

A Review of the McMurray Test: Definition, Interpretation, and Clinical Usefulness

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Like a phrase that has been distorted when whispered from one person to another around the campfire, so too has the description of the McMurray test been altered from that originally reported by McMurray (11). At that time, he described the test as follows:

"In carrying out the manipulation with patient lying flat, the knee is first fully flexed until the heel approaches the buttock; the foot is then held by grasping the heel and using the forearm as a lever. The knee being now steadied by the surgeon's other hand, the leg is rotated on the thigh with the knee still in full flexion. During this movement the posterior section of the cartilage is rotated with the head of the tibia, and if the whole cartilage, or any fragment of the posterior section, is loose, this movement produces an appreciable snap in the joint. By external rotation of the leg the internal cartilage is tested, and by internal rotation any abnormality of the posterior part of the external cartilage can be appreciated. By altering the position of flexion of the joint the whole of the posterior segment of the cartilages can be examined from the middle to their posterior attachments. Thus, if the leg is rotated with knee at right angles the cartilages in their mid-section come under pressure, but, anterior to this point, the pressure exerted on the cartilage is so diminished that accurate examination is impossible. When a loose segment of the cartilage is caught between the

Clinicians frequently use the results of clinical diagnostic tests to make decisions concerning patients. The intent of this paper is to review the technical aspects and measurement properties of the McMurray test and, more globally, to illustrate the impact that indiscriminate test application has on test interpretation. The literature shows that diagnostic accuracy studies, which evaluate the test described by McMurray, yield remarkably similar estimates of sensitivity (about 26%) and specificity (about 94%). These test characteristics are applied to three case scenarios to illustrate the impact that history-specific prevalence (ie., the likelihood a patient has the condition based on the history) has on the predictive values. The results show a high false positive rate when applied to patients who, based on the history, have a low pre-physical examination likelihood for the condition of interest and a higher false negative rate when applied to patients who have a high history-specific prevalence. Readers are warned that the exhaustive examination approach effectively lowers the prevalence and results in a high false positive rate. The impact that the exhaustive approach has on increasing the false positive rate is universal to all diagnostic investigations and is not unique to the McMurray test.

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bones during the rotation, the sliding of the femur over the loose fragment is accompanied by a thud or click, which can sometimes be heard but can always be felt, and the size of the detached portion can be judged by the rocking of the tibia, and usually also by the severity of the sound produced. This method of examination is not easy to master; the rotation requires a considerable amount of practice, and the whole procedure must be carried out systematically if success is to be attained. Probably the simplest routine is to bring the leg from its position of acute flexion to a right angle, whilst the foot is retained first in full internal, and then in full external rotation. . . . When the click occurs with a normal but lax cartilage, the patient experiences no pain

or discomfort, but when produced by a broken cartilage, which has already given trouble, the patient is able to state that the sensation is the same as he experienced when the knee gave way previously."

In contrast to this statement, Table 1 provides an anthology of how others have described the McMurray test. A notable difference is the inclusion of varus and valgus (adduction and abduction) forces at the knee during the test. While emphasizing this distinction may seem rather pedantic, it is essential to recognize that the consequence of this difference is to define a distinctly different test. Accordingly, different tests are likely to have different measurement properties and it is the measurement properties that determine a test's clinical

Author	Description	Original Article Cited
Gillis (6)	"With the patient lying on his back the examiner holds the foot of the side to be tested so that the knee is flexed to its full range of flexion, heel to buttock if possible, with external rotation of the foot, and an abduction strain at the knee; the knee is then steadily extended. When a loose segment of the medial meniscus semilunar interferes between the tibial and femoral articular surfaces, a click is heard during extension of the leg and a painful thud may be experienced. The same technique as above is employed, except that the foot is internally rotated and an adduction force is applied to the base during extension. The click, which is often painful, may be heard or felt by the examiner."	No
Hoppenfeld (8)	"... rotate the leg internally and externally to loosen the knee joint. Push on the lateral side to apply valgus stress to the medial side of the joint, while, at the same time, rotating the leg externally. Maintain the valgus stress and external rotation, and extend the leg slowly as you palpate the medial joint line. If this maneuver causes a palpable or audible click within the joint, there is a probable tear in the medial meniscus, most likely in its posterior half."	No
Salter (12)	"With the patient's knee acutely flexed and one finger of the examiner's hand holding the foot, the tibia is alternately internally and externally rotated and abducted and adducted. The free end of a posterior horn tear is thereby made to slip in and out between the joint surfaces with a palpable, and sometimes audible click. If no such sign is detected with the knee in acute flexion, the test is repeated in gradually increasing extension since it is only as the knee is partially extended that the click from the free end of an anterior horn tear will be palpated: indeed, the greater the extension of the knee at the time of the click the farther forward is the tear in the anterior horn."	No
Insall (10)	"As described by its originator, it is done with the patient supine, the hip flexed 90 degrees and the knee flexed more than 90 degrees. For examining the right knee, the examiner stands to the right of the patient with left hand on the knee and the right hand holding the foot. The foot is taken from a position of abduction and external rotation to one of adduction and internal rotation. The maneuver is repeated for various angles between full flexion and 90 degrees."	Yes
Gould and Davies (7)	"The knee is flexed and placed into external rotation, after which the examiner applies a valgus force. The knee is then extended. A positive test elicits a popping or snapping sensation."	No
Wadsworth (13)	"With the patient supine, the examiner lifts the leg and flexes the knee, and laterally rotates the tibia by grasping the foot. The examiner uses his other hand to impart a valgus stress on the knee, and to palpate the medial joint line, as he slowly extends the knee. A click or pain at the medial joint line indicates a positive test for meniscal injury."	No
Edwardson (2)	"... the patient's knee is fully flexed with the patient in the supine position. The therapist's proximal grip is on the lateral aspect of the knee joint, with a finger placed on the medial joint line. The distal grip is above the ankle. The therapist laterally rotates the leg, applies a valgus force to the outer side of the knee and, maintaining the external rotation, slowly extends the knee. The sound of a click, or the feel of one on the medial joint line, indicates a posterior medial meniscus lesion. To pick up a tear in the posterior lateral meniscus, the leg is internally rotated and a varus force is applied to the inside of the knee as the leg is extended."	No

TABLE 1. Various descriptions of the McMurray test.

usefulness. The purposes of this paper are to illustrate an application of diagnostic test methodology and to demonstrate that positive and negative test findings provide contributions of varying certainties depending on the pretest application (the McMurray test is this example) likelihood of a tear.

TEST CHARACTERISTICS OF THE MCMURRAY TEST

The diagnostic accuracy of a clinical test is determined by comparing the test's performance with a measure of the truth. Within the context of this discussion, the test is the McMurray maneuver and the truth is visualization of the meniscus at the time of surgery. Methodological criteria

for designing and critically appraising diagnostic studies have been reported previously and we will not elaborate on them in this paper (1, 9). Table 2 depicts a common method of summarizing the results from a diagnostic study. The following definitions represent several terms and concepts that are of particular interest.

Prevalence represents the percentage of patients who truly have meniscal tears $[100 \times (a+c)/(a+b+c+d)]$.

Sensitivity characterizes those patients correctly identified by the test as having meniscal tears as a percentage of all those who truly have the meniscal tears $[100 \times (a/[a+c])]$. Specificity defines those patients correctly identified by the test as not

having meniscal tears as a percentage of all those who truly do not have meniscal tears $[100 \times (d/[b+d])]$. Positive predictive value depicts those patients correctly identified by the test as having meniscal tears as a percentage of all those identified by the test as having meniscal tears $[100 \times (a/[a+b])]$.

Negative predictive value represents those correctly identified by the test as not having meniscal tears as a percentage of all those identified by the test as not having meniscal tears $[100 \times (d/[c+d])]$.

A particularly important concept is the notion that sensitivity and specificity are not influenced by prevalence, whereas, predictive values are prevalence dependent. Specifically, an increase in the prevalence results

	Truth Visualization at Surgery		
	Cases	Controls	
	Meniscal Tear Present	Meniscal Tear Absent	
McMurray test Positive	a True positives	b False positives	a+b
Negative	c False negatives	d True negatives	c+d
	a+c	b+d	a+b+c+d

TABLE 2. Typical 2 × 2 table used to express diagnostic test characteristics.

Test	Citation	Sensitivity (%)	Specificity (%)
McMurray	Evans (4) (experienced examiner)	20	91
	(less experienced examiner)	25	95
McMurray	Fowler and Lubliner (5)	29	96
Apley (compression)	Fowler and Lubliner (5)	16	80
Joint line tenderness	Fowler and Lubliner (5)	85	30
Pain on forced flexion	Fowler and Lubliner (5)	51	70
Block to extension	Fowler and Lubliner (5)	44	86

TABLE 3. Meniscal test characteristics.

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in an increase in the positive predictive value and a decrease in the negative predictive value.

While a review of the literature has revealed a number of diagnostic accuracy studies (3–8,10,12,13) which makes reference to the McMurray test, only two represent the test as described by McMurray (3,5). Table 3 summarizes the test characteristics from these studies as well as the test characteristics of competing meniscal tests. It is interesting to note that both studies demonstrate remarkably similar estimates of sensitivity and specificity for the McMurray test (4,5).

CLINICAL USEFULNESS

Like all diagnostic tests, the clinical usefulness of the McMurray test is not only defined by its test characteristics, but by how the test is incorporated into clinical practice. In addition to the technical proficiency required to perform the test, one must also consider the clinical reasoning process as it pertains to determining whether the test should be applied as well as the interpretation of the test result itself. To help clarify this statement, consider the following three clinical vignettes. For each case, readers may wish to: 1) generate several likely hypotheses; 2) estimate the probability of a meniscal lesion; and 3) consider all tests they would perform during the physical examination.

The first patient is a 14-year-old female volleyball player who complains of anterior knee pain with activity. Specifically, jumping and landing, squatting, going up and down stairs, and sitting for prolonged periods of time with her knee partially flexed increases the discomfort. There is no history of trauma and

the knee neither locks nor swells. This problem had a gradual onset and has been going on for about 3 months.

Patient 2 is a 21-year-old varsity soccer player who twisted her knee while kicking the ball. There was immediate medial pain; however, she was able to continue the last 2 minutes of play, albeit limping. Furthermore, there was moderate swelling 6 hours postinjury. She has noticed some improvement over the past 4 weeks; however, the knee continues to swell slightly and she continues to have medial discomfort when twisting or flexing the knee fully.

The third patient is a 37-year-old furnace repairman who twisted his knee while squatting on the job. There was immediate pain, swelling by the next morning, and he had to take several days off work. The knee has locked on several occasions and on each occasion he must “work the knee around to free it up.” The last time it locked for about 1 hour. It is now 5 weeks postinjury.

While there will be variation in the probability of meniscal tear assigned to these patients, it is likely that most clinicians will allocate a low probability value to Patient 1, a mid-range value for Patient 2, and a high probability of meniscal tear to Patient 3. In order to proceed with this discussion, let us assume the following probabilities were assigned: 1% for Patient 1, 50% for Patient 2, and 95% for Patient 3. These values represent the history-specific prevalences for these three patients. In brief, these values approximate the pretest chance of a tear for each patient. The next step in determining the clinical usefulness of the McMurray test is to consider the consequence of applying it to each of these patients and forming a judgment based on its interpretation. This is accomplished by using the sensitivity and specificity values—recall that these characteristics are independent of prevalence—from reported clinical studies (3–5) and changing the prevalence so that

Patient	Estimated Prevalence (%)	Positive Predictive Value (%)	100% Minus Positive Predictive Value (%)	Negative Predictive Value (%)	100% Minus Negative Predictive Value (%)
1	1	4	96	99	1
2	50	81	19	56	44
3	95	99	1	6	94

TABLE 4. Predictive values for patient scenarios. Predictive values are based on the estimated prevalences and a sensitivity and specificity of 26% and 94%, respectively.

it equals the estimated probability of a meniscal tear for each patient. Based on the literature, sensitivity and specificity were estimated to be 26% and 94%, respectively. Table 4 provides a summary table of the predictive values for each of these patients. Table 5 shows the steps used to obtain the cell values for Patient 2.

The following section considers the potential impact of applying the McMurray test to each of these patients and labeling them based on the test's finding. In patients who have histories similar to the patient with anterior knee pain, only 4% of those who test positive will actually have a meniscal tear. More importantly, 96% of the patients who test positive will be falsely labeled as having a meniscal lesion. A negative test finding provides no more information than not performing the test at all (ie., in this case, 100% minus the negative predictive value equals the prevalence). In the soccer player, a positive McMurray test increases the diagnostic accuracy of a meniscal tear from 50% (prevalence estimate for this patient) to 81% at the expense of incorrectly labeling 19% of patients as having a tear. Decisions based on a negative test finding will lead to mislabeling 44% of patients with a meniscal tear as not having a tear. This results in a gain of only 6% over that based on the prevalence. Finally, a positive test finding in the furnace repairman increases the chance of a meniscal tear from 95 to 99%, while acting on a negative test finding marginally increases the percentage of patients labeled as not having a tear from 5 to 6%.

These findings illustrate several important points. First, an increase in the prevalence results in an increase in the positive predictive value and a decrease in the negative predictive value. The opposite is also true. Building on this point, the application of a diagnostic test should be reserved for those patients for whom there is a reasonable chance of having the condition for which the test is being applied; however, a reasonable degree of uncertainty about the

diagnosis should also exist. Stated another way, the greatest gain in diagnostic accuracy is achieved for patients whose histories suggest prevalences in about the 30–70% range. Applying the test to patients with histories that suggest extreme prevalences can be uninformative as illustrated by the furnace repairman or downright misleading as shown in the volleyball player with anterior knee pain. While these principles have been illustrated using the McMurray test, the impact that prevalence has on predictive values is a mathematical phenomenon that is applicable to all diagnostic investigations. Accordingly, clinicians who routinely engage in exhaustive physical examinations and scans effectively lower the prevalence for many of the conditions for which tests are being applied. The consequence of an exhaustive examination approach will

Based on studies reported in the literature (4,5), we set the sensitivity and specificity to 26% and 94%, respectively.

For Patient 2, the estimated prevalence was 50%. We start by arbitrarily letting $a+b+c+d$ equal 100.

Calculation of cell (a, b, c, d) and marginal (a+c, b+d) values.

$a+c=50$ [ie., 50% of 100]
 $b+d=50$ [ie., $(a+b+c+d) - (a+c)$]
 $a=13$ [ie., $(a+c) \times \text{sensitivity}$]
 $c=37$ [ie., $(a+c) - a$]
 $d=47$ [ie., $(b+d) \times \text{specificity}$]
 $b=3$ [ie., $(b+d) - d$]

Positive (+) predictive value = 81% [ie., $(a/[a+b]) \times 100$]

Negative (–) predictive value = 56% [ie., $(d/[b+d]) \times 100$]

The interpretation is that a positive test significantly increases the likelihood of a meniscal tear, whereas a negative test result provides little additional information.

	Truth		
	Meniscal Tear Present	Meniscal Tear Absent	
McMurray test Positive	a 13	b 3	a+b 16
Negative	c 37	d 47	c+d 84
	a+c 50	b+d 50	a+b+c+d 100

TABLE 5. Sample calculation of predictive values.

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be to falsely label many patients as having problems they truly do not have.

SUMMARY

This paper describes the technical and test characteristics of the McMurray test. It suggests that the greatest gain in diagnostic accuracy can be

achieved in patients whose histories suggest a moderate chance (about a 30 to 70% chance) of having the condition of interest. Finally, and as a principle that goes beyond the McMurray test, readers are warned that the exhaustive examination approach may lead to labeling patients with problems that truly do not exist. JOSPT

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