Evaluation of Acute Knee Pain in Primary Care

Jeffrey L. Jackson, MD, MPH; Patrick G. O'Malley, MD, MPH; and Kurt Kroenke, MD

Background: **The evaluation of acute knee pain often includes radiography of the knee.**

Objective: **To synthesize the literature to determine the role of radiologic procedures in evaluating common causes of acute knee pain: fractures, meniscal or ligamentous injuries, osteoarthritis, and pseudogout.**

Data Sources: **MEDLINE search from 1966 to October 2002.**

Study Selection: **We included all published, peer-reviewed studies of decision rules for fractures. We included studies that used arthroscopy as the gold standard for measuring the accuracy of the physical examination and magnetic resonance imaging (MRI) for meniscal and ligamentous knee damage. We included all studies on the use of radiographs in pseudogout.**

Data Extraction: **We extracted all data in duplicate and abstracted physical examination and MRI results into 2 × 2 tables.**

Data Synthesis: **Among the 5 decision rules for deciding when to use plain films in knee fractures, the Ottawa knee rules (injury due to trauma and age >55 years, tenderness at the head of the fibula or the patella, inability to bear weight for 4 steps, or inability to flex the knee to 90 degrees) have the strongest supporting evidence. When the history suggests a potential meniscal or ligamentous injury, the physical examination is moderately sensitive (meniscus, 87%; anterior cruciate ligament, 74%; and posterior cruciate ligament, 81%) and specific (meniscus, 92%; anterior cruciate ligamen, 95%; and posterior cruciate ligament, 95%). The Lachman test is more sensitive and specific for ligamentous tears than is the drawer sign. For meniscal tears, joint line tenderness is sensitive (75%) but not specific (27%), while the McMurray test is specific (97%) but not sensitive (52%). Compared with the physical examination, MRI is more sensitive for ligamentous and meniscal damage but less specific. When the differential diagnosis for acute knee pain includes an exacerbation of osteoarthritis, clinical features (age >50 years, morning stiffness <30 minutes, crepitus, or bony enlargement) are 89% sensitive and 88% specific for underlying chronic arthritis. Adding plain films improves sensitivity slightly but not specificity. Plain films for pseudogout are not sensitive or specific, according to limited-quality studies.**

Conclusions: **We recommend the Ottawa knee rules to decide when to obtain plain films for suspected knee fracture. A careful physical examination should be sufficient to decide whether to refer patients with potential meniscal and ligament injuries, and we prefer clinical criteria rather than plain films for evaluating osteoarthritis. We do not recommend using plain films to diagnose pseudogout.**

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For author affiliations, see end of text.

Knee pain is present in up to 20% of the adult general population (1, 2) and is associated with clinically significant disability (1–5). Acute knee pain, a common subset of all knee pain, accounts for more than 1 million emergency department (6) and 1.9 million primary care outpatient (7) visits annually. Six percent of patients presenting to an adult primary care clinic with a physical symptom have knee pain; 17% of them have experienced knee pain for less than 3 days and 46% for less than 1 month (8).

Plain radiographs of the knee are among the most commonly ordered radiographs in U.S. emergency departments (7, 9); 60% to 80% of patients with knee pain have a knee film (6, 10) at an estimated annual cost of $1 billion (6). Radiographs of the knee show fractures in only 6% to 11% of cases of acute knee pain for which plain films are obtained in the emergency department (11–13). Radiographic imaging is common in other ambulatory settings as well. In 1996, 25% to 34% of outpatients with knee pain had radiographic imaging, 0.5% had magnetic resonance imaging (MRI), and 1% had ultrasonography (7).

Many clinicians have difficulty with evaluating acute knee pain and are uncertain when to order imaging tests. Delayed diagnosis of fracture can result in poor clinical outcomes (14). In 1995, malpractice awards for failure to diagnose fractures, including those not involving the knee, averaged $55 600, making an evidence-based approach to managing patients with potential fractures paramount (15). Internal derangement of the knee, such as meniscal or ligamentous tears, also raises diagnostic dilemmas. Should the clinician refer patients to an orthopedic surgeon on the basis of the physical examination alone or perform MRI of the knee first? Are plain films necessary if the clinical diagnosis suggests osteoarthritis? Do other potential acute knee pain diagnoses, such as pseudogout, warrant knee films?

We systematically reviewed the literature on the accuracy of the history, physical examination, and imaging tests of the knee to determine when the history and physical examination are sufficient for managing patients with acute knee pain and when clinicians should perform imaging procedures.

Methods

Definitions

Differentiating "acute" from "chronic" knee pain in clinical settings can be difficult because patients frequently present with acute exacerbations of a chronic problem. We define acute knee pain as that beginning less than 1 week before the patient seeks medical attention.

Table 1. **Ottawa Decision Rule for Radiography in Acute Knee Injuries***

Criteria†	Sensitivity	Specificity	Positive Likelihood Ratio	Negative Likelihood Ratio
Age ≥55 y; tenderness at head of fibula; isolated tenderness of patella‡; inability to flex knee to 90 degrees; or inability to bear weight both immediately and in the emergency department (4 steps)§	1.0 (0.94–1.0)	0.49 (0.46–0.52)	1.96 (1.92–1.99)	0.11 (0.06–0.18)

* Values in parentheses are 95% CIs.
† A knee radiograph examination is required only for patients with acute knee injury who meet 1 or more criteria related to age, tenderness, or function.
‡ No bone tenderness of knee other than patella.
§ Patient cannot transfer weight twice onto each lower limb, regardless of limping.

Literature Search

For each clinical question, we searched MEDLINE from 1966 through October 2002. Details of the search strategies appear in **Appendix 1** (available at www.annals.org). Our specific questions were 1) How useful are clinical decision rules to manage suspected knee fracture? 2) How sensitive and specific is the physical examination in evaluating possible cartilage and ligament injuries? 3) How sensitive and specific is MRI of the knee for cartilage and ligament damage? 4) What is the utility of plain films for diagnosing osteoarthritis in patients with acute pain? and 5) What is the utility of plain films in diagnosing pseudogout?

We reviewed the titles of all articles identified by the search strategy, read the abstracts of all articles with titles that seemed to be potentially pertinent, and searched the bibliographies of each retrieved article for other articles. Two internists abstracted all data, and when differences occurred, they reached consensus. Whenever possible, we abstracted the data necessary to calculate the sensitivity and specificity of physical findings and test results. A few studies reported test sensitivity and specificity but provided inadequate information on how many patients were included to abstract the data into 2 × 2 tables. In these cases, we recorded the test's reported sensitivity and specificity. Additional abstracted data included year and country of study and the number of patients. We calculated sensitivity and specificity and constructed fitted receiver-operating characteristic (ROC) curves for each study (16). In **Appendix 2** (available at www.annals.org), we discuss how the ROC curves were used to estimate summary values for sensitivity and specificity and why we chose this method rather than using other meta-analytic methods. We took the summary test sensitivity from the point on the fitted ROC curve corresponding to the median specificity from the observed data (16). We calculated confidence intervals for sensitivity and specificity from the fitted ROC curves at the median specificity based on the standard deviation of the fitted line derived from the ROC curves (16). We measured study quality for each included study by using tools adapted from the McMaster method for critically appraising diagnostic test articles (17, 18). We analyzed subgroups comprising studies with similar quality scores; the results were the same for high- and low-quality studies. Estimates for the prevalence of each diagnosis among patients presenting with acute knee pain to either primary care or orthopedic clinics were based on analysis of data from the National Ambulatory Medical Care Survey (19). The survey is a weighted, geographically stratified sampling of outpatient visits from across the United States. Each data point in the set is weighted to provide a nationally representative sample. For our analysis, primary care clinicians were internists, family practitioners, and general practitioners. We performed all analyses by using Stata software, version 7.0 (Stata Corp., College Station, Texas).

Data Synthesis

Prevalence of Diagnoses in Various Clinical Settings

Knowing the prevalence of a diagnosis among all patients with a primary symptom is the first step to estimating its post-test probability. In 1999, patients made 3.7 million visits to a primary care physician for knee pain. The most common diagnoses among patients presenting with acute knee pain in the adult primary care setting are osteoarthritis (estimated prevalence, 34%), meniscal injuries (9%), collateral (7%) and cruciate (4%) ligamentous injuries, gout (2%), and fracture (1.2%). Less common diagnoses include rheumatoid arthritis (0.5%), infectious arthritis (0.3%), and pseudogout (0.2%) (7). Other causes, such as sprains and strains, account for 42% of all cases. We use these frequencies as the pretest probability from which we calculate post-test probabilities for the physical examination and imaging tests throughout the paper. An effusion was present in the primary care setting in 2.4% of patients with knee pain.

Some diagnoses were more common in settings other than primary care. For example, orthopedic surgeons classified 24% of patients with acute knee pain as having osteoarthritis, 11% as having meniscal tears, 7% as having collateral ligament tears, 7% as having fractures, and 4% as having anterior cruciate ligament tears. In the emergency department, 92% of patients presenting with an acute knee injury had plain films taken, and 6% to 11% had a fracture.

What Should I Do When I Need To Rule Out Knee Fracture?

Our MEDLINE search uncovered 7 studies of clinical prediction rules for deciding when to order a plain film of the knee to rule out a fracture (11–13, 20–23). We excluded 2 studies reported only in abstract form (12, 24) and assessed the quality of the remaining 5 studies by using the method of Wasson and colleagues (25).

Studies

These 5 articles reported on studies of 4 decision rules: the Pittsburgh knee rules (11), Weber and colleagues' rule (22), the Ottawa knee rules (13), and Fagan and Davies' rule (19). **Appendix Tables 1** and **2** (available at www.annals.org) show the characteristics of each rule and the study quality ratings, respectively. The Ottawa rules have had the most thorough validation, and we recommend them (**Table 1**).

The Ottawa knee rules resulted from a prospective study of 1047 patients with knee pain for less than 7 days presenting to 1 of 2 Canadian teaching hospitals' emergency departments. All patients had a standardized history, physical examination, and knee radiography; 68 patients had knee fractures. These decision rules had a sensitivity of 100% and a specificity of 54%. Stiell and colleagues (23) tested the Ottawa rules in a prospective cohort of 1096 patients with acute knee pain presenting to 2 Canadian emergency departments. The rules had a sensitivity of 100% and a specificity of 49%. The rules did not miss any fractures. Physician interobserver agreement for interpreting the rules was excellent ($\kappa = 0.77$). Physicians reported feeling uncomfortable about relying on the rules to decide to order a knee radiograph in only 5% of cases. This rule has been validated in 6 additional studies. The sensitivities ranged from 85% to 100% and the specificities ranged from 17% to 25% (26–31). In most studies, using the Ottawa rules would have reduced the use of plain knee radiographs by about 25%.

Recommended Strategy

The Ottawa decision rules have received the most rigorous evaluation to date, and we recommend them for deciding when to obtain a plain film to assess for fractures among patients presenting with acute knee injuries. According to the rules, a radiograph is indicated in patients with acute knee injury due to a fall or a blow to the knee and with at least 1 of 4 characteristics: age older than 55 years, tenderness at the head of the fibula or isolated to the patella, inability to bear weight for at least 4 steps (that is, the patient cannot take 4 steps across the room with the injured knee bearing the full weight of the patient unassisted, although some limping is permissible), or inability to flex the knee to 90 degrees. While the rules are sensitive, they have relatively poor specificity, which means that only 3% of patients seen in primary care who meet 1 criterion have a fracture (assuming that the prevalence of knee fracture in primary care settings is 1.2%). In emergency department settings, where the prevalence of knee fractures is greater, the yield of fractures is higher, with up to 30% having a fracture on radiographs on the basis of the Ottawa knee rules.

Referral for a knee film does not guarantee an accurate diagnosis. Plain radiography of the knee is not a perfect test; in published studies, its sensitivity ranges from 85% to 100% and its specificity ranges from 88% to 92% for detecting fractures among studies with several weeks of follow-up that included repeated plain films or bone scans of patients with persistent symptoms (30–34). Hence, among patients presenting in primary care who receive a plain film on the basis of the Ottawa rules with negative radiographic results, 3 in 1000 will have a missed fracture. Furthermore, on rare occasions, a patient who does not get a knee film because of reliance on the Ottawa rules will have a fracture. Consequently, clinicians must explain that the patient has a small chance of a fracture and should have a well-documented follow-up plan. In the studies that created and validated the Ottawa rules, patients with persistent pain 10 days after an initially negative evaluation routinely had a repeated plain film.

Evaluating Suspected Torn Meniscus or Knee Ligament

Clinical History

Patients with meniscal injuries frequently report knee pain after twisting their leg while the foot is bearing their full weight. They often experience a popping or tearing sensation, followed by severe pain. Swelling takes several

Table 2. **Test Characteristics of Physical Examination and Magnetic Resonance Imaging for Detecting Meniscal, Ligamentous, and Cartilage Tears***

Characteristic	Physical Examination				Magnetic Resonance Imaging			
	Sensitivity	Specificity	Positive Likelihood Ratio	Negative Likelihood Ratio	Sensitivity	Specificity	Positive Likelihood Ratio	Negative Likelihood Ratio
Medial meniscus	0.86 (0.79–0.92)	0.72 (0.61–0.83)	3.1 (0.54–5.7)	0.19 (0.11–0.77)	0.89 (0.83–0.95)	0.80 (0.73–0.87)	4.5 (3.9–9.5)	0.14 (0.09–0.28)
Lateral meniscus	0.88 (0.77–0.99)	0.92 (0.89–0.95)	11.0 (1.8–20.2)	0.13 (0.0–0.25)	0.79 (0.73–0.85)	0.91 (0.84–0.98)	8.7 (5.6–11.7)	0.23 (0.15–0.31)
Anterior cruciate ligament tear	0.74 (0.60–0.88)	0.95 (0.92–0.98)	15.0 (5.1–23.0)	0.27 (0.12–0.42)	0.87 (0.83–0.91)	0.91 (0.88–0.94)	9.6 (4.5–14.6)	0.14 (0.09–0.19)
Posterior cruciate ligament tear	0.81 (0.63–0.98)	0.95 (0.81–1.0)	16.2 (5.2–25.0)	0.20 (0.13–0.49)	0.75 (0.65–0.85)	0.93 (0.88–0.98)	11 (4.7–17.3)	0.27 (0.16–0.37)
Cartilage	0.51 (0.37–0.65)	0.96 (0.91–1.0)	13.0 (2.7–24.0)	0.51 (0.40–0.62)	0.84 (0.67–1.0)	0.90 (0.85–0.96)	8.4 (2.7–14.7)	0.17 (0.0–0.33)

* All values in parentheses are 95% CIs, derived from the fitted receiver-operating characteristic curve at the median true-positive rate.

Table 3. **Comparison of 3 Clinical Examination Techniques for Diagnosing Anterior Cruciate Ligament Tears***

Study (Reference)	Lachman Test		Anterior Drawer Test		Pivot Test	
	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity
Boeree and Ackroyd (14)	0.63	0.90	0.56	0.92	0.31	0.97
Hardaker et al. (40)	0.74	NA	0.18	NA	0.29	NA
Donaldson et al. (41)	0.99	NA	0.35	NA	0.70	NA
Jonsson et al. (42)	0.87	NA	0.33	NA		
Liu et al. (43)	0.95	NA	0.61	NA		
Braunstein (59)	0.91	1.0				
Torg et al. (71)	0.95	NA	0.61	NA	0.71	NA
Katz and Fingeroth (75)	0.89	NA	0.41	0.95	0.78	0.98
Noyes et al. (76)		NA	0.56	NA	0.89	NA
Lee et al. (79)	0.89	NA	0.78	1.0		
Hughston et al. (81)			0.58	0.23		
Summary statistic (95% CI)	0.87 (0.76–0.98)	0.93 (0.89–0.96)	0.48 (0.38–0.59)	0.87 (0.83–0.91)	0.61 (0.40–0.82)	0.97 (0.93–0.99)

* NA = not assessed. These studies evaluated test results among patients known to have the injury; hence, only sensitivities were assessed. In the remaining blank cells, the studies did not investigate these maneuvers.

hours to appear, in contrast to ligamentous injuries, in which swelling is often immediate because of hemorrhage. Walking up and down stairs is frequently difficult with meniscal tears, and squatting may be painful. In contrast, ligamentous damage and fractures usually occur with forceful stresses on the knee or a direct blow to the knee while the extremity is bearing weight. A valgus stress (force applied to the lateral aspect of the knee) injures the medial collateral ligament, varus stress (force applied to the medial aspect of the knee) damages the lateral collateral ligament, hyperextension damages the posterior cruciate ligament, and excessive medial rotation with a planted foot stresses the anterior cruciate ligament. Patients often report a popping or tearing sensation. Unfortunately, few studies have measured the accuracy of the clinical history in patients with suspected torn ligament or meniscus. These studies found that the history can heighten clinical suspicion but is of little value in distinguishing between meniscal and ligamentous injury or in pinpointing which ligament has sustained damage (14, 15). In contrast to the history, physical examination of the knee is accurate.

Test Performance of the Physical Examination

Of 3539 potentially relevant articles identified by MEDLINE, 248 articles on knee examination were found. Fifty articles compared the clinical examination with either arthroscopy or arthrotomy. We excluded 18 studies: 4 had no extractable data (35–38), 11 reported only the sensitivity of physical findings (39–48), 2 reported only the results of examinations performed under general anesthesia (49, 50), and 1 used MRI rather than arthroscopy as the gold standard (14). We were left with 35 analyzable studies (51–85).

In all studies, the examining physician was blinded to the arthroscopic results. Either orthopedic surgeons or sports medicine physicians performed all studies; no study assessed interrater agreement. Problems common to all studies included lack of normal controls, a selected study sample, and arthroscopy performed by orthopedists who knew the results of the physical examination. Nineteen studies provided data on the medial meniscus, 17 provided data on the lateral meniscus, and 18 provided data on the anterior cruciate ligament tears. Five studies provided data on the physical examination for meniscal damage, 2 studies provided data on the posterior collateral ligament, and no study provided data on medial or lateral collateral ligaments.

Table 2 summarizes the test characteristics. The **Appendix Figure** (available at www.annals.org) shows the ROC curves for each knee lesion. The physical examination was reasonably sensitive in detecting meniscal, anterior cruciate ligament, and posterior collateral ligament tears (74% to 81%) but less sensitive for detecting other cartilaginous damage (51%). For all lesions, except medial meniscus lesions, specificity was high (92% to 96%), suggesting that physical examination is usually normal in patients without damage to these structures.

The studies of physical examination maneuvers had many problems. Most did not state which maneuvers the examining clinician used, only that they recorded their best estimate after performing a "thorough history and physical." Some studies assessed the test characteristics of specific maneuvers: 9 studies for the Lachman maneuver, 10 for the anterior drawer sign, 6 for the pivot test, 4 for the McMurray maneuver, and 3 for joint line tenderness (**Tables 3** and 4). No study assessed interexaminer agreement.

The best-studied tests for detecting a ligamentous tear (**Figure**) are the Lachman maneuver, the anterior drawer test, and the pivot test (86). Among these, the Lachman maneuver is the most sensitive (0.87 [95% CI, 0.76 to 0.98]), but its reported specificity (0.93 [CI, 0.89 to 0.96]) is not as high as that of the pivot test (0.97 [CI, 0.93 to 0.99]). The specificity of the pivot test is based on only 2 studies, both conducted by the developer of the maneuver, while the Lachman maneuver has been more rigorously studied. Both the Lachman and pivot tests have better sensitivities and specificities than the anterior drawer test (**Table 3**) (14, 40–42, 59, 71, 75, 76, 79, 81).

Two specifically studied methods to detect meniscal injuries include the joint line tenderness sign and the McMurray maneuver. Joint line tenderness is sensitive (0.76 [CI, 0.65 to 0.87]) but not very specific (0.29 [CI, 0.10 to 0.46]), while the McMurray test is specific (0.97 [CI, 0.87 to 0.99]) but not very sensitive (0.52 [CI, 0.35 to 0.68]). The **Figure** describes how to perform these maneuvers.

Probability of Condition given Physical Examination Findings

The knee examination, in the hands of the trained examiner, is accurate in evaluating meniscal and ligamentous tears. On the basis of the prevalence of the lesions in primary care, a negative examination makes the likelihood of a ligamentous or meniscal tear less than 1.5%, sufficiently low that the patient can be followed clinically. Because this strategy will miss a few lesions, a careful follow-up plan is essential. As shown in **Table 5**, the post-test probability of the specific lesion after a positive examination result is 50%, while a negative examination result essentially rules a lesion out. For the primary care physician whose examination suggests internal knee derangement, the decision is between obtaining an MRI scan or referring the patient to an orthopedic surgeon; plain films are of limited value in assessing the presence of meniscal or ligamentous damage (87).

Test Performance of MRI

We identified 2696 articles on MRIs in evaluating knee pain in MEDLINE and retrieved 848 articles. In 113 articles, MRI was compared to a gold standard of either arthroscopy or arthrotomy. We excluded 24 of these studies: 11 had no extractable data (39, 87–96), 1 reported duplicate data (97), 6 reported only test sensitivity among patients with known disease (98–103), 2 assessed indirect MRI signs for anterior cruciate ligament tears (104) or focused on explaining discrepancies between MRI and arthroscopy (105), 1 compared the clinical examination with MRI findings (43), and 2 had fewer than 7 patients (106, 107). After these exclusions, we had 89 articles evaluating the test characteristics of MRI (15, 43, 52, 58, 60, 62, 64, 65, 72, 75, 76, 78, 108–187).

All studies used arthroscopy or arthrotomy as a gold standard. Forty-five studies provided data on the medial meniscus, 47 provided data on the lateral meniscus, 51 provided data on the anterior cruciate ligament, 15 provided data on the posterior collateral ligament, 23 provided data on cartilage abnormalities, and 1 provided data on plica. Study quality problems included lack of blinding of the arthroscopist to MRI findings in 70 studies, lack of blinding of the radiologist to arthroscopy results in 7 studies, and lack of normal controls in all but 8 studies involving cadaveric knees. Thirty-one studies had evidence of referral bias; patients only underwent arthroscopy on the basis of abnormal MRI findings.

Table 3 summarizes the test characteristics, and the **Appendix Figure** (available at www.annals.org) shows the ROC curves. The summary estimate of sensitivity of MRI was 75% to 87% for detecting meniscal, posterior collateral ligament, and anterior cruciate ligament tears and 84% for cartilage damage. For all 4 joint structures, the summary estimate of specificity was 80% to 93%, suggesting that patients without knee damage usually have a normal MRI scan. The likelihood of having a specific internal knee diagnosis after either a positive or negative MRI result is provided in **Table 6**. The magnetic resonance imaging is good at ruling in specific lesions but less able to rule them out at prevalences one would encounter in clinical practice.

Recommended Strategy

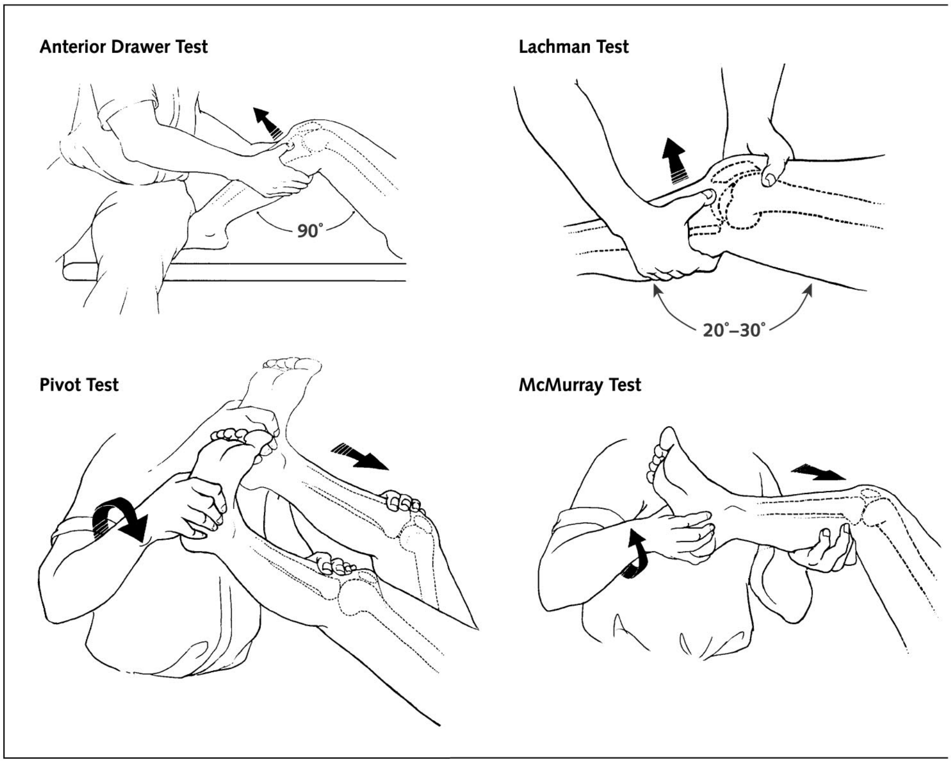
The few studies of the accuracy of the history suggest that it is not very useful in diagnosing a knee injury. Fortunately, the physical examination is specific and moderately sensitive. If the physical examination is negative for meniscal or ligamentous damage, the likelihood that the patient has these lesions is low enough to manage the patient conservatively. Given that 1% to 2% of patients with these lesions will be missed with this strategy, careful follow-up is essential and reevaluation is necessary if the patient does not improve. If the examination suggests internal derangement of the knee, referral to an orthopedic surgeon on the basis of the physical examination may be a better strategy than routinely obtaining an MRI scan. Although MRI may identify ligament or meniscal damage, findings are frequently abnormal, even in asymptomatic knees (188–192). Because specificity is relatively low, a positive test result indicates only an intermediate probability of injury on subsequent arthroscopy. The success of this

Table 4. **Comparison of 2 Common Physical Examination Tests for Meniscal Pathology***

Study (Reference)	Joint Line Tenderness		McMurray Test	
	Sensitivity	Specificity	Sensitivity	Specificity
Anderson and Lipscomb (38)	NA	NA	0.58	0.95
Noble and Erat (39)	0.67	0.13	0.63	0.58
Fowler and Lubliner (63)	0.85	0.29	0.29	0.95
Barry et al. (83)	0.76	0.43	0.56	1.0
Summary statistic (95% CI)	0.76 (0.65–0.87)	0.29 (0.10–0.46)	0.52 (0.35–0.68)	0.97 (0.87–0.99)

* NA = not assessed.

Figure. **Common maneuvers of the knee for assessing possible ligamentous and meniscal damage.**



Top left. *Anterior drawer test*. Place patient supine, flex the hip to 45 degrees and the knee to 90 degrees. Sit on the dorsum of the foot, wrap your hands around the hamstrings (ensuring that these muscles are relaxed), then pull and push the proximal part of the leg, testing the movement of the tibia on the femur. Do these maneuvers in 3 positions of tibial rotation: neutral, 30 degrees externally, and 30 degrees internally rotated. A normal test result is no more than 6 to 8 mm of laxity. **Top right**. *Lachman test*. Place patient supine on examining table, leg at the examiner's side, slightly externally rotated and flexed (20 to 30 degrees). Stabilize the femur with 1 hand and apply pressure to the back of the knee with the other hand with the thumb of the hand exerting pressure placed on the joint line. A positive test result is movement of the knee with a soft or mushy end point. **Bottom left**. *Pivot test*. Fully extend the knee, rotate the foot internally. Apply a valgus stress while progressively flexing the knee, watching and feeling for translation of the tibia on the femur. **Bottom right**. *McMurray test*. Flex the hip and knee maximally. Apply a valgus (abduction) force to the knee while externally rotating the foot and passively extending the knee. An audible or palpable snap during extension suggests a tear of the medial meniscus. For the lateral meniscus, apply a varus (adduction) stress during internal rotation of the foot and passive extension of the knee. **Not shown**: *Joint line tenderness*. Palpate medially or laterally along the knee until one comes to the joint line between the femur and tibial condyles. The presence of pain on palpation is a positive finding.

strategy of relying on the physical examination depends on a skillful knee examination. Our findings suggest that good training in examining the knee could decrease costs. Clinicians should know how to properly perform knee examinations for ligamentous and meniscal injury.

The Role of Plain Knee Radiographs when Osteoarthritis Is Included in the Differential Diagnosis of Acute Knee Pain

Osteoarthritis is usually a chronic rather than acute problem. Most patients followed for osteoarthritis will have a long history of chronic knee pain, which makes the diagnosis of an acute exacerbation relatively straightforward. However, patients with osteoarthritis sometimes present with an acute exacerbation, and every patient eventually given a diagnosis of osteoarthritis will initially present with knee pain of an uncertain cause before someone establishes the diagnosis.

Test Performance of Physical Examination Findings

In an effort to standardize the diagnosis of osteoarthritis of the knee, the American College of Rheumatology has developed clinical, laboratory, and radiographic criteria by pooling several osteoarthritis cohorts and using expert, consensus diagnostic opinion as the "gold standard" (193). The clinical criteria for osteoarthritis are age older than 50 years, stiffness for less than 30 minutes, crepitus, bony tenderness, bony enlargement, and no palpable warmth. If at least 3 clinical characteristics are present, the sensitivity for osteoarthritis is 95% and the specificity is 69%. If 4 criteria are present before diagnosis of osteoarthritis, the sensitivity decreases to 84% but the specificity increases to 89%. Given a 34% prevalence of osteoarthritis as the cause of knee pain among adults, patients who have at least 3 clinical criteria for osteoarthritis have a 62% chance of having osteoarthritis. In those patients with 2 or fewer criteria, the probability of having osteoarthritis is 4%. Since these criteria were developed among patients with chronic knee pain diagnosed as osteoarthritis, the performance of these criteria among patients with acute knee pain is less certain. Among patients presenting with acute knee pain, in which application of the Ottawa rules does not suggest a fracture and in which the physical examination does not suggest meniscal or ligamentous injury, the differential diagnosis narrows. Applying these criteria for osteoarthritis can reassure the clinician that the cause of this presentation of knee pain is probably osteoarthritis, although no studies have specifically examined this question. Taking account of other laboratory findings, such as factoring in normal synovial fluid, a normal erythrocyte sedimentation rate, and negative rheumatoid factor, increases the sensitivity but decreases the specificity of the clinical criteria (**Appendix Table 3**, available at www.annals.org).

Arthrocentesis should be a consideration in the 2.4% of patients presenting in primary care with knee pain and concomitant effusion. Arthrocentesis is indicated in all cases in which clinical concern for an infection is present. In patients with knee pain and significant effusion, arthrocentesis can have therapeutic value as well. Noninflammatory synovial fluid provides further evidence that the cause is probably osteoarthritis. Examining synovial fluid can also rule out other causes of acute knee pain, such as the crystalline arthopathies. If the diagnosis of acute knee pain with effusion is uncertain, arthrocentesis is indicated.

Test Performance of Knee Radiographs

The best-known knee radiographic grading system is that of Kellgren and Lawrence (194), also called the Kellgren and Lawrence grading system. The Kellgren and Lawrence grading system was developed with non–weight-bearing radiographs of the knee in the supine position and not including the patellofemoral joint. The diagnostic criteria include osteophytes, sclerosis, joint space narrowing, and cystic subchondral bone. Since the original system was based on non–weight-bearing radiographs, diagnosing osteoarthritis by using the Kellgren and Lawrence grading system relied heavily on the presence of osteophytes. Most current trials use weight-bearing films and incorporate a measurement of joint space width. When MRI is used as the gold standard, the presence of osteophytes has a sensitivity of 77% and specificity of 83% for knee osteoarthritis. For patellofemoral osteoarthritis, a form of osteoarthritis (1), the sensitivity of the Kellgren and Lawrence criteria is 82% and the specificity is 45%. Compared with arthroscopy, the Kellgren and Lawrence criteria often miss early articular cartilage defects. Therefore, the plain knee radiograph is a poor test for ruling out early osteoarthritis (195).

The accuracy of the Kellgren and Lawrence grading system depends on the radiographic abnormality. Osteophytes correlate with pain (196–198) and clinical findings (199), but joint space narrowing does not correlate with knee pain or predict clinical outcomes, such as disability or eventual need for joint replacement (200, 201).

Clinical versus Radiologic Osteoarthritis Criteria

The American College of Rheumatology has 3 sets of criteria for osteoarthritis (**Appendix Table 3**, available at www.annals.org). The one that combines clinical, laboratory, and radiographic features includes osteophytes on plain radiographs and at least 1 of the following: age older than 50 years, crepitus, and morning stiffness of 30 minutes or less. This combination of findings is 91% sensitive and 86% specific for osteoarthritis. The set of clinical criteria for osteoarthritis (having at least 3 of the following: age >50 years, stiffness <30 minutes, crepitus, bony tenderness, bony enlargement, and no palpable warmth) is more sensitive for osteoarthritis (95%) but less specific (69%) than the set of criteria that combines the clinical features with plain radiograph results.

Recommended Strategy

When a patient presents with acute knee pain, the physician must decide whether a plain radiograph of the knee will help to make the diagnosis. The plain knee film is useful for osteoarthritis and for knee fracture, so the decision rests on the probability of these 2 diagnoses. The overall prevalence of underlying osteoarthritis in adults with acute knee pain is 34%. Given this high pretest probability, patients meeting Kellgren and Lawrence criteria on plain films have a 70% chance of having osteoarthritis, compared with a 79% probability in patients with clinical characteristics alone (age >50 years, morning stiffness, crepitus, or bony enlargement). A negative plain film reduces the probability to 13%, compared with 6% if clinical criteria are absent. Since clinical findings outperform plain radiograph of the knee in diagnosing osteoarthritis, the physician should diagnose osteoarthritis on the basis of clinical findings, remembering that these findings establish a diagnosis of chronic arthritis and do not prove that acute

Table 5. **Effect of Physical Examination and Magnetic Resonance Imaging Findings on the Likelihood of Knee Diagnoses***

Knee Diagnosis	Pretest Probability	Post-Test Probability, if Positive		Post-Test Probability, if Negative	
		Physical Examination	Magnetic Resonance Imaging	Physical Examination	Magnetic Resonance Imaging
	←		%		→
Anterior cruciate ligament tear	4	38	40	1	0.6
Posterior cruciate ligament tear	1	14	11	0.2	0.3
Medial meniscus	6	17	29	1	0.9
Lateral meniscus	6	41	55	0.8	1

* This table uses the pretest probability of the condition, based on the prevalence in primary care, and calculates the likelihood of having the problem with either a positive or a negative physical examination or magnetic resonance imaging result.

Table 6. **Algorithmic Approach for Acute Knee Pain**

Step	Question	Action
1	Has there been a recent injury and at least 1 of the following predictors of fracture? Age >55 y Tenderness at head of the fibula or isolated to the patella Inability to bear weight for at least 4 steps of walking Inability to flex knee >90 degrees	Plain films
2	Is there an effusion?	Arthrocentesis (especially to rule out infectious or crystalline arthritis)
3	Does the physical examination suggest meniscal or ligamentous injury or history of locking or give-way sensation?	Orthopedic referral (for examination and decision on need for magnetic resonance imaging or arthroscopy)
4	Are there clinical criteria suggesting osteoarthritis? At least 3 of the following: History Age >50 y Morning stiffness lasting >30 min Physical examination Crepitus Bony enlargement No palpable warmth	Symptomatic treatment, including: Analgesics (such as acetaminophen or nonsteroidal anti-inflammatory drugs) Exercise Plain films may be considered, although evidence for their utility is weak
5	Is there evidence of a systemic rheumatologic disorder (such as rheumatoid arthritis, seronegative inflammatory arthropathy, or reactive arthropathy)? Polyarticular involvement, especially the hands Morning stiffness lasting >30 min	Serum rheumatologic assays Rheumatoid arthritis: rheumatoid factor Systemic lupus erythematosus: antinuclear antibody
6	Does the pain persist or remain undiagnosed despite symptomatic treatment and clinical follow-up?	Rheumatology or orthopedic referral

knee pain is due to an exacerbation of this condition. The decision for radiography should depend on the likelihood of knee fracture, as determined by the Ottawa rules for ruling out fractures.

Other Causes of Acute Knee Pain

Other causes of acute knee pain include crystalline arthritis, septic arthritis, rheumatologic conditions, reactive arthropathy, and rare tumors. The clinical presentation of crystalline diseases and septic arthritis typically includes warmth, erythema, and knee effusion. A patient with acute knee pain and knee effusion, particularly if infection is suspected, should have arthrocentesis and synovial fluid examination rather than plain films. Acute knee pain occurs in chronic rheumatologic conditions, and the physician should seek clinical clues to the underlying disease (morning stiffness lasting >30 minutes, involvement of multiple joints, and, especially for rheumatoid arthritis, involvement of the hands). If the clinical findings suggest that the patient has a chronic rheumatologic condition, the physician should obtain serum assays of autoantibodies (such as rheumatoid factor for rheumatoid arthritis or antinuclear antibodies for lupus) rather than plain films of the knee.

The Role of Plain Radiographs in Suspected Pseudogout

Pseudogout is knee pain due to calcium pyrophosphate crystals in the joint. Plain films of the knee can demonstrate calcification along tendons and menisci, which is believed to be a good marker for pseudogout. While there are few rigorous studies on pseudogout, plain films may have several limitations. First, radiologic chondrocalcinosis is present in up to 26% of patients older than 60 years of age (201–204). Chondrocalcinosis is often present in patients with asymptomatic knees (205) and other causes of acute knee pain (osteoarthritis [206–209], gout [210, 211], and rheumatoid arthritis [211]). Therefore, chondrocalcinosis does not prove that pseudogout is the cause of acute knee pain. Second, some patients with confirmed pseudogout do not have radiologic calcification (212–215), so its absence does not exclude pseudogout.

SUMMARY

Acute knee pain is common in primary care, and physicians can choose from several imaging tests or rely on clinical findings to make a diagnosis. **Table 6** summarizes an algorithm for evaluating the patient with acute knee pain. A careful physical examination is especially important. For acute knee pain after trauma, a plain film should be obtained to rule out fracture if the patient is older than 55 years of age, has tenderness at the head of the fibula or isolated tenderness of the patella, cannot flex the knee to 90 degrees, or cannot bear weight for at least 4 steps (the Ottawa rules criteria).

For suspected meniscal and ligamentous injuries, the issue is whether to refer the patient to a surgeon. The diagnostic accuracy of the physical examination is remarkably good in the hands of a trained examiner, and MRI adds only marginal value in deciding whether to refer a patient with 1 of these conditions. Physicians should decide to refer on the basis of their physical examination without first obtaining an MRI scan.

If a patient with acute knee pain is unlikely to have knee fracture and meniscal or ligamentous damage, other common causes, such as sprains or strains (the cause in almost half of all cases of acute knee pain) or osteoarthritis, should be considered. Patients with acute knee pain and evidence of effusion should undergo arthrocentesis, which is the diagnostic test of choice for crystalline diseases and septic arthritis. Evidence of acute inflammation in the synovial fluid in an acutely painful knee suggests these diagnoses. Lack of inflammation suggests other less serious causes, such as an acute sprain or strain or an acute exacerbation of chronic osteoarthritis (216). Clues suggesting underlying osteoarthritis include bony enlargement of the knee, age older than 50 years, crepitus, and morning stiffness lasting less than 30 minutes. A careful clinical history with selected serum markers of autoimmune disease is the first approach to patients with suspected rheumatologic disorders. Plain films of the knee are less valuable than hand films in diagnosing rheumatoid arthritis (217).

Accurately sorting patients with this algorithm presupposes reliable information about the accuracy of imaging tests of the knee and excellent skills in examining the knee. Published research has some important limitations: lack of blinding to test results when comparing the index test with the gold standard test, lack of or inappropriate comparison groups without the target knee condition, incomplete description of the content of the examination of the knee, and knee examinations performed by specialists rather than generalist physicians. Training to examine a knee is often inadequate, and no one has measured interobserver agreement for physical examination maneuvers of the knee.

The research agenda for studying the evaluation of acute knee pain should also include the following types of studies: validation of the proposed algorithm in a large sample of primary care patients; cost-effectiveness analysis of the diagnostic tests; evaluation of empirical analgesic treatment and watchful waiting rather than immediate referral to a specialist; evaluation of the accuracy of the knee physical examination in primary care settings, including measurement of interobserver reliability; and evaluation of the history for detecting meniscal and ligamentous damage.

From the Uniformed Services University of the Health Sciences, Bethesda, Maryland; Walter Reed Army Medical Center, Washington, DC; and Indiana University School of Medicine and Regenstrief Institute, Indianapolis, Indiana.

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Requests for Single Reprints: Jeffrey L. Jackson, MD, MPH, Medicine-EDP, 4301 Jones Bridge Road, Bethesda, MD 20814.

Current author addresses are available at www.annals.org.

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APPENDIX 1: MEDLINE SEARCH STRATEGIES

Physical Examination

The initial clinical examination search strategy was *physical examination* [MeSH terms] OR *clinical examination* [text word] AND *knee* [MeSH terms] OR *knee* [text word] AND *English* [la] AND *diagnosis* [subheading] OR *diagnosis* [MeSH terms]) OR *diagnosis* [text word], which produced 3539 articles. Further searching was done by using the search filters of Haynes (1). Sensitive search: *physical examination* [MeSH terms] OR *clinical examination* [text word] AND *knee* [MeSH terms] OR *knee* [text word] AND *English* [la] AND *sensitivity and specificity* [MeSH terms] OR *sensitivity* [word] OR *diagnosis* [subheading] OR *diagnostic use* [subheading] OR *specificity* [word], which produced 1247 articles. Specific search: *physical examination* [MeSH terms] OR *clinical examination* [text word] AND *knee* [MeSH terms] OR *knee* [text word] AND *English* [la] AND *sensitivity and specificity* [MeSH terms] OR *predictive* [word] AND *value** [word], which produced 127 articles.

Decision Rules on Use of Plain Films To Rule Out Fractures

The search strategy of Haynes was used (204):

1. *Knee pain* or *sensitivity* or *specificity* or *sensitivity and specificity* [MeSH terms] or *diagnosis* [subject heading] or *diagnostic use* [subject heading].
2. *Knee pain* or *sensitivity and specificity* [MeSH term] or *predictive* and *value**.
3. *Knee pain* or *cohort studies* [MeSH term] or *risk* [MeSH term] or *odds* or *ratio* or *relative* or *risk* or *case* or *control*.
4. *Knee pain* or *case-control studies* [MeSH term, unexploded] or *cohort studies* [MeSH term, unexploded].

Magnetic Resonance Imaging

Magnetic resonance imaging [MeSH terms] OR *magnetic resonance imaging* [text word] AND *knee* [MeSH terms] or *knee* [text word] AND *English* [la], which produced 1440 articles. Additional searches were performed using the search filters suggested by Haynes, for both sensitive and specific diagnostic searches. Specific filter: *magnetic resonance imaging* [MeSH terms] OR *magnetic resonance imaging* [text word] AND *knee* [MeSH terms] OR *knee* [text word] AND *English* [la] AND *sensitivity and specificity* [MeSH terms] OR *predictive* [word] AND *value** [word], which produced 200 articles. Sensitive filter: *magnetic resonance imaging* [MeSH terms] OR *magnetic resonance imaging* [text word] AND *knee* [MeSH terms] OR *knee* [text word] AND *English* [la] AND *sensitivity and specificity* [MeSH terms] OR *sensitivity* [word] OR *diagnosis* [subheading] OR *diagnostic use* [subheading] OR *specificity* [word], which produced 1256 articles.

APPENDIX 2: EXPLANATION FOR USE OF ROC CURVES

There are 2 methods for combining data from diagnostic tests: Combine weighted sensitivities and specificities from each study to obtain an overall result by using a fixed-effects model, or calculate the true-positive rate (sensitivity) and false-positive rate (1 – specificity) for each study and combine the studies by using fitted ROC curves. If there is evidence of heterogeneity, it is inappropriate to use the weighted sensitivity and specificity method to obtain a summary result because it is possible that the different study authors are using different cut-points to define a positive test result. For example, one group of orthopedists may, over time, develop a similar feel for what defines a positive anterior drawer test result. At the most extreme, if one group finds a maneuver to be 100% sensitive but 0% specific, and another study reports the test to be 0% sensitive with 100% specificity, weighted results (assuming equal size and variance between the 2 studies) would give a summary estimate of 50% sensitivity and 50% specificity. This could be highly misleading, since a perfect test will produce this range of sensitivities and specificities if the cut-points vary. Weighted methods of summarizing the results produce distorted results in the face of heterogeneity. Relying on statistical tests for heterogeneity is a problem as these tests are not very sensitive. While our results had no evidence of statistical heterogeneity for any of the test results, the ranges of results for each test were wide; for example, physical examination of the medial meniscus had sensitivities ranging from 0.26 to 0.93 and specificities ranging from 0.22 to 1.0. To test for the possibility that this range could be a cut-point effect, we performed the analyses of MRI and physical examination results by using both weighted and ROC methods. Although most results were nearly identical, in those instances in which the studies reported wider ranges, the results obtained by using weighted methods were systematically lower than the results obtained by using fitted ROC curves. This is an expected finding when cut-points are influencing the results and an argument for the need to use ROC methods (16). A second benefit to using ROC curves is that the area under the ROC curves allows for direct comparison between 2 diagnostic tests. If 1 test's ROC curve is higher than another at all cut-points, then it is a superior test, although the decision to use either test would hinge on other important factors, such as cost and risks. Plotting the ROC curves for the physical examination on the same axis as the MRI graphically demonstrates the magnitude of the differences between the tests.

The method for combining data by using ROC curves requires transforming the data. First, calculate the logit of the false-positive and true-positive rates, respectively:

$$U = \log it(FPR) = \ln\left(\frac{FPR}{1 - FPR}\right) = \ln\frac{b}{d}$$

and

$$V = \log it(TPR) = \ln\left(\frac{TPR}{1 - TPR}\right) = \ln\left(\frac{a}{c}\right)$$

where:

	Disease Present	Disease Absent
Positive test result	*a*	*b*
Negative test result	*c*	*d*

Next, define $S = V + U$ and $D = V - U$ then fit a straight line: by using linear regression, where D is the dependent variable and

Appendix Table 1. **Decision Rules for Obtaining Knee Radiographs To Evaluate for Fracture***

Study, Year (Reference)	Quality†	Patients	Decision Rule	Sensitivity, %	Specificity, %	Radiograph Utilization Decrease, %	Validated	Comments
Seaberg and Jackson (11), 1994	7	Retrospective: ED patients with knee pain <1 wk (n = 201) Prospective: ED patients with acute knee pain (n = 133)	Inability to ambulate, fall or blunt trauma, age <12 y or >50 y	100	79	NS	Yes	Inclusion of children and patients with multiple trauma may make rule less valid in most patients with acute knee pain
Weber et al. (22), 1995	5	ED patients with acute (<24 h) knee injuries (n = 242)	Seaberg and Jackson's rules (see above)	100	24	19		Unlike Seaberg and Jackson, Weber et al. excluded patients with multiple trauma
			Inability to walk without limping; twist injury with effusion	100	34	29	No	Radiographs obtained at discretion of clinician; can't determine missed fractures
Stiell and colleagues (10), 1995	7	ED patients with knee pain <1 wk (n = 1047)	Age >55 y, tenderness at head of fibula or isolated tenderness of patella, flexion <90 degrees, inability to bear weight for 4 steps	100	54	NR		Interobserver agreement for interpretation of rule was excellent (κ = 0.77): Would have saved patients an average of 39 min
Stiell and colleagues (13), 1996	9	ED patients with knee pain <1 wk (n = 1046)	Same as above	100	49	28	Yes	Same as above
Fagan and Davies (19), 2000		Retrospective chart review (n = 370)	Age >55 y, inability to bear weight, hemarthrosis, point bony tenderness, effusion	95	62	NR	No	

* ED = emergency department; NR = not reported; NS = not significant.
† Study quality was measured by using tools adapted from the McMaster method for critically appraising diagnostic test articles (17, 18).

S is the independent variable. From this regression, you obtain a slope (B) and an intercept (A), which you fit into the equation:

$$FPR = \left[1 + e^{\frac{-A}{(1-B)}}\left(\frac{1 - TPR}{TPR}\right)^{\left(\frac{1+B}{1-B}\right)}\right]^{-1}$$

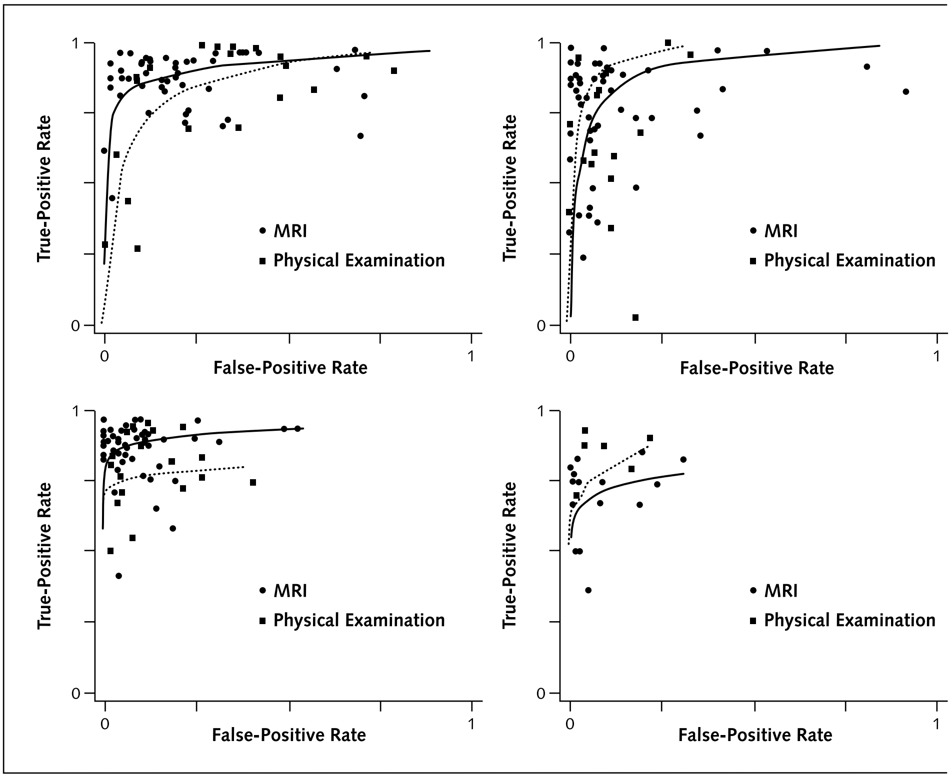
With the results from this equation, a series of fitted points for each true-positive rate can be generated to produce an ROC curve that fits the true-positive rate against the false-positive rate. To give a single summary number, use either the mean or the median true-positive rate (sensitivity) and calculate the corresponding false-positive rate (1 − specificity) from this equation.

Appendix Table 2. **Knee Fracture Decision Rule Quality Ratings**

Methodologic Criteria*	Ottawa Rules				
	Seaberg and Jackson (11), 1994	Weber et al. (22), 1995	Stiell et al. (10), 1995	Stiell et al. (13), 1996	Fagan and Davies (19), 2000
Explicit outcome definition	Yes	No	Yes	Yes	Yes
Blinded assessment	Yes	Yes	Yes	Yes	No
Explicit definition of findings to predict outcome	Yes	Yes	Yes	Yes	Yes
Interobserver agreement given	No	No	No	Yes	No
Patient age or sex stated	Yes	Yes	Yes	Yes	Yes
Study site described	Yes	Yes	Yes	Yes	Yes
Mathematical modeling technique described	Yes	Yes	Yes	Yes	Yes
Test of misclassification rate	Yes	No	Yes	Yes	No
Effects of clinical use prospectively tested	Yes	No	No	Yes	No

* Data from Wasson et al. (25).

Appendix Figure. **Fitted receiver-operating characteristic (ROC) curves.**



Fitted ROC curves for physical examination and magnetic resonance imaging (*MRI*) examination of knee pathology: medical meniscus (*top left*), lateral meniscus (*top right*), anterior cruciate ligament tear (*bottom left*), and posterior cruciate ligament tear (*bottom right*).

Appendix Table 3. **Likelihood of Osteoarthritis Based on Pretest Probability of Osteoarthritis and whether American College of Rheumatology Clinical Criteria for Osteoarthritis Are Present***

Pretest Probability of Osteoarthritis	Post-Test Probability of Osteoarthritis	
	No ACR Criteria Present	ACR Criteria Present
←——	—— % ——	——→
10	1	45
20	3	64
30	5	76
34†	6	79
40	8	83
50	11	88
60	16	92
70	23	95
80	33	97
90	53	99

* American College of Rheumatology (ACR) criteria: 1) Clinical and radiographic: osteophytes and at least 1 of 3: age >50 y, crepitus, morning stiffness ≤30 min (sensitivity, 91%; specificity, 86%); 2) Clinical: At least 3: age >50 y, stiffness <30 min, crepitus, bony tenderness, bony enlargement, or no palpable warmth (sensitivity, 95%; specificity, 69%); 3) Clinical and laboratory: At least 5 of 9: age >50 y, stiffness <30 min, crepitus, bony tenderness, bony enlargement, no palpable warmth, erythrocyte sedimentation rate <40 mm/h, rheumatoid factor titer <1:40, synovial fluid clear, viscous with leukocyte count $<2 \times 10^9$ cells/L (sensitivity, 92%; specificity, 75%).
† The overall prevalence in primary care.

Current Author Addresses: Dr. Jackson: Medicine-EDP, 4301 Jones Bridge Road, Bethesda, MD 20814.
Dr. O'Malley: 4103 Oliver Street, Chevy Chase, MD 20815.
Dr. Kroenke: Regenstrief Institute, 1050 Wishard Boulevard, Indianapolis, IN 46202.