & Nephew.

TABLE 1
Patient Demographics

	Multiligament Reconstruction With Meniscal Repair (n = 43)	Multiligament Reconstruction Without Meniscal Repair (n = 62)	*P* Value
Sex, female/male, n	16/27	25/37	.63
Age, mean (range), y	34.0 (16-63)	33.6 (16-66)	.80
Body mass index, mean (range), kg/m^2	25.9 (19.5-35.9)	24.6 (18.8-34.0)	.091
Chondral defects (Outerbridge grade III-IV), n	7	17	.51

joint capsule, such that the sutures were placed both on the superior and inferior borders of the meniscus between 3 to 4 mm apart to create a vertical mattress pattern. If another tear configuration was encountered, a horizontal mattress suture was utilized to maintain perpendicularity of the tear-suture complex. The needles were cut from the sutures, and the suture ends were clamped with numbered hemostats while maintaining slight tension. Multiple sutures were used to create a stronger construct and restore the hoop stresses of the meniscal tissue. With the knee flexed to 90°, all sutures were tied, being cautious to not overtighten the tissue or entrap nearby soft tissue structures. After meniscal repair, ligamentous reconstruction was completed, and the grafts were secured in the previously mentioned sequence.[2,3,21,22]

Rehabilitation

Patients were kept nonweightbearing for 6 weeks in a knee immobilizer in extension except when working on passive knee motion.[10,15,18] Passive range of motion exercises between 0° and 90° were initiated the day after surgery and continued for 2 weeks. After this time, patients were allowed full motion as tolerated and transitioned to a functional brace at 6 weeks postoperatively. Weightbearing was initiated along with the utilization of a low-resistance stationary bicycle and 25% body weight leg presses to a maximum of 70° of knee flexion. Additional increases in low-impact knee exercises were permitted as tolerated starting at 12 weeks postoperatively. Physical therapy was similar in all patients for the first 6 weeks except for patients who underwent concurrent PCL reconstruction in which prone knee flexion was performed instead of supine knee flexion.

Statistical Analysis

Data were tested for normal distribution by using the Kolmogorov-Smirnov *Z* test. For preoperative and postoperative comparisons of dependent variables, the paired-samples *t* test was utilized for normally distributed data, and the Wilcoxon signed-rank test was utilized for nonnormally distributed data. Preoperative and postoperative SF-12 PCS and SF-12 MCS scores in each of the meniscal cohorts (medial, lateral, or both) were analyzed, and analysis of variance was performed. Preoperative and postoperative Lysholm, Tegner, and WOMAC scores in each meniscal cohort were analyzed using the Kruskal-Wallis test. Comparisons of 2 categorical data, including age, sex, and BMI, were performed by using chi-square tests and Fisher exact tests. All *P* values were 2-tailed, and *P* values $<.05$ were considered statistically significant. All statistical analyses were performed by using SAS version 9.4 (SAS Institute).

RESULTS

Demographics

There were 45 patients who met the inclusion criteria for multiligament reconstruction with meniscal repair; 2 patients refused to participate, leaving 43 patients (16 female, 27 male) who were included in this study. Sixty-two patients (25 female, 37 male) met the inclusion criteria for multiligament reconstruction without meniscal repair; all 62 patients were available for final follow-up. Follow-up was obtained in 93% of the overall cohort (98/105): 84% in the meniscal repair group (36/43) and 100% in the control group (62/62), with a mean follow-up of 3.0 years (range, 2.0-4.7 years). In the meniscal repair group, there were 33 patients treated acutely and 10 patients treated greater than 6 weeks from the injury; the mean time from injury to surgery for this group was 23.3 weeks (range, 1 day to 4 years). In the control group, there were 39 patients treated acutely and 23 patients treated greater than 6 months from the injury; the mean time from injury to surgery in this group was 39.2 weeks (range, 2 days to 19 years). When comparing the mean time to surgery of the 2 groups, a *P* value of .38 resulted. There were no significant differences in demographics or concomitant Outerbridge III or IV chondral defects between the 2 groups (Table 1). There were 19 patients who underwent medial meniscal repair, 17 patients who underwent lateral meniscal repair, and 7 patients who underwent both medial and lateral meniscal repairs. No patients in the control group underwent additional surgeries. Nine patients from the meniscal repair group went on to undergo additional surgeries: 5 patients underwent lysis of adhesions for arthrofibrosis, 1 patient underwent deep hardware removal, 1 patient underwent open reduction internal fixation for a patellar fracture, 1 patient underwent medial patellar chondroplasty, and 1 patient underwent MCL reconstruction.

Ligament Tear Pattern and Concomitant Chondral Injuries

Ligament tear patterns were identified preoperatively with a comprehensive physical examination, stress radiographs (kneeling and varus/valgus depending on the case), and

TABLE 2
Ligament Tear Patterns by Group[a]

	Multiligament Reconstruction With Meniscal Repair (n = 43)	Multiligament Reconstruction Without Meniscal Repair (n = 62)	*P* Value
ACL, FCL	19 (44)	23 (37)	.54
ACL, MCL	13 (30)	12 (19)	.24
ACL, PCL	2 (5)	0 (0)	.17
PCL, MCL	1 (2)	8 (13)	.08
PCL, FCL	0 (0)	6 (10)	.08
ACL, PCL, FCL	1 (2)	6 (10)	.23
ACL, MCL, FCL	6 (14)	1 (2)	.012
ACL, MCL, PCL	1 (2)	5 (8)	.40
PCL, FCL, MCL	0 (0)	1 (2)	.90

[a]Values presented as n (%). ACL, anterior cruciate ligament; FCL, fibular collateral ligament; MCL, medial collateral ligament; PCL, posterior cruciate ligament.

magnetic resonance imaging (MRI) and were confirmed at the time of surgery. The meniscal repair group had significantly more ACL/MCL/FCL injuries than the control group (n = 6 vs n = 1, respectively; $P = .012$); however, other configurations were comparable. The frequency of the remaining multiligament tear combinations was not significantly different between the 2 groups. Specific injuries and the tear pattern distribution are displayed in Table 2.

Meniscal Tear Characteristics and Number of Sutures for Repair

The mean number of sutures utilized for the medial meniscus cohort was 7 (range, 2-16), and 7 (range, 2-12) for the lateral meniscus cohort. There was no significant difference in the number of sutures used based on tear laterality ($P = .481$). The characterization of intraoperative meniscal tears is presented in Table 3.

TABLE 3
Intraoperative Meniscus Data by Cohort[a]

	Patients
Meniscal suture repair	43 (100)
Medial	19 (44)
Lateral	17 (40)
Medial and lateral	7 (16)
No. of sutures, mean (range)	
Medial	7 (2-16)
Lateral	7 (2-12)
Medial tear type	26 (100)
Horizontal	3 (12)
Longitudinal/vertical	16 (62)
Flap/bucket/complex	7 (27)
Lateral tear type	24 (100)
Horizontal	0 (0)
Longitudinal/vertical	14 (58)
Flap/bucket/complex	6 (25)
Radial	4 (17)
Medial tear zone	26 (100)
Red-red	11 (42)
Red-white	11 (42)
White-white	4 (15)
Lateral tear zone	24 (100)
Red-red	9 (38)
Red-white	11 (46)
White-white	4 (17)

[a]Values presented as n (%) unless otherwise specified.

Outcome Scores

There was a significant improvement between all preoperative and postoperative outcome scores ($P < .05$) for both groups. The meniscal repair group had significantly lower preoperative Lysholm and Tegner scores than the control group ($P = .009$ and $P = .02$, respectively). There were no significant differences between any other outcome scores preoperatively.

There was no significant difference in any postoperative outcome score at a minimum 2-year follow-up between the 2 groups. Patient outcomes by group are displayed in Table 4. An intergroup comparison of patient-reported outcomes is shown in Table 5. There were no differences in outcome scores based on laterality of the meniscal injury. A detailed comparison between medial, lateral, and combined meniscal repairs (medial and lateral) is presented in Table 6. The overall symptomatic failure rate for the meniscal repair group was 2.8% (1 patient). The patient was a 16-year-old boy who originally had a vertical tear in the red-red zone of the posterior horn of the medial meniscus and had a reinjury with a small radial tear of his medial meniscus.

An analysis of isolated ACL reconstruction (2 tunnels), double-bundle PCL reconstruction (3 tunnels), and bicruciate reconstruction (5 tunnels) demonstrated no significant differences between the groups (Table 7).

DISCUSSION

The most important finding in this study was that comparable postoperative outcomes were achieved between patients who had undergone inside-out meniscal suture repair during multiligament reconstruction and patients

TABLE 4
Preoperative and Postoperative Outcome Scores for All Patients Who Completed Follow-up Questionnaires[a]

	Preoperative	Postoperative	*P* Value
Multiligament reconstruction with meniscal repair (n = 43)			
Lysholm score	38.2 (0-64)	86.7 (64-100)	<.001
WOMAC score	34.0 (0-94)	6.5 (0-53)	<.001
SF-12 PCS score	34.4 (21.5-56.4)	53.0 (38.5-62.2)	<.001
SF-12 MCS score	50.0 (29.3-69.7)	54.8 (35.3-65.4)	.016
Tegner score[b]	1.5 (0-8)	5.8 (1-10)	<.001
Multiligament reconstruction without meniscal repair (n = 62)			
Lysholm score	51.0 (2-91)	84.0 (26-100)	<.0001
WOMAC score	35.4 (0-87)	8.3 (0-59)	<.0001
SF-12 PCS score	36.0 (22.5-58.2)	51.4 (24.4-62.9)	<.0001
SF-12 MCS score	51.4 (24.0-71.8)	52.5 (26.3-64.9)	.45
Tegner score[b]	7.5 (1-10)	6.3 (1-10)	.0001

[a]Values presented as mean (range) unless otherwise specified. SF-12 MCS, Short Form–12 mental component summary; SF-12 PCS, Short Form–12 physical component summary; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.
[b]Values presented as median (range).

TABLE 5
Comparison of Preoperative and Postoperative Outcome Scores by Group[a]

	Multiligament Reconstruction With Meniscal Repair (n = 43)	Multiligament Reconstruction Without Meniscal Repair (n = 62)	*P* Value
Preoperative			
Lysholm score	38.2 (0-64)	51.0 (2-91)	.009
WOMAC score	34.0 (0-94)	35.4 (0-87)	.52
SF-12 PCS score	34.4 (21.5-56.4)	36.0 (22.5-58.2)	.45
SF-12 MCS score	50.0 (29.3-69.7)	51.4 (24.0-71.8)	.41
Tegner score[b]	1.5 (0-8)	7.5 (1-10)	.02
Postoperative			
Lysholm score	86.7 (64-100)	84.0 (26-100)	.39
WOMAC score	6.5 (0-53)	8.3 (0-59)	.45
SF-12 PCS score	53.0 (38.5-62.2)	51.4 (24.4-62.9)	.40
SF-12 MCS score	54.8 (35.3-65.4)	52.5 (26.3-64.9)	.15
Tegner score[b]	5.8 (1-10)	6.3 (1-10)	.44

[a]Values presented as mean (range) unless otherwise specified. SF-12 MCS, Short Form–12 mental component summary; SF-12 PCS, Short Form–12 physical component summary; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.
[b]Values presented as median (range).

who had undergone only multiligament reconstruction; while the preoperative Lysholm and Tegner scores were significantly lower, the presence of a meniscal tear requiring repair in the context of a multiligament injury did not affect postoperative outcomes. This finding suggests that despite the more severe injury pattern, the repair of associated meniscal injuries in this group can allow for significant improvements in patient outcomes, regardless of lower preoperative scores. This study also demonstrates that inside-out meniscal suture repair using multiple sutures was highly reliable, with low failure rates, irrespective of meniscus laterality in the multiligamentous reconstructed knee. To our knowledge, this is the first study to examine the outcomes of meniscal repair with concomitant multiligament reconstruction.

Utilizing the technique described herein, the outcomes and failure rates of inside-out meniscal repair with multiligament reconstruction were similar, or improved, compared with those reported for concomitant ACL reconstruction and meniscal repair.[11,16,24] In this study, inside-out meniscal suture repair was utilized in all cases with a mean of 7 sutures, with an overall failure rate of 2.7%. The biological support yielded from marrow stimulation by way of the creation of intra-articular reconstruction tunnels and the mechanical strength derived from the increased number of sutures might explain the high success and low failure rates from this series. However, more cases of arthrofibrosis were identified in the meniscal repair group compared with the control group (5 vs 0, respectively). This could be because of the more serious nature of the initial injury that yielded intra-articular damage as well.

Nepple et al[16] performed a systematic review of the literature and a meta-analysis of meniscal repair outcomes with a minimum 5-year follow-up, reporting a failure rate of 26.9% for meniscal repair with concomitant ACL reconstruction. A recent systematic review reported on

TABLE 6
Comparison of Patient-Reported Outcomes Between Medial, Lateral, and Combined Meniscal Repairs[a]

	Medial (n = 15)	Lateral (n = 14)	Both (n = 7)	*P* Value
SF-12 PCS score	51.2 (40.8-62.2)	55.9 (45.1-61.7)	50.7 (38.5-57.6)	.118
SF-12 MCS score	54.7 (40.9-64.6)	54.9 (44.5-62.3)	54.7 (35.3-65.4)	.998
WOMAC score	10 (0-53)	4 (0-24)	4 (0-12)	.105
Lysholm score	85 (64-100)	89 (69-100)	85 (70-96)	.363
Tegner score[b]	6 (1-10)	6 (2-8)	8.5 (3-10)	.246
Patient satisfaction	8 (1-10)	6.5 (1-10)	8 (6-10)	.573

[a]Values presented as mean (range) unless otherwise specified. SF-12 MCS, Short Form–12 mental component summary; SF-12 PCS, Short Form–12 physical component summary; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.
[b]Values presented as median (range).

TABLE 7
Analysis of the Effect of the Number of Intra-articular Tunnels on Postoperative Outcomes Following Multiligament Reconstruction With or Without Meniscal Repair[a]

	P Value
Multiligament reconstruction with meniscal repair (n = 43)	
Lysholm score	.64
WOMAC score	.97
SF-12 PCS score	.58
SF-12 MCS score	.58
Tegner score	.56
Multiligament reconstruction without meniscal repair (n = 62)	
Lysholm score	.14
WOMAC score	.07
SF-12 PCS score	.20
SF-12 MCS score	.27
Tegner score	.74

[a]Comparison of isolated anterior cruciate ligament reconstruction (2 tunnels), double-bundle posterior cruciate ligament reconstruction (3 tunnels), and bicruciate reconstruction (5 tunnels). As no differences were found, no post hoc test was performed. SF-12 MCS, Short Form–12 mental component summary; SF-12 PCS, Short Form–12 physical component summary; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

21 studies of meniscal repair performed concurrently with ACL reconstruction.[24] A total of 1126 patients with a mean follow-up of almost 6 years were included in that study. The clinical failure rate for all-inside meniscal repair was 16%, compared with 10% for inside-out repair ($P = .016$). It has also been reported that patients who underwent repair had high function and high patient satisfaction at an average of 16 years after meniscal repair,[20] reinforcing the concept of long-term survivorship after meniscal repair.[19,20] The failure rate within this study was lower than may have been expected, considering the severity of injuries within the patient population. We believe that the relatively high number of sutures used for meniscal repair in the current study compared with other studies contributed to the low failure rate. It is also possible that limited postoperative weightbearing and a more elevated healing response due to the increased severity of the original injury contributed to the favorable outcomes reported herein. Further, because of the severity of the injury, a return to full activity or sporting competition may be delayed compared with isolated ligamentous repair or meniscal repair, and this prolonged limitation in returning to such activity may also be protective of the repair in this cohort of patients.

The biological component derived from intra-articular tunnel reaming has been reported to play a key role in the meniscal healing process by the stimulation of important growth factors such as insulin-like growth factor 1 (IGF-1),[7] which induces fibroblast proliferation and differentiation and collagen deposition[24]; platelet-derived growth factor (PDGF),[8,11] which is important in the initial phases for knee homeostasis restoration; and vascular endothelial growth factor (VEGF) and vascular endothelial growth factor receptor 2 (VEGF-R2), which promote angiogenesis. In addition, recent animal models have demonstrated improved meniscal healing with marrow stimulation procedures.[9,14]

In the present study, postoperative patient-reported outcomes were not significantly different between patients who underwent multiligament reconstruction without meniscal repair and patients who underwent multiligament reconstruction with meniscal repair. Previous studies have reported similar outcomes after multiligament knee reconstruction without concomitant meniscal repair (Tegner scores of 3-4 and Lysholm scores of 83-84).[1,6,7,14,17,23] These findings are supported in the current study by the significantly lower preoperative Lysholm score in the meniscal repair group and similar postoperative outcome scores to the control group. This highlights that although the meniscal repair group may have been more limited preoperatively, these patients can expect similar outcomes compared with patients who did not undergo concomitant meniscal repair with multiligament reconstruction. The medium- to long-term prevalence of knee osteoarthritis has been reported in the range of 23% to 87%; however, most of these studies had heterogeneous populations in regard to the ligaments involved, making any conclusions challenging.[1,6,7,14,17,23] Nonetheless, other multiligament reconstruction studies have reported findings comparable with those of the present study. Fanelli and Edson[8] reported 2- to 10-year follow-up on 35 arthroscopically repaired multiligament injuries, with a similar

ligament injury distribution to the present study. The authors reported significantly decreased side-to-side laxity differences as measured by the KT-1000 arthrometer and significantly improved Lysholm and Tegner scores at latest follow-up. In another study, Ibrahim et al[14] studied 20 patients retrospectively who underwent multiligament reconstruction. At a mean follow-up of 43 months, patients had significantly improved Lysholm scores (mean, 91) and Tegner scores (mean, 5.3).[14] Taken together, the findings of the above studies and the present study demonstrate the capability of multiligament reconstruction to restore patient function after surgery. Furthermore, the present study demonstrates that inside-out meniscal repair at the time of multiligament reconstruction does not detract from the positive outcomes after isolated multiligament reconstruction.

We acknowledge some limitations to the present study. Data were reviewed retrospectively; however, all data were collected prospectively. In addition, it is recognized that the use of multiple vertical mattress sutures requires an experienced team and may not be possible in all circumstances or centers. The use of a single technique performed by the same experienced surgeon diminishes the variables considerably, especially in a large cohort study; however, generalizability for practices with multiple surgeons may be diminished. Additionally, meniscal integrity assessments and failure definitions could not be completely precise because a retear might not be symptomatic and MRI has been reported to have a lower sensitivity for detecting retears after surgery. We encourage further studies to determine the long-term outcomes of meniscal repair performed concurrently with multiple ligament reconstruction.

CONCLUSION

Good to excellent patient-reported outcomes were reported for both groups with no significant differences in outcomes between the cohorts. Additionally, the failure rate for inside-out meniscal repair with concomitant multiligament reconstruction was low, regardless of meniscus laterality and tear characteristics. Several sutures and the biological augmentation resulting from intra-articular cruciate ligament reconstruction tunnel reaming may be partially responsible for the stability of the construct and thereby contribute to the overall improved outcomes and low failure rate of meniscal repair, despite lower preoperative Lysholm and Tegner scores in the meniscal repair group.

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