

2012

# Diagnostic Accuracy of the Thessaly Test for Predicting Meniscal Tears in Patients aged 15 to 50 as Measured by Sensitivity, Specificity, and Likelihood Ratios

John Peixoto  
*Pacific University*

Alexandra Tarpo  
*Pacific University*

Follow this and additional works at: <http://commons.pacificu.edu/ptcats>



Part of the [Physical Therapy Commons](#)

## Notice to Readers

This work is not a peer-reviewed publication. Though the author of this work has provided a summary of the best available evidence at the time of writing, readers are encouraged to use this CAT as a starting point for further reading and investigation, rather than as a definitive answer to the clinical question posed or as a substitute for clinical decision-making.

Select copyrighted material from published articles may be included in this CAT for the purpose of providing a context for an informed critical appraisal. Readers are strongly encouraged to seek out the published articles included here for additional information and to further examine the findings in their original presentation. Copyrighted materials from articles included in this CAT should not be re-used without the copyright holder's permission.

---

## Recommended Citation

Peixoto, John and Tarpo, Alexandra, "Diagnostic Accuracy of the Thessaly Test for Predicting Meniscal Tears in Patients aged 15 to 50 as Measured by Sensitivity, Specificity, and Likelihood Ratios" (2012). *PT Critically Appraised Topics*. Paper 29.  
<http://commons.pacificu.edu/ptcats/29>

This Critically Appraised Topic is brought to you for free and open access by the School of Physical Therapy at CommonKnowledge. It has been accepted for inclusion in PT Critically Appraised Topics by an authorized administrator of CommonKnowledge. For more information, please contact [CommonKnowledge@pacificu.edu](mailto:CommonKnowledge@pacificu.edu).

---

# Diagnostic Accuracy of the Thessaly Test for Predicting Meniscal Tears in Patients aged 15 to 50 as Measured by Sensitivity, Specificity, and Likelihood Ratios

## **Disciplines**

Physical Therapy

## **Rights**

Terms of use for work posted in CommonKnowledge.

**Title: (Diagnosis)** Diagnostic Accuracy of the Thessaly Test for Predicting Meniscal Tears in Patients aged 15 to 50 as Measured by Sensitivity, Specificity, and Likelihood Ratios.

**Introduction:** For the purposes of our clinical question, we want to know what the research says about the diagnostic accuracy of the Thessaly test for diagnosing a meniscal tear in patients aged 15 to 50 in an outpatient orthopedic clinic setting. The recommended ‘gold standard’ for diagnosing a meniscal tear is both an initial MRI and arthroscopic knee examination (Harrison et al, 2009 and Konan et al., 2009). Research indicates that arthroscopic surgery provides approximately 90-95% accuracy in diagnosing a meniscal tear (Konan et al., 2009). Additionally, MRI is capable of identifying meniscal tears with 95% accuracy (Karachilos T et al., 2005). On the other hand, the diagnostic accuracy of various older clinical tests— the Joint Line Tenderness and the McMurray tests— has been questioned and conflicting results have been provided. While these two tests are currently the most widely used, they do not consistently provide an accurate meniscal diagnosis. Recently, a newly developed Thessaly test has been added to this array of clinical tests as researchers continue to search for which is most accurate. While arthroscopic surgery and MRI are the gold standards, researchers continue to search for an inexpensive clinical test that can detect a meniscal tear early and accurately.

**Clinical Scenario:** During our first clinical internship, in two different outpatient orthopedic clinics, we were able to assist in treating patients with various knee injuries. From total knee replacements to repaired anterior cruciate ligaments, the knee was without a doubt the most commonly injured joint within our clinics. While our patients experienced an array of knee injuries, the most frequently observed and were meniscal tears. Throughout our four week internship, we learned of a variety of physical diagnostic tests available for determining if a meniscal tear is present. However, we are unsatisfied with the accuracy that current research has reported for the commonly used McMurray and Joint Line Tenderness tests. In this critically appraised topic, we wish to assess if the Thessaly Test can improve one’s clinical decision of a meniscal tear by providing relatively high diagnostic accuracy, sensitivity, and specificity values in comparison to a Magnetic Resonance Imaging of the knee, the McMurray Test, and the Joint Line Tenderness Test.

**Clinical Question:** Does the Thessaly test accurately detect meniscal tears in individuals aged 15 to 50 years old in comparison to MRI, the McMurray Test, and the Joint Line Tenderness Test?

**Clinical PICO:**

**P-** Outpatient physical therapy patients aged 15 to 50.

**I-** Thessaly test with 20° knee flexion

**C-** Medical Resonance Imaging, McMurray Test, Joint Line Tenderness Test

**O-** Specificity, Sensitivity, Likelihood ratios, and Diagnostic Accuracy

**Overall Clinical Bottom Line:**

Based on the results of the outcomes from Karachalios et al., Konan et al., and Harrison et al., the Thessaly test does demonstrate a consistently high accuracy with regards to detecting meniscal tears. While both Karachalios et al. and Harrison et al. reported high sensitivity, specificity, and diagnostic accuracy values for the Thessaly test with 20° knee flexion, Konan et al. conveyed results that demonstrated limitations of the test to accurately predict meniscal tears. According to Karachalios, the Thessaly test with 20° knee flexion provided the highest average sensitivity and specificity values of 89% and 97% respectively for the medial meniscus. Similarly, it provided the highest sensitivity and specificity values of 92% and 96% respectively for the lateral meniscus. Additionally, the test indicated the highest diagnostic accuracy of 94% and 96% for the medial and lateral menisci respectively. Harrison et al also reported high sensitivity, specificity, and diagnostic accuracy values for the Thessaly Test with 20° knee flexion of 90.3%, 97.7%, 88.8% respectively. In light of the results from these two studies, we feel confident in the test's ability to accurately diagnose meniscal tears in adults with chronic knee symptoms that are consistent with a meniscal injury. Still, more research is necessary regarding the Thessaly test, as indicated by the drastically low sensitivity and diagnostic accuracy values reported by Konan et al. Overall, we feel that based upon overwhelming research and clinical experience, the Thessaly Test with 20° knee flexion is a useful tool for diagnosing meniscal tears.

Although the Thessaly test with 20° knee flexion has a consistently high diagnostic accuracy, we have several concerns regarding its ability to safely predict meniscal tears for the general population. Our first concern involves the neglect of each group of researchers to include patients who were acutely injured. This flaw limits the ability of the results from each study to be extrapolated to the general population. Another primary concern regarding the Thessaly test relates to the stress it places upon the patient's knee. According to Karachalios, several of the patients experienced aggravated knee symptoms during testing, requiring the use of analgesic tablets and one subject experienced severe knee locking.

We feel that the Thessaly test is accurate in predicting meniscal tears but still further research is needed. Despite our concerns, the Thessaly test is easy, inexpensive, and available. Although MRI and arthroscopic surgery remain as the gold standards for diagnosing meniscal tears, it is important to continue to look for a cheaper and easier method. While we believe that further research is necessary, the Thessaly test should be used to help accurately diagnose meniscal tears prior to receiving an expensive and time consuming MRI.

**Search Terms:** Thessaly test, meniscal tear, knee injury, physical examination, diagnosis of meniscal tears.

**Appraised By:** John Peixoto, SPT & Alexandra Tarpo, SPT

School of Physical Therapy

College of Health Professions

Pacific University

Hillsboro, OR 97213

[Peix6895@pacificu.edu](mailto:Peix6895@pacificu.edu) & [Tarp4100@pacificu.edu](mailto:Tarp4100@pacificu.edu)

**Rational for Chosen Articles:**

For the purpose of this CAT demonstration, we chose to select three articles that focused entirely on an adult population ranging in age from 15 to 50 years of age that assessed the Thessaly test using sensitivity, specificity, and diagnostic accuracy values. Our criteria for selection was based on which study had the best research design while also answering our clinical question of whether or not the Thessaly Test is more accurate in diagnosing meniscal tears compared to the McMurray and Joint Line Tenderness test.

**Table 1:** Comparison of Articles QUADAS Scores:

	<b>Karachalios et al</b>	<b>Konan et al</b>	<b>Harrison et al</b>
<b>Was the spectrum of patients representative of patients who will receive the test in practice?</b>	Y	Y	Y
<b>Were selection criteria clearly described?</b>	Y	Y	U
<b>Is reference standard likely to correctly classify target condition?</b>	Y	Y	Y
<b>Is time period between reference standard and index test short enough to be reasonably sure the target condition did not change between the two tests?</b>	Y	U	U
<b>Did the whole sample or random selection of the sample receive verification using a reference standard of diagnosis?</b>	Y	Y	Y
<b>Did patients receive the same reference standard regardless of index test result?</b>	Y	Y	Y
<b>Was the reference standard independent of the index test?</b>	Y	Y	Y
<b>Was the execution of the index test described in sufficient detail to permit replication of the test?</b>	Y	Y	Y
<b>Was execution of the reference standard described in sufficient detail to permit replication of the test?</b>	Y	N	N
<b>Were the index test results interpreted without knowledge of the results of the reference standard?</b>	U	U	U
<b>Were the reference standard results interpreted without knowledge of the results of the index test?</b>	U	U	U
<b>Were the same clinical data available when test results were interpreted as would be available when the test is used in practice?</b>	Y	Y	Y
<b>Were uninterpretable/intermediate test results reported?</b>	N	N	N
<b>Were withdrawals from the study explained?</b>	Y	Y	Y
<b>TOTAL SCORE:</b>	<b>8/14</b>	<b>9/14</b>	<b>8/14</b>

\* Y=yes, N=no, U=unclear

**Article #1:** Karachalios T, Hantes M, Zibis A, Zachos V, Karantanas A, Konstantinos M. (2005). Diagnostic Accuracy of a New Clinical Test (the Thessaly Test) For Early Detection of Meniscal Tears. *The Journal of Bone & Joint Surgery* 87 (5), 954-961.

**Clinical Bottom Line:** The Thessaly Test with 20° knee flexion is the most consistently accurate of the five clinical tests for diagnosing meniscal tears in an adult population. Comparing all five tests, the Thessaly Test with 20° knee flexion demonstrated the highest average sensitivity and specificity values of 89% and 97% respectively for the medial meniscus. Similarly, it provided the highest sensitivity and specificity values of 92% and 96% respectively for the lateral meniscus. Additionally, the test indicated the highest diagnostic accuracy of 94% and 96% for the medial and lateral menisci respectively. Thus, we feel confident in the test's ability to accurately diagnose meniscal tears in adults suffering from chronic knee symptoms that are consistent with a meniscal injury. However, we are concerned about both its ability to accurately diagnose acutely injured patients and the stress that it places upon the knee joint. Overall, our patients will be happy to know that they can receive an inexpensive and accurate test rather than a pricey and time consuming MRI.

**Article PICO:**

**P-**Adult population between the ages of 18 and 55 who experienced a knee injury at least four weeks prior to study.

**I-**Thessaly Test (5° of knee flexion) and Thessaly Test (20° of knee flexion).

**C-**Magnetic Resonance Imaging, McMurray Test, Joint Line Tenderness.

**O-**Specificity, Sensitivity, and Diagnostic Accuracy.

**Representative Sample:** The subjects who participated within the study were reasonably representative of the patients treated within our orthopedic clinics. However, because the researchers did not include patients with acute knee injuries, the applicability of the results from this study are limited.

**Blind Comparison:** Each subject was evaluated by a pair of both experienced and inexperienced researchers who were blinded to the outcome of the MRI. Conversely, the subjects were not blinded to their group allocation. However, this did not serve as a weakness because the diagnostic tests did not require input from the subjects.

**Independent Reference Standard:** All subjects were evaluated using the four diagnostic tests as well as the gold standard of a magnetic resonance image. However, there was no overlap between the tests and the MRI, implying that all tests were performed independently.

**Reliability of Clinical Test and Reference Test:** The authors did not report their own reliability values for each of the diagnostic tests nor did they cite the reliability from other researchers. However, each subject underwent two separate rounds of testing facilitated by two different sets of examiners in order to

improve the reliability of their results. Additionally, the authors reported to have performed an error analysis prior to performing the experiment, but failed to mention any exact values.

**Ascertainment:** During the length of the study, all patients who performed the four meniscal diagnostic tests were also assessed with a diagnostic MRI.

**Validation in Second Independent Sample:** The authors did not reference any similar study that evaluated these diagnostic tests.

**The Study:**

Using both a control group and a convenience sampling technique, the authors conducted a study over an 11 month period that attempted to compare the sensitivity and specificity of the McMurray Test, the Joint Line Tenderness Test, and the Thessaly Test at both 5° and 20°. The authors also evaluated the Apley Test; however, due to its minimal use in our clinics, this test is not applicable to our clinical question. Overall, their goal was to identify which of the tests was most accurate in diagnosing a meniscal tear and compare the results to the gold standard of MRI.

The study focused on adults between the ages of 18 and 55 that were categorized into two groups, including 213 symptomatic subjects (experimental group) and 197 asymptomatic subjects (control group). Symptomatic subjects were reported to have had an initial diagnosis of a meniscal tear based on their conveyed mechanism of injury at least four weeks prior to the study. Exclusion criteria for the experimental group included a history of knee surgery, musculoskeletal pathologies, indications of osteoporosis, and disorders of the synovium. Asymptomatic subjects had neither knee symptoms nor a history of knee disorders. Both groups were reported to be similar with regard to age, gender, body weight, and the knee being tested. Subjects in both groups were evaluated by two pairs of blinded examiners for all four diagnostic tests.

Each test was administered to all 410 subjects followed by MRI for comparison. Specifically, the Joint Line Tenderness is performed by palpating the lateral and medial sides of knee joint near the location of each meniscus. Any pain reported is recorded as a positive test. The McMurray Test involves applying a valgus or varus compressive stress while the knee is extended and the tibia is rotated. Additionally, the Thessaly Test is accomplished by having the subject stand on one foot and internally and externally rotate the knee while flexing the knee at either 5° or 20°. Both the McMurray and Thessaly test are positive if the patient reports any locking or catching accompanied with pain. Overall, all four diagnostic tests were assessed in terms of their ability to accurately report meniscal tears as compared to MRI.

**Summary of Internal Validity:** While the study contained several threats to internal validity, it also included many strong components as well. One of the major threats included the failure of the authors to perform a power analysis. Failure to report such values impairs the ability of the study's results to be

applied to both our clinical population and society as whole. Additionally, the authors neglected to report both reliability and validity values for the examiners who were facilitating the diagnostic tests. Despite their attempt to use two sets of examiners to help improve the reliability of the tests, we believe this to be a minor threat to their study. Although the groups were not randomized, this threat does not appear to affect the outcomes of the study.

In addition to the above mentioned threats to internal validity, the authors also included several strong factors within their study. Specifically, each subject received initial screening for age, gender, body weight, and knee history to ensure that no substantial disparities existed at baseline. This increases the likelihood that all of the subjects were similar enough to rule out inter-subject differences and maturation; thus, improving the quality of the results. Also, the examiners who assessed baseline and post-treatment values were blinded to group allocation and the condition of each subject. Blinding the raters ensured that the expectations of the examiners themselves had minimal effect on the measurements recorded for each subject. In addition, using a control group helps to improve the quality and strength of the study. Despite their neglect to perform a power analysis, the examiners used a large population that may be sufficient in allowing the results to be extrapolated to the general population.

**Evidence:**

In their results, the authors reported that the sensitivity, specificity, and diagnostic accuracy values were consistently the highest for the Thessaly Test with 20° knee flexion followed by the Thessaly Test with 5° knee flexion, The Joint Line Tenderness Test, and The McMurray Test. Due to its extreme dominance over the other four tests, we chose to only perform an in-depth analysis of the Thessaly Test with 20° knee flexion. Using the data recorded by the authors, we constructed *Tables 1 (medial meniscus)* and *2 (lateral meniscus)* below that demonstrate the sensitivity, specificity, likelihood ratios, and diagnostic accuracies for each of the tests. In addition, we constructed *Tables 3 and 4* to display the subject outcomes for the Thessaly Test with 20° knee flexion.

**Table 1** Diagnostic test values for medial meniscal tears reported using the McMurray Test, the Joint Line Tenderness Test, the Thessaly Test with 5° knee flexion, and the Thessaly Test with 20° knee flexion for symptomatic and asymptomatic patients.

	<b>The McMurray Test:</b>	<b>The Joint Line Tenderness Test:</b>	<b>The Thessaly Test with 5° knee flexion</b>	<b>The Thessaly Test with 20° knee flexion</b>
<b>Sensitivity</b>	48%	71%	66%	89%
<b>Specificity</b>	94%	87%	96%	97%
<b>False Positive</b>	4.2%	8.8%	2.9%	2.2%
<b>False Negative</b>	17.6%	10%	11.4%	3.6%
<b>Positive Likelihood Ratio</b>	NA	NA	NA	26.86
<b>Negative Likelihood Ratio</b>	NA	NA	NA	0.11
<b>Diagnostic Accuracy</b>	78%	81%	86%	94%

NA: Not applicable to clinical question

**Table 2** Diagnostic test values for lateral meniscal tears reported using the McMurray Test, the Joint Line Tenderness Test, the Thessaly Test with 5° knee flexion, and the Thessaly Test with 20° knee flexion for symptomatic and asymptomatic patients.

	<b>The McMurray Test:</b>	<b>The Joint Line Tenderness Test:</b>	<b>The Thessaly Test with 5° knee flexion</b>	<b>The Thessaly Test with 20° knee flexion</b>
<b>Sensitivity</b>	65%	78%	81%	92%
<b>Specificity</b>	86%	90%	91%	96%
<b>False Positive</b>	12.4%	9.3%	8%	3.7%
<b>False Negative</b>	3.2%	2%	1.7%	0.73%
<b>Positive Likelihood Ratio</b>	NA	NA	NA	22.85
<b>Negative Likelihood Ratio</b>	NA	NA	NA	0.08
<b>Diagnostic Accuracy</b>	84%	89%	90%	96%

NA: Not applicable to clinical question

**Table 3** Results of medial meniscal tears reported from Thessaly Test with 20° knee flexion for symptomatic and asymptomatic patients.

	<b>+ True</b>	<b>- True</b>	
<b>+ Trial</b>	124	9	<b>133</b>
<b>- Trial</b>	15	262	<b>277</b>
	<b>139</b>	<b>271</b>	<b>410</b>

**Table 4** Results of lateral meniscal tears reported from Thessaly Test with 20° knee flexion for symptomatic and asymptomatic patients.

	<b>+ True</b>	<b>- True</b>	
<b>+ Trial</b>	34	15	<b>49</b>
<b>- Trial</b>	3	358	<b>361</b>
	<b>37</b>	<b>373</b>	<b>410</b>

**Discussion:**

The authors conducted a well-controlled study that is relatively applicable to our clinical population. Ultimately, of the 213 symptomatic subjects, 130 were determined to have a medial meniscal tear and 37 had a lateral meniscal tear based on MRI. Of the 197 asymptomatic subjects, nine had a medial meniscal tear determined by MRI. It is important to note that the pretest probability of 25% used in our calculations for subjects with a history of knee problems was chosen based on our previous clinical experience. Also, 3.3% of the subjects receiving the Thessaly Test experienced aggravated knee symptoms during testing, requiring the use of analgesic tablets and one subject experienced severe knee locking. Ultimately, the Thessaly Test with 20° knee flexion demonstrated the best diagnostic accuracy for detecting both medial and lateral meniscal tears.

All four tests were analyzed in terms of their specificity, sensitivity, and diagnostic accuracy. Specificity refers to the number of true condition negatives (no meniscal tear) that are identified by a negative test. On the other hand, sensitivity is the number of true condition positives (meniscal tear) that are identified by a positive test. Overall, the Thessaly Test with 20° knee flexion demonstrated the highest specificity, sensitivity, and diagnostic accuracy values for both the medial and lateral meniscal trials. Comparing all five tests, the Thessaly Test with 20° knee flexion demonstrated the highest average sensitivity and specificity values of 89% and 97% respectively for the medial meniscus. Similarly, it provided the highest sensitivity and specificity values of 92% and 96% respectively for the lateral meniscus. With a specificity of 96%, we can consistently expect a positive test to rule in a lateral meniscal tear. Conversely, a sensitivity value of 92% indicates that we can consistently expect a negative test to rule out a lateral meniscal tear. The 95% confidence interval for the specificity of the medial meniscal trials was determined to range from 94.9% to 98.4%. Thus, we can expect the specificity for the Thessaly Test with 20° knee flexion to range from 94.9% to 98.4%, ninety-five percent of the time. Additionally, the 95% confidence interval for the sensitivity of the medial meniscal trials ranged from 84.1% to 94.4%. The 95% confidence intervals for the specificity and sensitivity of the lateral meniscal trials were 94.1% to 97.9% and 83.1% to 100.7% respectively. Additionally, the test indicated the highest diagnostic accuracy of 94% and 96% for the medial and lateral menisci respectively. Positive and

negative likelihood ratios were also performed. For the medial meniscal trials, a positive likelihood ratio of 26.86 indicates that a subject with a positive test is 26.86 times more likely to have a medial meniscal tear than someone without a positive test. Thus, the chances of having a medial meniscal tear for someone with a positive test would increase from his or her 25% pretest probability to 91%. Additionally, a positive likelihood ratio of 22.85% indicates that a subject with a positive test is 22.85 times more likely to have a lateral meniscal tear than someone without a positive test. Thus, the chances of having a lateral meniscal tear for someone with a positive test would increase from his or her 25% pretest probability to 88%.

Ultimately, the Thessaly Test with 20° knee flexion is a quick and cost-effective test that is also exceptionally accurate. However, we are concerned about the accuracy of the test for detecting meniscal tears in acute patients due to lack of research. Overall, our patients will be happy to know that they can receive an inexpensive and accurate test rather than a pricey and time consuming MRI.

#### **Applicability of Study Results:**

##### **Clinical Test Availability/Affordability/Accuracy:**

The Thessaly Test with 20° knee flexion is both easy and inexpensive. We feel confident in the test's ability to accurately diagnose both medial and lateral meniscal tears in adults suffering from chronic knee symptoms that are consistent with a meniscal injury. However, we are concerned about its ability to accurately diagnose acutely injured patients. Overall, our patients will be happy to know that there is a more simple option for diagnosing a meniscal tear rather than a pricey and time consuming MRI.

##### **Summary of External Validity:**

The results of the study are applicable to adults who are experiencing chronic knee symptoms that are associated with a common meniscal mechanism of injury.

**Article #2:** Konan S, Rayan F, Haddad FS. (2009). Do Physical Diagnostic Tests Accurately Detect Meniscal Tears. *Knee Surg Sports Traumatol Arthrosc.* 17:806-811.

#### **Clinical Bottom Line:**

The Thessaly test, both with 5° and 20° of knee flexion, is considered less than accurate in predicting meniscal tears. The study examined in this report included 109 patients aged 16 to 56 years old with symptoms pointing to meniscal pathology. The Thessaly test at 20° of knee flexion provided a higher diagnostic accuracy, as well as higher sensitivity and specificity values compared to the Thessaly test at 5° of knee flexion. However, the Joint Line Tenderness test provided the best sensitivity for both medial and lateral menisci with values of 83% and 68% respectively. It also provided the best specificity values of both medial and lateral menisci with values of 76% and 97% respectively. The diagnostic accuracy is also higher for the Joint Line Tenderness test at a value of 81% for the medial meniscus and

90% for the lateral meniscus. The sensitivity for the Thessaly test with 20° of knee flexion was 59% for the medial meniscus and 31% for the lateral meniscus. The specificity for the Thessaly test with 20° of knee flexion was 67% for the medial meniscus and 95% for the lateral meniscus. The Thessaly test with 20° of knee flexion was reported to have a diagnostic accuracy value of 61% and 80% for the medial and lateral menisci respectively. The study presented with several threats to internal validity including poor selection, inadequate power, and lack of a control-group. The Thessaly test seems to be applicable to patients of both genders aged 15 to 50 years old that present with symptoms similar to that of a meniscal pathology, except for patients experiencing acute knee injuries or patients in a primary care setting. However, the Thessaly test has not been proven accurate in predicting a meniscal tear.

**Article PICO:**

**P**-Adult population between the ages of 16 and 56 who experienced symptoms similar to that of a common meniscal pathology.

**I**-Thessaly test with 5° degrees of knee flexion, Thessaly test with 20° of knee flexion, McMurray test, and Joint Line Tenderness test.

**C**-Diagnostic Magnetic Resonance Imaging (MRI) and arthroscopic knee examination.

**O**-Specificity, sensitivity, positive and negative predictive values, positive and negative likelihood ratios, and diagnostic accuracy.

**Representative Sample:**

The subjects represented in the article were relatively representative of the types of patients that we observed during our first clinical internship in outpatient orthopedic settings. However, the researchers did not include patients with acute knee injuries, which limits the applicability of the results from this study.

**Blind Comparison:**

The individual who was assigned to examine each patient was blinded to the following information: history, site or nature of the meniscal tear, details of the procedure to be performed, associated injuries, and MRI findings. However, the authors did not state whether or not the individuals determining the results of the MRI or the single specialist arthroscopic knee surgeon were blinded to the information mentioned above. More so, it was also not stated whether the patients were blinded. However, this does not serve as a threat to internal validity because the diagnostic tests are objective and not subjective.

**Independent Reference Standard:**

There was no overlap between the four physical diagnostic tests, the arthroscopic knee examination, and MRI.

**Reliability of Clinical Test and Reference Test:**

The authors stated that the Joint Line Tenderness test and the McMurray's test have been reported to have low specificity, sensitivity, and diagnostic accuracies; thus, limiting their usefulness in diagnosing meniscal tears. However, the authors did not cite references or values to support their statements. Citations were provided by the authors for the diagnostic accuracy of the Thessaly test at 20° of knee flexion. Diagnostic accuracy was reported as 94% and 96% for detecting tears of the medial and lateral meniscus respectively. Additionally, the authors cited references implicating an increase in diagnostic accuracy of the MRI scan and 90-95% diagnostic accuracy for arthroscopic knee examination.

**Ascertainment:**

During the length of the study, all patients who performed the four physical diagnostic tests were also assessed with diagnostic MRI and underwent an arthroscopic knee examination.

**Validation in a Second Independent Sample:**

There was not a second sample.

**The Study:**

The patients selected for this study were registered between October 2006 and April 2007. There were 109 patients, both male and female (80 males and 29 females), with ages ranging from 16 to 56 years old. An individual was included in the study if they presented with symptoms similar to that of a meniscal pathology. Patients were asked for information on history of knee injuries, symptoms of knee pain or discomfort, 'clicking' sensation during movement of the knee, locking of the knee, and swelling of the knee. An individual was excluded from the study if they did not consent for the diagnostic tests or if they did not feel they were able to perform the maneuvers because of either anxiety or pain. Each patient underwent a diagnostic MRI and an arthroscopic knee examination. Additionally, each patient was observed by an independent observer for all four physical diagnostic tests—the Thessaly test with 5° of knee flexion, the Thessaly test with 20° of knee flexion, the McMurray's test and the Joint Line Tenderness test.

During the assessment session, each patient performed the four physical diagnostic tests in order to determine if a meniscal tear was present. The details of the tests were explained at which point each patient was required to consent to performing each test. Each patient was independently evaluated by the assigned blinded rater. The authors provided a detailed procedure for performing all but the Joint Line Tenderness test.

**Summary of Internal Validity:**

The internal validity of the study was 'fair' to 'poor'. The study presented with several threats to internal validity including inter-subject differences, poor selection, and lack of a control-group. The authors did screen each subject for age and sex, however, this information was not used to control for

inter-subject differences. With regards to selection, the authors failed to mention where and how they obtained patients for this particular study. This limits our knowledge of the authors' selection process, which could have led to erroneous conclusions if randomization did not occur. Additionally, the study lacks information on whether or not a power of analysis was performed to properly estimate the adequate number of necessary participants for the study. Lastly, the study lacked a control group. However, due to the nature of this study, a control group is not logical. This limits the author's ability to eliminate such conflicts as patient history.

Despite the presented threats to internal validity, the study did demonstrate several strong components. During the length of the study no subjects were lost. This indicates a safe and secure study which was able to examine whether meniscal tears were present in a manner that was within each patient's comfort level.

**Evidence:**

The outcome measures related to our clinical question are sensitivity, specificity, likelihood ratios and diagnostic accuracy of the Thessaly test with 5° of knee flexion, the Thessaly test with 20° of knee flexion, the McMurray test and the Joint Line Tenderness test. All meniscal injuries which were visualized on MRI were later confirmed with an arthroscopic knee examination.

Results for sensitivity, specificity, likelihood ratios, and diagnostic accuracy of the four physical diagnostic tests are presented in *Table 5* (shown below). The comparisons are made between the data presented from all four physical diagnostic tests from each patient. The authors gave the values.

Pre-test probability, positive and negative post-test probabilities for the Thessaly test with 20° of knee flexion and Joint line tenderness test are shown below in *Tables 6 and 7*. We decided to include the results of the Thessaly test with 20° of knee flexion because our clinical question focuses on the Thessaly test as an effective diagnostic tool. The Joint Line Tenderness test was assessed due to its high sensitivity and specificity values. In determining the pre-test probabilities, we used a 25% pre-test probability as indicated by our clinical experience. These pre-test probabilities plus sensitivity and specificity were used to calculate the positive and negative post-test probabilities for each individual diagnostic test.

**Table 5** Outcome Measures for Physical Diagnostic Tests with Medial and Lateral Menisci Comparisons.

Physical Diagnostic Test	Sensitivity (95% CI)	Specificity (95% CI)	Positive Likelihood Ratio (95% CI)	Negative Likelihood Ratio (95% CI)	Diagnostic Accuracy (95% CI)
<b>Thessaly Test with 5° knee flexion</b>	*N/A	Medial meniscus: 68% (47,84) Lateral meniscus: 89% (78,94)	Medial meniscus: 1 (1-2) Lateral meniscus: 1 (0-59)	Medial meniscus: 0.9 (0.8-1) Lateral meniscus: 1 (0.8-1)	Medial meniscus: 49% (38,60) Lateral meniscus: 71% (61,80)
<b>Thessaly Test with 20° knee flexion</b>	Medial meniscus: 59% (47,71) Lateral meniscus: 31% (15,54)	Medial meniscus: 67% (45,83) Lateral meniscus: 95% (87,98)	Medial meniscus: 2 (1-2) Lateral meniscus: 6 (2-25)	Medial meniscus: 0.6 (0.5-1) Lateral meniscus: 0.7 (0.6-1)	Medial meniscus: 61% (50,71) Lateral meniscus: 80% (70,87)
<b>McMurray Test</b>	Medial meniscus: 50% (38,62) Lateral meniscus: 21% (9,43)	Medial meniscus: 77% (57,90) Lateral meniscus: 94% (85,98)	Medial meniscus: 2 (1-3) Lateral meniscus: 3 (0.3-35)	Medial meniscus: 0.6 (0.6-0.7) Lateral meniscus: 0.8 (0.8-1)	Medial meniscus: 57% (46,67) Lateral meniscus: 77% (67,85)
<b>Joint Line Tenderness Test</b>	Medial meniscus: 83% (71,90) Lateral meniscus: 68% (46,85)	Medial meniscus: 76% (55,89) Lateral meniscus: 97% (89,99)	Medial meniscus: 3 (2-5) Lateral meniscus: 22 (8-64)	Medial meniscus: 0.2 (0.2-0.3) Lateral meniscus: 0.3 (0.2-0.4)	Medial meniscus: 81% (71,88) Lateral meniscus: 90% (82,95)

\*Authors did not report information

**Table 6:** Pre-test Probability, Positive Post-test Probability and Negative Post-test Probability for the Thessaly test with 20° of knee flexion.

Thessaly test with 20° of knee flexion	Medial Meniscal Tears	Lateral Meniscal Tears
<b>Pre-test Probability</b>	25%	25%
<b>Positive Post-test Probability</b>	37%	67%
<b>Negative Post-test Probability</b>	17%	19%

**Table 7:** Pre-test Probability, Positive Post-test Probability and Negative Post-test Probability for the Joint Line Tenderness test.

<b>Joint line tenderness test</b>	<b>Medial Meniscal Tears</b>	<b>Lateral Meniscal Tears</b>
<b>Pre-test Probability</b>	25%	25%
<b>Positive Post-test Probability</b>	54%	88%
<b>Negative Post-test Probability</b>	7%	10%

**Discussion:**

The study examined in this report is relatively applicable to our clinical population. It is important to note that the authors of this study did not discuss any results of potential pre-test probabilities. We decided to use a statistical calculator to calculate the post-test probabilities and report the results with their associated likelihood ratio values. Ultimately, the Thessaly test is considered less than accurate in predicting meniscal tears.

The diagnostic accuracy of the Thessaly Test with 5° of knee flexion, the Thessaly test with 20° of knee flexion and the McMurray test for the medial and lateral menisci respectively were: 49% and 71%, 61% and 80%, 57% and 77%. However, the Joint Line Tenderness test presented with the greatest diagnostic accuracy for the medial and lateral menisci 81% and 90% respectively. These results demonstrate that the Joint line tenderness has a greater ability to discriminate between a 'healthy' knee and one that contains a meniscal tear than the other three physical diagnostic tests.

When assessing sensitivity and specificity regarding all four diagnostic tests, the highest sensitivity for the medial and lateral menisci of 83% and 68% was provided by the Joint Line Tenderness test. Such a relatively high sensitivity alludes to a fairly consistent ability to expect a negative test to predict an absence of a meniscal tear. The Thessaly test with 20° of knee flexion followed with sensitivity for the medial and lateral menisci of 59% and 31% respectively. Such a low sensitivity alludes to an inconsistent ability to expect a negative test to predict a lack of meniscal tear. The highest specificity for the medial and lateral menisci of 76% and 97% was also provided by the Joint Line Tenderness test. This provides a consistent ability to expect a positive test to predict a meniscal tear in a patient presenting with a knee pathology. Following the Joint line tenderness test with the second highest specificity value for both the medial and lateral menisci was the McMurray test at 77% and 94% respectively.

The Joint Line Tenderness test resulted in the highest sensitivity and specificity values. This indicates that the Joint Line Tenderness test is the most accurate in predicting when a patient may or may not have a meniscal tear. A patient with a medial meniscal tear is 3 times more likely to have a positive test result when performing the Joint Line Tenderness test. Therefore, the ability of this test to determine a meniscal tear increases from a pre-test probability of 25% to a positive post-test probability of 54%. Additionally, a patient with a lateral meniscal tear is 22 times more likely to have a positive test result when performing the Joint line tenderness test. Thus, the ability of this test to determine a meniscal tear increases from 25% to 88%.

The Thessaly test performed at 20° of knee flexion resulted in higher sensitivity and specificity values than when performed at 5° of knee flexion. A patient with a medial meniscal tear is 2 times more likely to have a positive test result when performing the Thessaly test at 20° of knee flexion. Therefore, the ability of this test to determine a meniscal tear increases from a pre-test probability of 25% to a positive post-test probability of 37%. Additionally, a patient a lateral meniscal tear is 6 times more likely to have a negative test result when performing the Thessaly test with 20° of knee flexion. Thus, the ability of this test to determine a meniscal tear increases from 25% to 67%.

According to the provided results, the Thessaly test is not the most beneficial and accurate physical diagnostic test in predicting meniscal tears. The 95% CI presents a rather significant range of values demonstrating an inconsistency in the Thessaly test. Therefore, this test should not be used as a first step in the clinical screening of a meniscal tear.

#### **Applicability of Study Results:**

##### **Clinical Test Availability/Affordability/Accuracy:**

The patients represented in the article were reasonably representative of the types of patients that we saw for potential meniscal tears. The Thessaly at both 5° and 20° of knee flexion is available, affordable and easy to perform in a clinical setting. However, the Thessaly test demonstrated to be less accurate than both the Joint Line Tenderness test and the McMurray test when completed with 5° of knee flexion. With regards to the Thessaly test at 20° of knee flexion, the authors demonstrated that it is more accurate than the Thessaly test with 5° of knee flexion and the McMurray test.

The results of the Thessaly test may help determine if a patient needs an orthopedic referral. The results of this study presented us with two concerns. Firstly, the Thessaly test could make the symptoms of some patients worse. However, it could be determined that a patient may benefit from an easy and inexpensive test versus MRI or an arthroscopic knee examination. The second concern is that the results of the study may not hold true for individuals with acute knee injuries.

**Summary of external validity:**

The results of the study are applicable to adults who are experiencing chronic knee symptoms that are associated with a common meniscal mechanism of injury.

**Article #3:** Harrison BK, MD, Abell BE, DO, Gibson TW, DO. (2009). The Thessaly Test for Detection of Meniscal Tears: Validation of a New Physical Examination Technique for Primary Care Medicine. Clin J Sport Med. 19(1):9-12.

**The Clinical Bottom Line:**

The Thessaly test was proven to be a good predictor of meniscal tears. The study examined in this report included 116 patients aged 11 to 67 years old with symptoms pointing to a meniscal pathology. Sensitivity and specificity values for the Thessaly test were 90.3% and 97.7% respectively. The Thessaly test was reported to have a diagnostic accuracy of 88.8%. Assessed values from the Thessaly test would influence our clinical judgment when a positive or negative test outcome was consistent with the results provided from a detailed medical history. The study presented with two minor threats to internal validity including inter-subject differences and selection. The Thessaly test seems to be applicable to patients of both genders aged 15 to 50 years old that present with symptoms similar to that of a meniscal pathology. However, this physical diagnostic test may not be accurate in predicting a meniscal tear for patients experiencing acute knee injuries or patients in a primary care setting.

**Article PICO:**

**P-**Adult population between the ages of 11 and 67 who experienced a knee injury similar to the mechanism associated with a meniscal injury.

**I-**Thessaly test with 20° of knee flexion, assessment of an effusion, Joint Line Tenderness test, the McMurray test and the Apley compression test.

**C-**Intraoperative arthroscopic examination.

**O-**Specificity, sensitivity, positive and negative predictive values, positive and negative likelihood ratios, diagnostic accuracy, false positive and negative values.

**Representative Sample:**

The subjects used in the study were relatively representative of the types of patients that we observed in our orthopedic clinics. However, the researchers did not include patients with acute knee injuries. Thus, the applicability of the results are limited.

**Blind Comparison:**

It was not stated whether or not the individual who was assigned to examine each patient was blinded to the following information: history, site, or nature of the meniscal tear, details of the procedure to be performed, associated injuries, etc. Additionally, the authors did not state whether or not the

individuals determining the results of the arthroscopic knee examination were blinded to the information mentioned above. More so, it was also not stated whether the patients were blinded. However, this is not a threat to internal validity because the diagnostic tests are objective and not subjective.

**Independent Reference Standard:**

There was no overlap between the five physical diagnostic tests and the arthroscopic knee examination.

**Reliability of Clinical Test and Reference Test:**

The authors cited Resnick (1995) when reporting that the assessment of joint effusion, the Joint Line Tenderness test, the McMurray's test and the Apley compression test are difficult to perform and often produce errors in the diagnosis of meniscal injuries. Necessary citations were also provided by the authors when discussing conflicting results of the accuracy of the previously mentioned physical diagnostic tests. Stratford et al., reported that the most widely used McMurray test demonstrates sensitivity and specificity percentages of 52% and 97% respectively. However, other studies have shown the Joint Line Tenderness test to have a sensitivity of 75% and a specificity of 27%. Diagnostic accuracy for the Thessaly test was reported as being very high for detecting tears of the meniscus, according to Karachalios et al.

**Ascertainment:**

During the length of the study, all patients who performed the physical diagnostic tests also underwent an arthroscopic knee examination.

**Validation in a Second Independent Sample:**

There was not a second sample.

**The Study:**

The patients selected for this retrospective cohort study were selected between August 2005 and December 2006. There were 116 consecutively referred patients from the Department of Orthopedic Surgery at Dwight David Eisenhower Army Medical Center (DDEAMC). Patients were both male and female (59 males and 57 females), with ages ranging from 11 to 67 years old. The authors observed 66 right knees and 50 left knees. An individual was included in the study if they presented with symptoms similar to that of a meniscal pathology regardless of previous knee injuries. A clinical history and a physical examination were used to determine if there may be a meniscal pathology. An individual was included in the study if they had knee pain that was not responsive to physical therapy or any other non-operative treatments for 6 weeks or longer. Each patient also underwent an arthroscopic knee examination. The results of this examination were compared to the results of the physical diagnostic tests to determine if any meniscal injuries were present.

During the assessment session, each patient underwent a clinical examination that was conducted by one clinical faculty member. The examination included five physical diagnostic tests used to determine if a meniscal tear was present—the Thessaly test with 20° of knee flexion, assessment of an effusion, Joint Line Tenderness test, the McMurray test and the Apley compression test—in no particular order. All but the Joint Line Tenderness test were described in detail regarding their procedure.

**Summary of Internal Validity:**

The internal validity of the study was ‘good’. The study presented with two minor threats to internal validity: inter-subject differences and selection. The authors did screen each subject for age and sex, however, this information was not used to control for inter-subject differences. With regards to selection, the authors obtained their sample size through convenience sampling. This type of sampling could have led to erroneous conclusions and the results may not be able to be projected upon the general population.

Despite the presented threats to internal validity, the study did demonstrate some good controls. After each patient was observed through the physical diagnostic tests, each individual served as their own control by undergoing an arthroscopic knee examination to verify the results. This provided some accountability for inter-subject differences. During the duration of the study no subjects were lost. This indicates a safe and secure study, which was able to examine whether meniscal tears were present in a manner that was within each patient’s comfort level. Also, the authors performed a power analysis to properly estimate the adequate number of patients necessary for the study to be significant.

**Evidence:**

The outcome measures related to our clinical question are sensitivity, specificity, likelihood ratios and diagnostic accuracy of the Thessaly test with 20° of knee flexion, Joint Line Tenderness test, and the McMurray test. Assessment of an effusion and the Apley compression test were not analyzed as they do not pertain to our clinical question. The authors only reported the results of the Thessaly test with 20° of knee flexion. These outcome measures were calculated when comparing the results of all of the observed patients. Also, all meniscal injuries were later confirmed with an arthroscopic knee examination.

Results for sensitivity, specificity, likelihood ratios, and diagnostic accuracy were reported by the authors for the Thessaly test with 20° of knee flexion only and are presented in *Table 8* (shown below). The comparisons are made between the data presented from each patient. We obtained the 95% confidence interval (CI) values for sensitivity and specificity by inserting the positive and negative outcomes for the Thessaly test into a statistical calculator. The results are presented in *Table 8* (shown below).

*Table 9*, shown below, demonstrates the patients who obtained either a positive or negative outcome for a meniscal tear as demonstrated by the Thessaly test with 20° of knee flexion. These values

were also provided by the authors. Pre-test probabilities, as well as, positive and negative post-test probabilities are shown below in *Table 10*. In determining the pre-test probabilities, we used a 25% pre-test probability as indicated by our clinical experience. These pre-test probabilities plus sensitivity and specificity were used to calculate the positive and negative post-test probabilities.

**Table 8:** Outcome Measures for the Thessaly test with 20° of Knee Flexion.

Physical Diagnostic Test	Sensitivity (95% CI)	Specificity (95% CI)	Positive Likelihood Ratio	Negative Likelihood Ratio	Diagnostic Accuracy
Thessaly Test with 20° knee flexion	90.3% (0.849-0.957)	97.7% (0.950-0.1004)	39.3	0.09	88.80%

**Table 9:** Positive and Negative Outcomes for the Thessaly test with 20° of Knee Flexion and Meniscal Tears.

Thessaly Test with 20° of Knee Flexion	+ Meniscal Tear	- Meniscal Tear	Totals
Test +	65	1	66
Test -	7	43	50
Totals	72	44	116

**Table 10:** Pre-test Probability, Positive Post-test Probability and Negative Post-test Probability for the Thessaly test with 20° of knee flexion.

Thessaly test with 20° of knee flexion	Meniscal Tears
Pre-test Probability	25%
Positive Post-test Probability	93%
Negative Post-test Probability	3%

**Discussion:**

The study examined in this report is relatively applicable to our clinical population. It is important to note that the authors of this study did not report 95% CI values for sensitivity and specificity, but we were able to gather this information by using a statistical calculator. Also, the authors did not discuss any results of potential pre-test probabilities. We decided to use a statistical calculator to calculate

the probabilities and report the results with the likelihood ratio values. Ultimately, the Thessaly test with 20° knee flexion was demonstrated to be a good predictor of meniscal tears.

The Thessaly Test with 20° of knee flexion had a diagnostic accuracy of 88.8%. This result allows us to believe that this physical diagnostic test has a good ability to discriminate between a 'healthy' knee and one that contains a meniscal tear. When assessing sensitivity and specificity values regarding the Thessaly test with 20° knee flexion, the results were 90.3% and 97.7% respectively. Such a high sensitivity alludes to a fairly consistent ability to expect a negative test to predict a lack of a meniscal tear. A specificity of 97.7% provides a consistent ability to expect a positive test to predict a meniscal tear in a patient presenting with a knee pathology.

The results of the positive and negative likelihood ratios of the Thessaly test with 20° knee flexion were 39.3 and 0.09 respectively. This indicates that a patient with a meniscal tear is 39.3 times more likely to have a positive test result when performing the Thessaly test with 20° knee flexion. Therefore, the ability of the Thessaly test to determine a meniscal tear increases from a pre-test probability of 25% to a positive post-test probability of 93%. Vice versa, a patient without a meniscal tear is 0.09 times more likely to have a negative test result when performing the Thessaly test. Thus, the ability of the Thessaly test to rule out a meniscal tear decreases from 25% to 3%. Given the results of the likelihood ratios, it seems appropriate to state that it would be more useful to obtain a positive result on the Thessaly test than a negative result.

According to the provided results, the Thessaly test with 20° knee flexion is an accurate physical diagnostic test in predicting meniscal tears. The 95% CI presents a minor range of values demonstrating a consistency in the Thessaly test. Therefore, this test could be used as a first step in the clinical screening of a meniscal tear.

### **Applicability of Study Results:**

#### **Clinical Test Availability/Affordability/Accuracy:**

The patients represented in the article were reasonably representative of the types of patients that were seen for meniscal tears in our outpatient orthopedic clinical settings. However, the researchers did not include patients with acute knee injuries. Despite this limitation, the Thessaly test with 20° of knee flexion is available, affordable, easy to perform in a clinical setting, and accurate to some degree. If patients can tolerate performing the Thessaly test with 20° of knee flexion despite any presenting pain, then this can be considered a feasible clinical test. The financial cost and availability is not a concern as it would only be a minimal cost in time and money spent for one to be trained to appropriately assess patients with a possible meniscal pathology.

Data suggests that there is significance value for using the Thessaly test to diagnose meniscal tears. The validity and reproducibility of the Thessaly test may assist in determining if a patient needs an orthopedic referral.

The study did present with some limitations. The first concern for us is that the study only included one examiner limiting the strength of the provided conclusions. Also, the population in the study included patients already awaiting arthroscopy rather than patients with consecutive knee pain. This meant that the possibility of a meniscal tear was high, which likely increased the diagnostic accuracy of the Thessaly test. These limitations may decrease the ability of the results to be applied to a more general population.

**Summary of external validity:**

The external validity of this study is rated as ‘fair’. The Thessaly test seems to be applicable to a population between the ages of 15 and 50, excluding patients with acute knee injuries or patients from a primary care setting. The results can be extrapolated to a larger population because the inclusion criteria are very common for patients seen in our patient population. With the information presented, the Thessaly test individually is valid in accurately diagnosing a meniscal tear and can be used as a first-line clinical screening test. The internal validity of the study does not drastically compromise the ability to generalize the presented results.

**Overall Synthesis/Discussion:**

The original purpose of this Critically Appraised Topic was to determine if the Thessaly Test was more accurate than the McMurray and Joint Line Tenderness tests in diagnosing meniscal tears as compared to MRI. Overall, we feel that based upon overwhelming research and our clinical experience, the Thessaly Test with 20° knee flexion is a useful tool for diagnosing meniscal tears. However, we also feel that further research is needed to address several concerns. First and foremost, all three articles neglected to use acutely symptomatic patients. This flaw limits the ability of the results from each study to be extrapolated to the general population of orthopedic patients. Lastly, the invasiveness of the Thessaly test continues to be a major issue in clinical settings. Several patients within the three research studies as well as a few of our own patients experienced locking of the knee while performing the test.

After analyzing all three articles, we feel that the Thessaly test with 20° knee flexion is accurate in predicting meniscal tears but still further researched is needed. Despite our concerns and its low values for sensitivity, specificity, and diagnostic accuracy reported by Konan et al. , the Thessaly test is easy, inexpensive, and available. Although MRI and arthroscopic surgery remain as the gold standards for diagnosing meniscal tears, it is important to continue to look for a cheaper and easier method. While we

believe that further research is necessary, the Thessaly test should be used to help accurately diagnose meniscal tears prior to receiving an expensive and time consuming MRI.

**References:**

- Stratford PW, Binkley J. (1995). A Review of the McMurray test: definition, interpretation, and clinical usefulness. *J Orthop Sports Phys Ther.* 22:116-120.
- Karachalios T, Hantes M, Zibis A, Zachos V, Karantanas A, Konstantinos M. (2005). Diagnostic Accuracy of a New Clinical Test (the Thessaly Test) For Early Detection of Meniscal Tears. *The Journal of Bone & Joint Surgery.* 87(5):954-961.
- Konan S, Rayan F, Haddad FS. (2009). Do Physical Diagnostic Tests Accurately Detect Meniscal Tears. *Knee Surg Sports Traumatol Arthrosc.* 17:806-811.
- Resnick D. (1995). Internal Derangement of Joints. *Diagnosis of Bone and Joint Disorders.* 5(3):3076.
- Harrison BK, MD, Abell BE, DO, Gibson TW, DO. (2009). The Thessaly Test for Detection of Meniscal Tears: Validation of a New Physical Examination Technique for Primary Care Medicine. *Clin J Sport Med.* 19(1):9-12.