

# Knee Function Assessment in Patients With Meniscus Injury

## A Preliminary Study of Reproducibility, Response to Treatment, and Correlation With Patient-Reported Questionnaire Outcomes

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**Background:** Outcomes of meniscus surgery are typically assessed with patient questionnaires that help capture symptoms and functional limitations but may not provide an accurate representation of underlying joint health. There are currently no performance-based measures of knee function in patients with symptomatic meniscus injury.

**Purpose:** To assess the reproducibility, response to partial meniscectomy, and correlation with patient-reported questionnaire outcomes of novel performance-based knee function tests.

**Study Design:** Cohort study (diagnosis); Level of evidence, 2.

**Methods:** A battery of 9 tests for activities that require knee movements essential for everyday living was developed. Intra- and interrater reproducibility was assessed in 50 meniscus tear patients completing the battery at 2 preoperative assessments with either the same or different examiners. Response to arthroscopic partial meniscectomy was evaluated in 35 of these patients 6 weeks after surgery. Subjects also completed the Knee Injury and Osteoarthritis Outcome Score (KOOS) and International Knee Documentation Committee (IKDC) questionnaires pre- and postoperatively.

**Results:** The intrarater intraclass correlation coefficients (ICCs) were excellent for all tests (ICC > 0.8). Interrater ICC > 0.8 was observed for step-down, stair descent, star lunges, and timed treadmill travel. Performance on all tests improved significantly with surgery ( $P < .05$ ), with the greatest improvement in sit-to-stand and stair ascent and descent. A greater percentage response to surgery was seen on questionnaire outcomes (20%-65%) than on performance-based tests (3%-15%). Moderate to poor correlations existed between the KOOS activities of daily living subscale and the performance-based tests (all ICCs  $\leq 0.4$ ).

**Conclusion:** Performance-based knee function tests demonstrated good reproducibility and responsiveness in patients undergoing partial meniscectomy.

**Clinical Relevance:** As both patient perception and functional performance are determinants of patient outcomes, questionnaires and performance-based tests could be used simultaneously to provide complementary data to monitor short- and long-term outcomes after meniscus surgery.

**Keywords:** knee; meniscus; functional test; outcomes

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Approximately 850,000 arthroscopic meniscus surgeries are performed annually in the United States.<sup>15</sup> With growing literature support of nonoperative management of meniscus tears,<sup>11</sup> accurate assessment of knee function in patients with meniscus injury is important to guide treatment decisions and to monitor the natural history of

physical dysfunction and osteoarthritis associated with this injury.<sup>2,3,7</sup>

Outcomes of meniscus surgery are typically assessed with patient questionnaires.<sup>26</sup> Joint-specific questionnaires such as the Knee Injury and Osteoarthritis Outcome Score (KOOS) and International Knee Documentation Committee (IKDC) Subjective Knee Evaluation Form have been specifically validated for use in patients with meniscus injuries.<sup>10,17,18</sup> These instruments ask patients to self-report pain, symptoms, function, and quality of life, and

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they are typically coupled with global health questionnaires, such as the Short Form-12 (SF-12),<sup>22</sup> to assess overall physical or mental health.

While these questionnaires help capture symptoms and functional limitations that are important to the patient, they may not provide an accurate representation of underlying joint health or actual functional ability.<sup>9,24,25</sup> When questionnaires inquire about pain and difficulty with tasks, there is no standardization of how these tasks are performed. Many patients with symptomatic meniscus tears will alter their activities or movements to compensate for their injury. Other patients will avoid high-impact activities such as running or jumping altogether, making it difficult for them to reliably report symptoms related to these activities. Furthermore, questionnaires can be influenced by other psychosocial factors unrelated to the injured joint, including depression, fatigue, and cognition.<sup>8,9,16,25</sup> Therefore, questionnaires based on patient perception may not accurately reflect joint function and ability to perform everyday activities.

Performance-based measures allow for objective assessment of knee function and may provide data on patient outcomes distinct from patient subjective questionnaires.<sup>8,24,25</sup> There are no performance-based clinical tools that specifically measure knee function in patients with symptomatic meniscus injury. Prior studies have measured knee function in patients with a remote history of meniscus surgery.<sup>7,16,20</sup> These studies employed athletic tasks, including the single-leg hop for distance or single-leg rising, to look for early signs of knee dysfunction and osteoarthritis in patients several years after meniscus surgery. The high physical demand and impact of these exercises make them impractical for administration to patients with symptomatic meniscus injury or during postsurgical rehabilitation. Lower intensity performance-based knee function tests that can be feasibly administered preoperatively, and during postoperative rehabilitation, may provide additional longitudinal information about knee function that complements patient questionnaires.

We assembled a battery of 9 performance-based tests designed to evaluate knee movements essential to everyday living. This study investigates the preoperative reliability, response to surgical treatment, and correlation with patient-reported questionnaires of this performance-based battery in patients undergoing arthroscopic partial meniscectomy. To our knowledge, this was the first time performance-based testing has been studied in parallel with patient questionnaires to determine a functional response to meniscal surgery. We hypothesized that our performance-based battery of tests would be reproducible and would provide outcome data that are distinct from patient-reported questionnaires in patients undergoing arthroscopic partial meniscectomy.

## MATERIALS AND METHODS

Approval for this study was obtained from our institutional review board. To assess reproducibility and feasibility of the performance-based tests, we recruited 51 patients over a 1-year period (April 2009 to April 2010) who were diagnosed with a symptomatic meniscus injury and confirmed by routine knee magnetic resonance imaging from a single physician practice. Meniscus injuries were determined to be symptomatic if the patient had pain, swelling, or mechanical symptoms at initial presentation. Eligible patients were at least 18 years old, had knee pain or mechanical dysfunction, identified their affected knee as their primary functional limitation, and elected to undergo arthroscopic surgical treatment. Patients were ineligible if they had inflammatory arthropathy, ligamentous instability, or clinical varus/valgus malalignment.

To determine response to arthroscopic partial meniscectomy, additional eligibility criteria were imposed based on surgical findings. Eligible patients had confirmed arthroscopic evidence of meniscus injury and underwent arthroscopic partial meniscectomy. Patients undergoing meniscus repair were excluded. All patients were formally referred to physical therapy at our academic facility. Of the 51 patients undergoing surgery, 44 met criteria to repeat the tests postoperatively. Two of the excluded patients had meniscus repair, 2 had isolated articular cartilage injury without meniscus injury, and 3 developed additional injuries after surgery that limited function outside of the operative knee joint. Of the 44 eligible patients, 35 (80%) returned for postoperative assessment. Patients typically cited scheduling issues and logistic difficulties as the reason for not returning to clinic for follow-up at 6 weeks. All patients provided informed written consent for participation. This project was approved by our institutional review board.

### Knee Function Assessments

Nine performance-based tests were chosen through a review of the literature and the experience of the multidisciplinary research team, with their expertise in orthopaedic surgery, physical therapy, and epidemiology. The battery included active range of motion (ROM), passive ROM, sit-to-stand, stair ascent, stair descent, step-up, step-down, star lunges, and 6-minute timed treadmill travel. Tests were performed in order of increasing difficulty, beginning with basic ROM assessments and progressing to lunging, pivoting, and locomotion. To minimize the potential for ceiling effects, all tests were performed with no limit on maximal performance.

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**Figure 1.** Performance-based knee function assessments. (A) Active/passive range of motion; (B) sit-to-stand; (C) stair ascent; (D) stair descent; (E) step-up; (F) step-down; (G) star lunges; (H) 6-minute treadmill travel.

**Active and Passive Range of Motion.** ROM was assessed by international goniometer, as described by Lin et al.<sup>13</sup> With the patient supine, the observer centered the pivot point of the goniometer over the lateral femoral condyle, aligning the goniometer's stationary arm with the greater trochanter and the mobile arm with the lateral malleolus (Figure 1A). For active ROM, patients maximally extended and flexed their injured knee without assistance from the observer or use of the upper extremities. For passive ROM, the observer moved the patient's knee from full extension to full flexion. ROM was computed as the degrees of arc between full extension and full flexion.

**Sit-to-Stand.** The sit-to-stand test was adapted from the chair rise or knee bend tasks that are reproducible assessments of function in geriatric populations<sup>9,14</sup> and in patients with a remote history of meniscus surgery.<sup>3</sup> Patients sat on the edge of an adjustable bed with their feet shoulder-width apart on the floor and arms folded across their chest. The height of the bed was adjusted until the knees were bent to 110°. Patients then transitioned from sitting to standing and back to sitting continuously for 60 seconds (Figure 1B). The number of repetitions completed in 60 seconds was recorded.

**Single-Flight Stair Ascent and Descent.** This test required patients to ascend (Figure 1C) and descend (Figure 1D) a flight of 15 stairs (step height, 16.5 cm).<sup>14</sup> Patients

were instructed to avoid running, jumping, or using the side railing unless needed for safety. Time in seconds was recorded separately for ascending and descending.

**Step-up and Step-down.** Stepping tasks were assessed using a 15.2 cm-tall riser. For step-ups, patients began by facing the riser and stepping onto it with both feet. They then stepped backward down to the floor with both feet, stepping with the injured side first (Figure 1E). During step-downs, patients started with both feet on top of the riser, stepped down to the floor 1 foot at a time starting with the uninjured side first, and then stepped backward back onto the block with 1 foot at a time, returning to their starting position (Figure 1F). The injured leg is the lead leg in step-up, and the trailing leg in step-down, allowing for different loading conditions of the injured knee through these 2 tests. Both tests were performed continuously. The number of repetitions in 30 seconds was recorded.

**Star Lunges.** Forward lunges have been used to reliably assess performance in patients with anterior cruciate ligament injuries.<sup>1</sup> This test required our patients to lunge forward onto their injured leg. Lunging distance was based on the length of the injured leg measured from the greater trochanter to the floor, and distance was coded by colored tape on the floor. Patients were encouraged to achieve a 90° bend with their lead leg on every lunge. Patients lunged at alternating angles relative to their back foot (Figure 1G). Lunges

were performed in a sequence of 0°, 45°, 90°, 45°, and 0°. The number of lunges completed in 30 seconds was recorded.

**Six-Minute Treadmill Travel.** Patients were instructed to achieve the maximum distance possible on a treadmill in 6 minutes using any combination of walking, jogging, or running (Figure 1H).<sup>12</sup> Patients started at a 2-mph walking pace and then sped up or slowed down the treadmill to their desired pace. Distance traveled in meters after 6 minutes was recorded.

### Examiners

The study physical therapist trained 4 examiners to administer the test on healthy individuals. The examiners included research assistants, residents, and medical students without any expertise in physical therapy. The script and demonstrations were standardized to ensure that each patient received the same set of instructions.

### Reproducibility

Of the 51 patients in our original cohort, 50 completed the battery of tests on 2 separate occasions preoperatively, approximately 1 week apart (range, 3-12 days). Visit 1 was performed during the preoperative clinic appointment, and visit 2 was performed just prior to surgery check-in time. To assess inter- and intrarater reproducibility, patients were randomized so that 25 received the same examiner and 25 received different examiners at visits 1 and 2.

### Response to Treatment

Of the initial study population, 35 patients met eligibility criteria and volunteered to return for a postoperative assessment. Visit 3 was performed at approximately 6 weeks after surgery (range, 5-7.5 weeks), which coincides with when patients are released to full activity after partial meniscectomy in our clinical practice. Visits 1 and 3 were compared to assess response to treatment.

### Questionnaires and Subject Characteristics

Patients completed the KOOS, IKDC Subjective, and SF-12 questionnaires at the initial clinic visit and again at 6 weeks postoperatively. The KOOS and IKDC scores are reported on a normalized scale, with 100 indicating no symptoms. The SF-12 is reported on a similar 0 to 100 scale, where 100 indicates the highest quality of life. For the SF-12, physical component scores (PCs) and mental component scores (MCSs) are scaled to population norms to achieve a distribution with mean  $\pm$  SD of  $50 \pm 10$ .<sup>21</sup> Patient characteristics were collected from the initial clinic note. Location of meniscus injury, characteristics of meniscus tear, and International Cartilage Repair Society grade of concurrent articular cartilage injury were abstracted from the operative report.<sup>4</sup>

### Statistical Analyses

Characteristics at the preoperative visit of all patients and those who returned to visit 3 were summarized with means

and standard deviations for continuous variables and with proportions for categorical variables. Surgical findings are reported only for those who returned for visit 3. A multivariate regression analysis was used to evaluate for correlations between questionnaire outcomes and patient demographic or surgical data. Consistency between the repeated measures was examined with Pearson correlation coefficients. Intraclass correlation coefficients (ICCs) were calculated to determine reliability of measurements between visits 1 and 2.<sup>19</sup> Intrarater reliability for a randomly selected examiner for both visits was estimated with the equation ICC (2, 1). Interrater reliability for 2 different randomly selected judges at the visits was estimated by the equation ICC (1, 1).<sup>19</sup>

Differences between the mean performances during the preoperative and postoperative visits were compared using the paired Student *t* test. Since the performance-based battery was designed to simulate knee movements required for activities of daily living (ADL), we also estimated correlation coefficients between the KOOS ADL subscale and each performance-based test. The Spearman correlation was chosen to examine the relationship between (percentage change) KOOS ADL and physical performance test scores because the ADL could not be assumed to be normally distributed. All analyses were performed using SAS software version 9.2 (SAS Institute).

## RESULTS

The initial patient cohort had a mean age at examination of 45 years, body mass index (BMI) of 27.8 kg/m<sup>2</sup>, and a sex distribution of almost 2:1 males to females (Appendix). In our cohort, 62% reported a specific event that led to acute onset of knee symptoms. Among the 35 patients who subsequently returned for the postoperative visit, distributions of age and BMI were similar to the entire cohort. Medial meniscal tears were much more common than lateral, and the majority of meniscus tears involved less than 25% of the meniscus. Three patients had bucket-handle tear morphology that involved over 50% of the meniscus. Additionally, 46% of patients had grade III or IV concurrent articular cartilage injury. This rate of concurrent articular cartilage injury is similar to previously published data in meniscus tear patients.<sup>5,23,27</sup> Age, sex, BMI, concurrent articular cartilage injury, and size of meniscus tear did not significantly correlate with patient-reported questionnaire outcomes.

### Knee Function Assessments

All patients completed every test item at the 2 preoperative visits except 1, who declined to complete the visit 2 star lunges, and 1 patient who checked-in too late for surgery to complete visit 2. These patients were excluded from the reproducibility analysis. Most patients completed the test battery in 20 to 25 minutes per visit.

All tests demonstrated high intrarater ICC, especially in the higher demand tests (star lunges, step-down, and timed treadmill travel) (Table 1). Interrater ICCs ranged from 0.62 to 0.95. Timed treadmill travel, star lunges, and stair



TABLE 1  
 Reproducibility of Knee Function Test Measures  
 Among 50 Patients<sup>a</sup>

Knee Function Test	Intrarater ICC <sup>b</sup>	Interrater ICC <sup>c</sup>
Active ROM	0.94	0.71
Passive ROM	0.93	0.73
Sit-to-stand	0.91	0.62
Stair descent	0.83	0.90
Stair ascent	0.90	0.77
Step-ups	0.91	0.79
Step-downs	0.95	0.83
Star lunges	0.95	0.95
6-minute timed treadmill	0.95	0.93

<sup>a</sup>ICC, intraclass correlation coefficient; ROM, range of motion.

<sup>b</sup>Among 25 subjects assigned at random to be assessed by the same rater at visits 1 and 2.

<sup>c</sup>Among 25 subjects assigned at random to be assessed by different raters at visits 1 and 2.

descent had the highest interrater ICCs, while ROM assessments had the lowest interrater ICCs.

### Response to Treatment

Performance on all tests improved significantly in response to surgical treatment (Table 2). Percentage change in mean performance between preoperative and postoperative assessments is shown in Figure 2. Patients had the greatest improvement in the sit-to-stand task; on average, they had 2.6 more repetitions over the 60-second period, a 15% increase after surgery. Similarly, patients completed the single-flight stair descent and stair ascent tasks almost 1 second faster postoperatively, a 13% and 11% improvement, respectively. Step-down also improved by 11%, followed by star lunges (7%), timed treadmill (6%), and step-up (5%). Both active and passive ROM had the lowest response to surgery, increasing by 5° (or 4%) between pre- and postoperative assessments.

### Questionnaire Score Changes

Distributions of the questionnaire measures at the first preoperative visit were similar in the 51 patients initially enrolled and 35 who completed the postoperative visit (data not shown). Mean preoperative and postoperative questionnaire scores for the KOOS, IKDC, and SF-12 are displayed in Figure 3. Among the 5 KOOS subscales, sports and recreation and quality of life showed the greatest response to surgery, increasing by 48% and 65%, respectively. The KOOS ADL had the smallest improvement (22%). The IKDC improved by 53% from the preoperative score, the SF-12 PCS improved 20%, and the MCS did not significantly change.

### Correlation Between KOOS ADL and Knee Function Assessments

Correlations between the KOOS ADL and the performance-based battery were moderate to weak, with the Spearman

correlation coefficient ( $r$ ) ranging from near 0 to 0.41 (Table 3). Only the ROM tasks and single flight stair descent had statistically significant ( $P \leq .05$ ) correlations to the KOOS ADL subscale.

### DISCUSSION

This study demonstrated the reproducibility and response to treatment of a novel performance-based battery of tests for patients with meniscus injury. Patient performance improved significantly on all 9 tests after surgery, indicating that patient ability to perform activities of daily living improves at 6 weeks after arthroscopic partial meniscectomy.

All performance-based assessments demonstrated excellent intrarater reliability. The interrater ICCs were lower for most tests. Nevertheless, stair descent, step-down, star lunges, and timed treadmill tests had interrater ICCs >0.8. It should be noted that inter- and intrarater ICCs were estimated using different formulas, and the interrater ICC (1, 1) typically produces lower ICC values than does the intrarater ICC (2, 1) for the same data set.<sup>19</sup>

Among the tests in the performance-based battery, the greatest improvements in function tended to occur in tasks that applied a high load to a flexed knee joint, such as sit-to-stand, stair ascent, and stair descent. ROM tasks had the least improvement, as a ceiling effect is notable. Patients gained an average of 5° in ROM after surgery, which represented a relatively small change despite returning to complete joint motion. Tasks that required greater exertion and coordination, such as the treadmill travel and star lunges, only improved modestly after surgery. While patients have increased mechanical ability to load a flexed knee joint by 6 weeks after surgery, longer rehabilitation to improve strength and conditioning may be required for performing more athletic tasks.

To our knowledge, this is the first time a performance-based measure has been studied longitudinally across meniscus surgery. Comparable work by Bremander et al,<sup>3</sup> Roos et al,<sup>16</sup> and Thorlund et al<sup>20</sup> investigated performance-based knee function tests in patients with a remote history of meniscus surgery. They demonstrated that tests such as the single-leg hop for distance and knee bending (similar to sit-to-stand) could feasibly and reproducibly be administered to patients months to years after meniscus surgery.

Our goal was to make a performance-based measure to assess outcomes in both clinical and research settings for patients with symptomatic meniscus injury. Therefore, our battery had to be feasible for administration preoperatively in patients with symptomatic meniscus tears and postoperatively during early recovery. To achieve this, we focused our functional assessments on ADLs. We chose to not include more athletic tasks because these tasks exert high stresses on the injured knee that would be poorly tolerated by patients with symptomatic meniscus tears or during recovery after surgery. Feasibility of our battery was demonstrated by only 1 patient refusing to perform star lunges at 1 assessment and another missing an assessment due to scheduling. In addition, by assessing ADLs, our

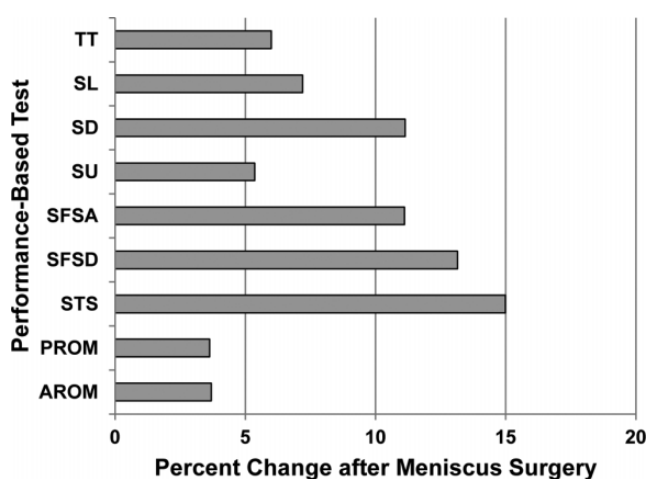
TABLE 2  
Change From Baseline in Performance-Based Test Scores at 6 Weeks After Surgery<sup>a</sup>

Test	Preoperative Cohort (n = 50)	Follow-up Cohort (n = 35)			P
		Before Surgery	After Surgery	Change <sup>b</sup>	
Active ROM, deg	134.7 ± 10.3	134.5 ± 10.7	139.5 ± 8.4	5.0 ± 9.1	<.01 <sup>c</sup>
Passive ROM, deg	144.0 ± 11.0	143.2 ± 10.3	148.4 ± 8.6	5.2 ± 7.2	<.01 <sup>c</sup>
Sit-to-stand, repetitions	17.5 ± 4.2	17.9 ± 3.9	20.6 ± 3.7	2.7 ± 3.5	<.01 <sup>c</sup>
Stair descent, s	7.3 ± 2.1	7.2 ± 2.3	6.2 ± 0.9	-0.9 ± 2.3	<.01 <sup>c</sup>
Stair ascent, s	8.0 ± 1.8	8.0 ± 1.9	7.1 ± 0.9	-0.9 ± 2.0	<.01 <sup>c</sup>
Step-ups, repetitions	10.8 ± 2.3	11.2 ± 2.2	11.8 ± 1.7	0.6 ± 2.1	<.01 <sup>c</sup>
Step-downs, repetitions	10.3 ± 1.9	10.5 ± 1.7	11.7 ± 1.3	1.2 ± 1.8	<.01 <sup>c</sup>
Star lunges, repetitions <sup>c</sup>	10.4 ± 2.1	10.8 ± 1.8	11.7 ± 1.3	0.9 ± 1.2	<.01 <sup>c</sup>
Timed treadmill, m	637 ± 263	682 ± 296	723 ± 273	41 ± 167	<.01 <sup>c</sup>

<sup>a</sup>All preoperative and postoperative performance values are expressed as mean ± SD. ROM, range of motion.

<sup>b</sup>The difference in mean performance between preoperative or postoperative assessment at 6 weeks.

<sup>c</sup>Statistically significant ( $P \leq .05$ ).



**Figure 2.** Percentage change in mean performance between preoperative and postoperative assessments. AROM, active range of motion; PROM, passive range of motion; SD, step-down; SFSA, single flight stair ascent; SFSD, single flight stair descent; SL, star lunges; STS, sit-to-stand; SU, step-up; TT, 6-minute treadmill travel.

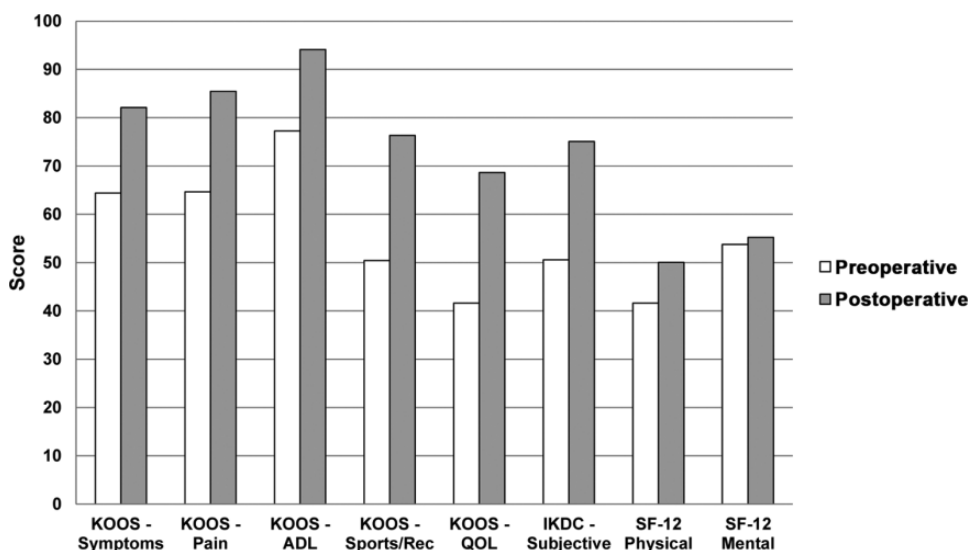
battery has the potential to be used for long-term follow-up in patients who may later develop knee dysfunction and osteoarthritis.

Overall, the knee-specific questionnaires demonstrated a higher response to treatment than the performance-based tests. The IKDC had a 53% improvement after treatment, much greater than the 3% to 15% improvements seen with the performance-based tests. Of the 5 KOOS subscales, sports and recreation and quality of life showed the largest change after arthroscopic meniscus surgery, with 48% and 65% improvements from the preoperative scores, respectively. The ADL subscale had the lowest improvement on the KOOS, with a 22% change from baseline. These questionnaire findings for the IKDC and KOOS are comparable with previously published data,<sup>6,17</sup> demonstrating that the IKDC, KOOS sports and recreation, and KOOS quality of life have

an excellent response to arthroscopic meniscus surgery. Activities of daily living tend to respond less to arthroscopic meniscus surgery than sports-related function for both the questionnaire and performance-based outcome measures. Additionally, reduced pain and symptoms with carrying out daily tasks may cause patients to perceive larger improvements in function than are actually assessed by the performance-based measures.

Since the performance-based battery was designed to measure knee movements essential to everyday living, we looked for correlations between each test in the battery and the KOOS ADL scores. The KOOS ADL asks patients to report their degree of difficulty with performing daily tasks that are specifically tested in our performance-based battery, such as “rising from sitting” and the sit-to-stand task or “walking on a flat surface” and the timed treadmill task. Despite these strong similarities, only modest to poor correlations were observed between the KOOS ADL and the performance-based tests. This finding supports our hypothesis that performance-based tests may provide distinct information about joint function that is not otherwise captured by patient questionnaires.

Our study had several limitations. First, our population was limited to patients from a single surgeon’s practice with unknown generalizability to other settings and patient populations. Only 80% of eligible patients returned for postoperative evaluation due to scheduling conflicts, which could bias the response to treatment results. The patients lost to follow-up did not differ significantly from the cohort with respect to demographics, surgical characteristics, or preoperative KFT assessments. To demonstrate reproducibility and feasibility of the novel performance-based battery, we intentionally included a heterogeneous meniscus tear population. Patient factors, including BMI, age, sex, concurrent cartilage injury, and size of meniscus tear, did not correlate with outcomes, but our study may be underpowered to detect these differences. We focused primarily on simple ADLs, which may not show as much change after meniscal surgery as the changes seen with high-intensity sports and recreation.<sup>16</sup> Thus, our battery may not have captured the functional change in high-



**Figure 3.** Mean pre- and postoperative questionnaire scores. ADL, activities of daily living; IKDC, International Knee Documentation Committee; KOOS, Knee Injury and Osteoarthritis Outcome Score; QOL, quality of life; SF-12, Short Form-12; Sport/Rec, sports and recreation.

**TABLE 3**  
Correlation Between KOOS ADL and Functional Tests After Surgery<sup>a</sup>

Test	Spearman Correlation	P
Active ROM	0.36	.04 <sup>b</sup>
Passive ROM	0.41	.02 <sup>b</sup>
Sit-to-stand	<0.01	.99
Stair descent	0.41	.02 <sup>b</sup>
Stair ascent	0.28	.12
Step-ups	0.32	.08
Step-downs	0.27	.14
Star lunges	0.01	.96
6-minute timed treadmill	0.10	.59

<sup>a</sup>ADL, activities of daily living; KOOS, Knee Injury and Osteoarthritis Outcome Score; ROM, range of motion.

<sup>b</sup>Statistically significant ( $P \leq .05$ ;  $n = 35$ ).

performance individuals. This study looked at short-term follow-up at 6 weeks. Further research is needed to examine the long-term results of our performance-based battery of tests in comparison with questionnaire data.

This initial study intentionally included activities that likely assess similar functions (eg, stair descent and step-down). We included these redundancies to investigate the reliability and responsiveness of each test. As each test demonstrated reliability and responsiveness, future research efforts can streamline the battery so that each test provides unique information about knee function.

Questionnaires and performance-based tests appeared to provide distinct and complementary information about patient outcomes. Joint-specific questionnaires generally use a patient-centric approach to identify patient relevant symptoms and functional limitations. In our study,

these questionnaires appeared to exhibit a greater response to partial meniscectomy than the performance-based battery. However, the poor correlation between questionnaire data and performance-based assessments suggests that patient perception may be distinct from actual joint function. As both patient perception and functional performance are determinants of patient outcomes, questionnaires and performance-based tests could be used simultaneously to provide complementary data to monitor short- and long-term outcomes after meniscus surgery.

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## APPENDIX

### Patient Demographics and Surgical Characteristics<sup>a</sup>

Characteristic	Preoperative Cohort (n = 50)	Follow-up Cohort (n = 35)
Age, y, mean ± SD	45 ± 13	44 ± 13
BMI, kg/m <sup>2</sup> , mean ± SD	27.8 ± 5.3	27.2 ± 4.8
Sex		
Male	32 (64)	25 (73)
Female	18 (36)	10 (27)
Tear location		
Medial		31 (88)
Lateral		2 (6)
Both menisci		2 (6)
Tear size		
0%-10%		5 (14)
11%-25%		18 (51)
26%-50%		9 (26)
>50%		3 (9)
Articular cartilage injury		
ICRS grade ≤II		19 (54)
ICRS grade ≥III		16 (46)

<sup>a</sup>Values are reported as n (%) unless otherwise indicated. Age, BMI, and sex were based on initial clinic note. Tear location, tear size, and articular cartilage injury were based on the surgical findings for the follow-up cohort. BMI, body mass index; ICRS, International Cartilage Repair Society.