

Knee Range of Motion as a Discriminatory Tool Indicating Potential Meniscal Tears

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Background: Primary care physicians often encounter patients with knee pain and are faced with the dilemma of whether to refer patients to a specialist. Meniscal tears are the most common intraarticular knee injury but are challenging to accurately diagnose because of a lack of quantitative, accurate, and easy-to-administer tests. We conducted a retrospective medical record review to evaluate whether measurement of knee range of motion (ROM) via goniometry could discriminate between healthy and meniscus-altered knees.

Methods: A total of 110 adult patients met the inclusion criteria: age ≥ 18 years; no history of contralateral knee pain, injury, or surgery; ROM data collected using a goniometer on both knees at the time of diagnosis; and a confirmed diagnosis of meniscus tear via magnetic resonance imaging. The following variables were obtained from medical records: age, sex, body mass index (BMI), ROM for both knees, surgical treatment, insurance coverage, Ahlbäck x-ray grades, Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), and the Oxford Knee Score (OKS).

Results: The majority of patients (96.4%) exhibited a $\geq 10^\circ$ difference in flexion between asymptomatic and symptomatic knees. No significant relationships were observed between age, BMI, and the decision to undergo surgery and the difference in flexion or extension ROM. Both the WOMAC and the OKS were significantly correlated with the degree of loss of flexion ROM.

Conclusion: The results suggest that knee flexion ROM may be a valuable tool for determining which patients presenting with new-onset ipsilateral knee pain should be referred to a specialist. Further investigation to determine the reliability and accuracy of knee ROM as a screening measure is warranted.

Keywords: Arthrometry–articular, diagnosis, range of motion–articular, referral and consultation, tibial meniscus injuries

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INTRODUCTION

Meniscal tears are the most common intraarticular lesions of the knee.¹ Arthroscopic partial meniscectomy is frequently used to surgically repair damaged areas to relieve pain and mechanical symptoms. National Survey of Ambulatory Surgery data show that the rate of knee arthroscopy in the United States increased by 49% from 1996-2006.² Young athletes tend to experience traumatic tears during sports, while the middle-aged and elderly tend to experience a slow process of meniscal tissue degeneration. Among males aged 70-90 years, the prevalence of meniscal tears is $>50\%$, while in females aged 50-59 years, the prevalence is 16% .³

The orthopedic patient population is expected to increase by 20%-45% by 2020, while the number of orthopedic surgeons is expected to increase by only 2%, creating a shortage of surgeons qualified to treat this growing population.⁴ The increase in demand for surgery and the shortage of or-

thopedic specialists require the development of easily administered screening tools to increase efficiency in the management of patients with operable meniscus pathology. Currently, no standard criteria exist for referring primary care patients who are experiencing intraarticular knee pain to specialists.⁵⁻⁷ Consequently, orthopedic surgeons are largely responsible for determining whether patients have operable vs manageable knee pain, reducing the time they have available for surgery.

In the clinic setting, the diagnosis of a torn meniscus requires the assessment of a constellation of clinical signs using physical examination maneuvers and magnetic resonance imaging (MRI). However, research indicates that clinical signs have a variable predictive value in diagnosing meniscus tears,^{5,8-11} and the use of clinical maneuvers vs MRI is controversial.^{3,5,9,11,12} Simple assessments (eg, measurement of knee flexion) that can be reliably performed

may help primary care physicians (PCPs) determine whether to refer patients with suspected meniscus tears.^{5,13} Comparing the ROM measurements of the affected and healthy knees could serve as a simple, easy-to-perform, quantitative screening to help PCPs manage patients with a suspected meniscus tear.

We designed this study to address 4 questions: (1) Does ROM differ between the affected and healthy knees in patients with diagnosed meniscus tears? (2) Does the difference in ROM between the affected and healthy knees change depending on patient characteristics? (3) Do patients who choose to undergo knee surgery exhibit any significant difference in ROM between the affected and healthy knees? (4) Can we identify a flexion and/or extension value that best differentiates between the affected and healthy knees?

METHODS

The Louisiana State University Health Sciences Center (LSUHSC) Institutional Review Board approved this retrospective study. To identify eligible patients, we queried the LSUHSC healthcare network database for encounters with a diagnosis of meniscus tear (ICD-9 codes 717.2, 717.3, 717.4, 717.42, 717.49, and 836.1) between May 2007 and August 2013. Inclusion criteria were age ≥ 18 years; MRI-confirmed diagnosis of ipsilateral meniscus tear; no recorded history of contralateral knee pain, injury, or surgery; and ROM data for both knees collected at the time of diagnosis.

A total of 1,960 encounters had a meniscus tear diagnosis in the specified time frame, of which 1,377 encounters were associated with a provider who recorded preoperative ROM measurements. From these encounters, we identified 685 unique events. Five events were excluded because of patient age < 18 years, resulting in 680 eligible events. A total of 251 unique events had an associated MRI. A total of 110 unique patients met the remaining inclusion criteria of MRI-confirmed diagnosis of ipsilateral meniscus tear; no recorded history of contralateral knee pain, injury, or surgery; and ROM data for both knees collected at the time of diagnosis.

A goniometer was used to determine ROM while patients were actively flexing and extending both of their knees. Flexion and extension measurements were performed as described by Brosseau et al.¹⁴ The following variables were obtained from patients' medical records: age, sex, body mass index (BMI), election to have surgery, insurance coverage, Ahlbäck x-ray grades, Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), and the Oxford Knee Score (OKS).

The Ahlbäck classification scale has 6 grades: grade 0 (no radiographic sign of arthritis), grade 1 (joint space narrowing < 3 mm), grade 2 (joint space obliteration), grade 3 (minor bone attrition 0-5 mm), grade 4 (moderate bone attrition > 5 -10 mm), and grade 5 (severe bone attrition > 10 mm). The WOMAC is a 24-item patient-reported outcome questionnaire used to assess pain, stiffness, and physical function in patients with hip and/or knee osteoarthritis on a 5-point Likert scale. A higher WOMAC score indicates worsening pain, stiffness, and functional limitations.¹⁵ The OKS was originally designed for inpatient use to assess the patient's perspective of outcomes following total knee arthroplasty, but its use has been validated as a reliable measurement for outpatients with osteoarthritis.¹⁶ The OKS is a 12-item survey that assesses knee pain and physical disabi-

lity with a 5-point Likert scale. A higher OKS indicates worse knee pain and function.

Data were analyzed using SAS/STAT software v.9.2 (SAS Institute, Inc.). Differences in flexion (DF) and extension (DE) between symptomatic and asymptomatic knees were calculated for each patient as the degrees for the symptomatic knee minus the degrees for the asymptomatic knee. We used the Wilcoxon signed rank test to determine whether median DF and DE values were significantly different from 0; the Wilcoxon Mann-Whitney test to compare median DF and DE scores of patients who elected to have surgery and patients who decided not to undergo surgery; and the Spearman rank correlation coefficient to examine the relationships between DF/DE and patient age, BMI, WOMAC score, and OKS. To determine ROM levels that best differentiated between the symptomatic and asymptomatic knee, we constructed binary variables for flexion and extension using various cutoff values. A receiver operating characteristic analysis was conducted using the logistic procedure, and the optimum cutoff values for flexion and extension were chosen so that they produced the greatest area under the curve (AUC) calculated using the trapezoidal rule. Sensitivity, specificity, positive predictive value, negative predictive value, accuracy, likelihood ratios for positive and negative test estimates, and 95% confidence intervals (CIs) were obtained using the frequency and GENMOD procedures. We considered 2-tailed *P* values < 0.05 statistically significant.

RESULTS

Table 1 presents the characteristics of the study sample. The sample was predominantly female (68.2%), had a mean age of 54.5 years (range, 23-79 years), and had a mean BMI of 33.6 kg/m² (range, 21.2-58.7 kg/m²). At the time of diagnosis, all patients were evaluated with weight-bearing anteroposterior analog printed knee x-rays; however, by the time of classification, we were unable to locate the printed x-rays for 9 patients. X-rays were available for 101 of the 110 patients, so those 101 patients could be diagnosed with no to mild osteoarthritis using the Ahlbäck x-ray classification system. Most patients (63.6%) opted to undergo surgical treatment for their torn meniscus.

Flexion and extension measurements are reported in Table 2. Flexion of the asymptomatic knees ranged from 95°-140°, with a median of 125°. In contrast, flexion of the symptomatic knees was considerably lower, ranging from 45°-130°, with a median of 105°. The distribution of flexion measurements for symptomatic and asymptomatic knees is displayed in the Figure, A. The median DF of -20° (range, -50° - 0°), calculated as the differences in degrees of the symptomatic knees minus the asymptomatic knees, was significantly different from zero ($P < 0.0001$). Most patients ($n = 106$; 96.4%) exhibited a reduction $\geq 10^\circ$ in flexion between asymptomatic and symptomatic knees, and 88 patients (80%) exhibited a reduction $\geq 15^\circ$ in flexion between the asymptomatic and symptomatic knees (Figure, B).

Extension ranged from -5° - 10° , with a median of 0° for the asymptomatic knee and from -5° - 30° for the symptomatic knee, with a median of 5° . The distribution of extension measurements for symptomatic and asymptomatic knees is displayed in the Figure, C. The median DE of 5° (range, -10° - 30°), calculated as the differences in degrees of the symptomatic knee minus the asymptomatic knees, was

Table 1. Study Participant Characteristics

Variable	Value n = 110
Age, years, mean ± SD (range)	54.5 ± 12.4 (23-79)
BMI, kg/m ² , mean ± SD (range)	33.6 ± 7.2 (21.2-58.7)
Sex	
Female	75 (68.2)
Male	35 (31.8)
Ahlbäck classification ^a	
0	73 (72.3)
1	27 (26.7)
2	1 (1.0)
Surgery	
Yes	70 (63.6)
No	40 (36.4)
Insurance type	
Private	41 (37.3)
Medicaid	32 (29.1)
Medicare	37 (33.6)

^aThe Ahlbäck classification scale has 6 grades: grade 0 (no radiographic sign of arthritis), grade 1 (joint space narrowing <3 mm), grade 2 (joint space obliteration), grade 3 (minor bone attrition 0–5 mm), grade 4 (moderate bone attrition >5–10 mm), and grade 5 (severe bone attrition >10 mm). The printed x-rays of 9 patients could not be located at the time of classification.
Note: Data are presented as n (%) unless otherwise specified.

significantly different from zero ($P < 0.0001$). Sixty-five patients (59.1%) exhibited a DE $\geq 5^\circ$, 41 patients (37.3%) had a 0° difference, and 4 patients (3.6%) had a negative difference in the symptomatic knee (Figure, D).

Table 3 reports the difference in degrees of flexion and extension in patients who chose to undergo surgery vs patients who did not have surgery. We found no significant difference in DF ($P = 0.549$) or DE ($P = 0.413$) between the 2 groups.

Table 4 reports the relationships between patient age, BMI, WOMAC score, and OKS and the DF and DE between the symptomatic and asymptomatic knees. We found no significant relationship between age or BMI and DF or DE. Both the WOMAC score ($r = 0.363$, $P = 0.0002$) and the OKS ($r = 0.339$, $P = 0.0004$) were significantly positively correlated with DF, indicating more impaired function and greater pain in patients with a larger DF between their asymptomatic and symptomatic knees. The OKS, but not the WOMAC score, was significantly positively correlated with DE. The statistically significant correlations between WOMAC or OKS scores and DF or DE were maintained after adjusting for sex, age, and BMI.

As stated in the Methods section, the optimal cutoff values for flexion and extension were selected so that the optimum combination of sensitivity and specificity was attained, as well as the highest likelihood ratio. The optimum levels of flexion and extension that provide the best discrimination points between symptomatic and asymptomatic knees were 120° for flexion (AUC = 81.8%) and 5° for extension (AUC = 77.5%).

Diagnostic parameters calculated for the chosen cutoff points are reported in Table 5. Using a cutoff value of 120°

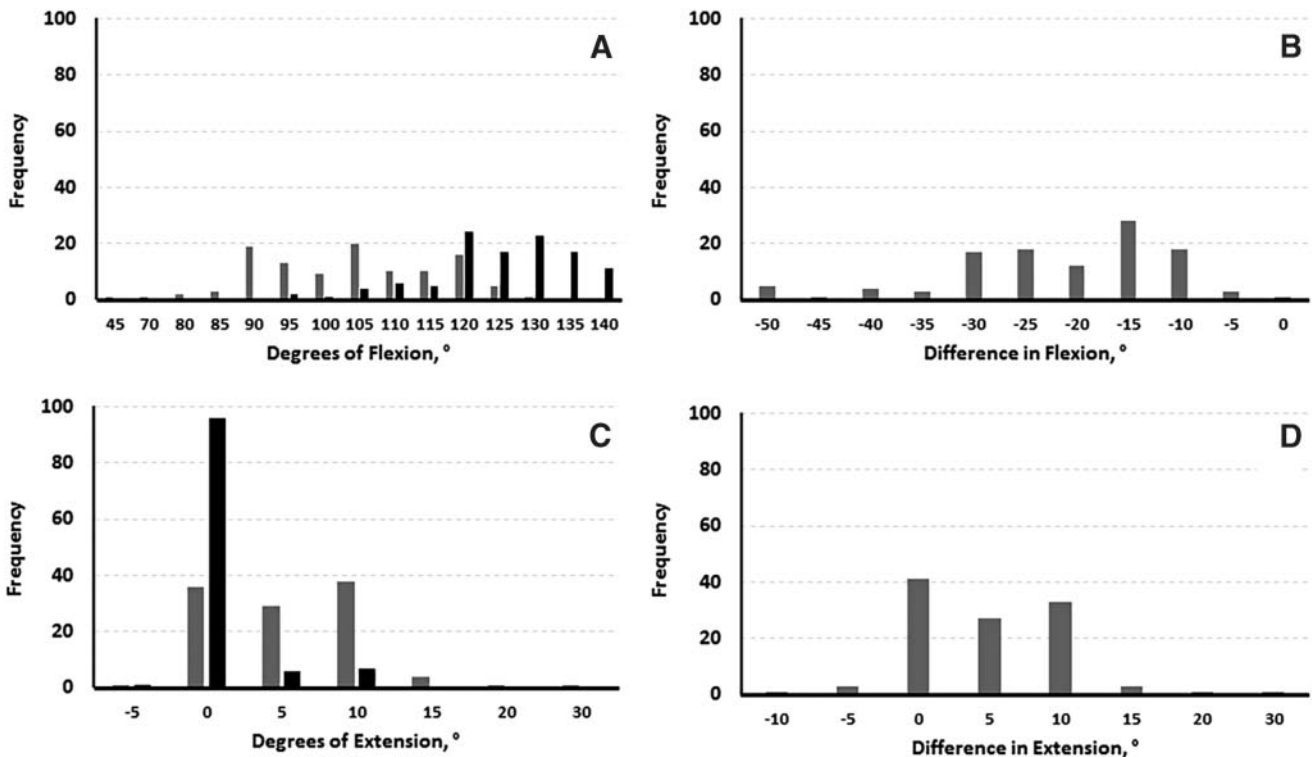


Figure. Distribution of bilateral knee flexion (A) for symptomatic (light grey) and asymptomatic (black) knees and their difference (B) and distribution of bilateral knee extension (C) for symptomatic (light grey) and asymptomatic (black) knees and their difference (D). The symptomatic ranges for degrees of flexion and extension range from 45° – 130° and from -5° – 30° , respectively. Frequencies at the tails of the symptomatic range are low and may be difficult to discern from the graph.

Table 2. Median Flexion and Extension Differences in Symptomatic and Asymptomatic Knees in Patients With Ipsilateral Meniscus Tears (n = 110)

Variable	Median	Range	P Value
Flexion			
Symptomatic	105°	45° to 130°	
Asymptomatic	125°	95° to 140°	
Difference ^a	-20°	-50° to 0°	<0.0001 ^b
Extension			
Symptomatic	5°	-5° to 30°	
Asymptomatic	0°	-5° to 10°	
Difference ^a	5°	-10° to 30°	<0.0001 ^b

^aDifferences in flexion and extension were calculated for each patient as the degrees for the symptomatic knee minus the degrees for the asymptomatic knee.

^bSignificantly different from 0.

for flexion resulted in an 80% sensitivity and an 83.6% specificity, with predictive values and accuracy slightly above 80%. Alternatively, the optimum extension cutoff value of 5° resulted in very low sensitivity (33.0%), specificity (11.9%), accuracy (22.5%), and predictive values.

DISCUSSION

Historically, methods for evaluating suspected meniscus tears, which are largely qualitative in nature, have shown variable sensitivity and specificity.^{9,11,13} Consequently, no widely accepted standard or uniform guideline exists to support decision-making regarding whether to refer patients with suspected meniscus tears to specialists. We found significant differences in DF and DE between asymptomatic and symptomatic knees in a cohort of patients with a confirmed diagnosis of meniscus tear, with the largest differences evident with flexion ROM; 96.4% of patients exhibited a ≥10° difference in flexion ROM. These results suggest that knee ROM, in combination with clinical maneuvers, could serve as a simple, low-cost, quantitative test to help determine whether PCPs should refer patients with a suspected meniscus tear for evaluation by an orthopedic surgeon.

The superiority of surgical vs conservative management of meniscus tears remains unclear. A longitudinal cohort study found that patients who received conservative, nonoperative management of medial meniscus tears experienced symptomatic and functional improvement during a 12-month follow-up period.¹⁷ Conversely, other studies have found no significant differences in outcomes after 3 years in patients with meniscus tears treated conservatively vs patients who underwent surgery.^{10,12} In our study, although patient-reported function and pain were positively correlated with reduced flexion and extension ROM, suggesting that loss of

Table 4. Spearman Rank Correlation Between Differences in Flexion and Extension and Age, Body Mass Index (BMI), and Patient-Reported Outcomes

Variable	Flexion Difference			Extension Difference		
	n	Rho ^a	P Value	n	Rho ^a	P Value
Age, years	110	0.082	0.393	110	-0.042	0.662
BMI, kg/m ²	110	0.026	0.786	110	0.020	0.835
WOMAC score	98	0.363	0.0002	98	-0.187	0.065
Oxford Knee Score	105	0.339	0.0004	105	-0.235	0.016
WOMAC score ^b	98	0.345	0.0006	98	-0.218	0.034
Oxford Knee Score ^b	105	0.385	0.0001	105	-0.276	0.007

^aSpearman rank correlation coefficient.

^bSpearman rank correlation adjusted for sex, age, and BMI.

WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

ROM is associated with greater functional limitations, we found no apparent relationship between ROM and patients' decision to undergo surgical meniscus repair, suggesting that this decision is influenced by other factors.

This study had several limitations. First, although arthroscopy is the gold standard for diagnosing a meniscus tear,^{8,13} the present study used MRI to confirm a diagnosis of meniscus tear, as arthroscopy would have confounded our ability to examine the relationship between ROM and patients' decisions to undergo surgical repair. Second, our findings may have limited generalizability to the broader population, as the study sample was limited to patients who had a contralateral knee free from injury, pain, and surgery. In addition, only a small portion of eligible patients had ROM measured in both knees. Last, although some evidence suggests that race may be significantly related to knee ROM,¹⁸ this analysis did not examine the relationship between race and knee ROM because of the small sample size available retrospectively.

CONCLUSION

Because the number of patients requiring evaluation for meniscus tears is expected to increase dramatically and the current methods for diagnosing meniscus tears have limitations, a simple and accurate screening tool to help generalist physicians determine whether to refer patients with suspected meniscus tears to a specialist is needed. Our results indicate that measurement of knee ROM with a goniometer could be an easily implemented, noninvasive, and inexpensive means of assessing patients presenting with new onset ipsilateral knee pain with a suspicion of significant intraarticular pathology. Further research is needed to determine optimal thresholds for loss of ROM that warrant referral and to determine the sensitivity and specificity of knee ROM as a screening tool for diagnosing meniscus tears.

Table 3. Flexion and Extension Difference in Patients Who Had Surgery vs Patients Who Did Not (n = 110)

Variable	Surgery Group	No-Surgery Group	P Value
Flexion difference	-20° (-50° to 0°)	-15° (-50° to -10°)	0.549
Extension difference	5° (-5° to 30°)	5° (-10° to 20°)	0.413

Note: Data are reported as median (range).

Table 5. Diagnostic Parameters for Using Flexion or Extension to Identify a Meniscus Tear

Item	Flexion ^a		Extension ^b	
	Estimate	95% CI	Estimate	95% CI
Sensitivity, %	80.0	72.5-87.5	33.0	24.2-41.9
Specificity, %	83.6	76.7-90.6	11.9	5.8-18.0
Positive predictive value, %	83.0	75.9-90.2	27.3	19.7-34.9
Negative predictive value, %	80.7	73.5-88.0	15.1	7.6-22.7
Diagnostic accuracy, %	81.8	76.7-86.9	22.5	16.9-28.0
Likelihood ratio of positive test	4.9	2.6-7.1	0.38	0.27-0.49
Likelihood ratio of negative test	0.24	0.14-0.34	5.6	2.5-8.8

CI, confidence interval.

^aFlexion cutoff for meniscus tear diagnosis was 120°.

^bExtension cutoff for meniscus tear diagnosis was 5°.

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