



Case series

Diagnostic value of clinical tests and Mri for meniscal injury in patients with anterior cruciate ligament injury: Case series study

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ABSTRACT

Introduction and importance: Meniscal tear is one of the most common knee injuries and knee surgery procedures. It is frequently associated with an anterior cruciate ligament (ACL) injury. We conducted this study, on patients with ACL reconstruction surgeries, which were occasionally accompanied by meniscal tears, in order to determine the diagnostic value of clinical examinations for meniscal tear, both individually and in combination, in correlations to magnetic resonance imaging (MRI) scans, with the goal of improving clinical diagnosis for patients with meniscal injuries in particular, as well as meniscal injuries associated with cruciate ligament knee injuries.

Case presentation: 50 patients were thoroughly clinically examined, using Joint line tenderness, Thessaly test, McMurray's test, Apley's test followed by MRI, before their scheduled ACL reconstruction arthroscopic surgeries. The meniscal tears were then identified during the procedure, and were treated, if necessary. The data before and after the surgery was taken into calculating, with arthroscopic findings serving as the gold standard. Results: the sensitivity, specificity and accuracy of each clinical tests and MRI scans respectively were: for medial meniscus, Joint line tenderness (70%; 53,3%; 60%); McMurray's test (80%; 73,3%; 76%); Apley's test (65%; 70%; 68%); Thessaly test (70%; 76,7%; 74%); MRI (90%; 83,3%; 86%); lateral meniscus: Joint line tenderness (73%; 66,7%; 70%); McMurray's test (69,2%; 75%; 72%); Apley's test (69,2%; 70,8%; 70%); Thessaly test (73,1%; 75%; 74%); MRI (88,5%; 87,5%; 88%). However, when combining at least two positive tests into a single composite test, the diagnostic value is considerably enhanced with sensitivity, specificity and accuracy of 85%, 73,3%, 78% for medial meniscus, 92,3%, 87,5%, 90% for lateral meniscus.

Clinical discussion: Clinical tests are essential for diagnosis of meniscal tears, although inconsistent. A composite test consisting of at least two positive tests can considerably enhance the diagnostic value, even comparable to MRI scans. However, after the clinical examination, MRI is still necessary for the diagnostic process of meniscal injuries in particular, as well as meniscal injuries associated with cruciate ligament knee injuries.

Conclusion: The combination of clinical tests and MRI images will give a precise diagnosis as well as surgical indication for meniscus injury in patients with anterior cruciate ligament tear.

1. Introduction

Meniscal tear is one of the most common knee injuries and knee surgery procedures. It is frequently associated with an anterior cruciate ligament (ACL) injury [1]. Meniscal tear diagnosis usually involves identifying, classifying, and grading lesions, which can assist surgeons in

providing appropriate and timely treatment plans (meniscectomy or conservation) [2,3]. Consequently, this is significantly vital in restoring knee joint movement as well as avoiding the unintended complications of meniscus injury, such as limited knee joint movement, muscle atrophy, osteoarthritis of the knee joint, or avoiding unnecessary surgical procedures, etc. [4]. Knee arthroscopy is considered the gold standard

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for detecting meniscal tears. However, arthroscopy is not recommended since it is a complicated invasive intervention that raises costs [5]. Meniscal injuries, in particular, as well as meniscal injuries associated with cruciate ligament knee injuries, have traditionally been diagnosed using clinical examinations and magnetic resonance imaging (MRI) with varying degrees of reliability [6]. MRI is recognized by many researchers as the primary method for diagnosing meniscus tears, with an accuracy rate of more than 85% [7,8]. Furthermore, MRI can also identify lesions, in terms of location and characteristics, and help surgeons to classify lesions, therefore providing appropriate treatment to patients [9,10]. Meanwhile, clinical examinations including the Joint line tenderness test, Thessaly test, McMurray's test, Apley's test frequently yielded inconsistent sensitivity and specificity in studies around the world, corresponding from 64%-89% and 58%-94% [11,12]. As a result, a meta-analysis study was conducted, which revealed that separated tests have a low diagnostic value, with sensitivity ranging from 60.7% - 70.5% and specificity ranging from 70.2% - 77.4% [13]. However, P. Antinolfi et al. in 2017 reported that performing a "composite test" (combining at least two tests) can significantly improve the sensitivity and specificity compared to each examination alone, with 91% and 87% respectively, potentially replacing the role of MRI [14].

As a matter of fact, during our ACL reconstruction surgeries, which were occasionally accompanied by meniscal tears, we also noticed a difference in diagnostic value when comparing clinical examinations and MRI scans to our findings of meniscal lesion in the arthroscopic surgeries. To clarify this disparity and further investigate the "composite test", we conducted this case series in order to determine the diagnostic value of clinical examinations, both individually and in combination, in correlations to MRI scans, with the goal of improving clinical diagnosis for patients with meniscal injuries in particular, as well as meniscal injuries associated with cruciate ligament knee injuries. Our case series has been reported in line with the PROCESS 2020 [22].

2. Materials & methods

2.1. Patients

From April 2017 to June 2018 at VietDuc University Hospital, Hanoi, Vietnam, 50 patients diagnosed with an ACL injury (with or without meniscus lesions) accepted to join our research. All the patients underwent ACL reconstruction arthroscopic surgery and the data before and after the surgery was taken into account (Table 1).

2.1.1. Selection criteria

Patients who underwent ACL reconstruction arthroscopic surgery, after clinical examination and MRI scans.

2.1.2. Exclusion criteria

Cases of meniscal pathology, such as discoid meniscus.

Patients with multi-ligament injuries.

Patients who refused to participate in the study.

2.2. Methods

2.2.1. Study design

Retrospective consecutive case series study, single institution center.

Table 1
Demographic data.

Age at surgery, y, mean \pm SD	31,8 \pm 9,7
Sex, male/total, n (%)	35/50 (70%)
Elapsed time (months) (range)	9,35 \pm 9,6
Sports injuries (number)	30 (60%)
Traffic accidents (number)	12 (24%)
Other (number)	8 (16%)

2.2.2. Evaluation process

- All patients scheduled for an arthroscopy were thoroughly examined for meniscal lesions using four different clinical tests: Joint line tenderness, McMurray's test, Apley's test, and 20 degrees Thessaly test.
- Pre-surgery MRI was subjected to all patients, performed on a 1.5 Tesla scanner. The MRI scans were evaluated by a radiology specialist and rated according to the grading system of Lotysch et al. [15]
 - + **Grade 1:** small focal area of hyperintensity, no extension to the articular surface
 - + **Grade 2:** linear areas of hyperintensity, no extension to the articular surface
 - + **Grade 3:** abnormal hyperintensity extends to at least one articular surface (superior or inferior)

Only a grade 3 meniscal signal on an MRI scan, which is visible during arthroscopy, can be considered a meniscal tear.

- All of the surgical procedures were performed by our senior surgeon. Meniscal injuries were identified during ACL reconstruction arthroscopy, since it is considered the gold standard. If a tear was found, the surgeon can treat it accordingly.
- Calculate the sensitivity, specificity, accuracy and DOR of each clinical test, the composite test and MRI scans results, in reference to the results collected during the arthroscopic procedure.
 - + Compare clinical tests, "composite tests" and MRI scans with arthroscopic results:
 - True positive (TP): If clinical examination or MRI found a torn meniscus and a torn meniscus was found during arthroscopy
 - True negative (TN): If examination or MRI found no tear and no tear was found during arthroscopy
 - False positive (FP): If clinical examination or MRI found a torn meniscus and no tear was found during arthroscopy
 - False negative (FN): If clinical examination or MRI found no tear and a torn meniscus was found during arthroscopy
 - + Calculate the sensitivity, specificity, accuracy and DOR accordingly:
 - Sensitivity: $(TP / (TP + FN)) \times 100\%$
 - Specificity: $(TN / (TN + FP)) \times 100\%$
 - Accuracy: $((TP + TN) / (TP + FP + TN + FN))$
 - Diagnostic Odd Ratio (DOR): $TP * TN / FP * FN$

2.3. Statistical analysis

- Statistical analysis of the research results was conducted using the SPSS 16.0. software.
- Descriptive statistics were used to determine numbers, percentages, mean, median, and standard deviation.
- Sensitivity, specificity and accuracy are displayed as a percentage \pm standard deviation within the 95% confidence interval.
- Direct comparison of clinical tests was calculated using McNemar's chi-square test
- The results were considered to be statistically significant at p -value less than 0.05 ($p < 0.05$).

2.4. Ethical approval

The study was conducted on patients who were scheduled to have surgery, and the data collection had no effect on the patients in terms of the diagnostic process or treatment plan, as well as expenses. This study, involving human subjects and human data, has been performed in accordance with the Declaration of Helsinki and has been approved by the Ethics Committee at the Hanoi Medical University, Hanoi, Vietnam, in March 2017.

This work has been reported in line with the PROCESS Guidelines [22].

3. Results

3.1. Confirmed cases during surgery

The results above have shown that in arthroscopic surgeries, there're a total of 38 cases of a torn meniscus, in which there are 12 cases of medial meniscus, 18 cases of lateral meniscus, and 8 of both (Table 2).

3.2. Diagnostic value of clinical exams and MRI scans

The McMurray's test has the highest sensitivity of all the diagnostic tests for medial meniscus with a sensitivity of 80% and a specificity of 73.3%, which can be compared with the Thessaly test (70% sensitivity and 76.7% specificity). Furthermore, among these two tests, the accuracy and DOR both provide the highest value. On the contrary, the accuracy and DOR of the Joint line tenderness were the lowest. Moreover, the DOR of the Joint line tenderness has shown that it is not statistically significant ($p = 0,1078$). The accuracy of the composite is 78% for the medial meniscus, and with a sensitivity of 85%, it is higher than all individual tests. But its specificity is only 73.3%, which is even lower than the Thessaly test. Except for the Joint line tenderness, there is no statistically significant difference between the tests ($p > 0,05$).

Meanwhile, the MRI results showed more accurate results than all the tests with 90% sensitivity, 83.3% specificity, and 86% accuracy. However, this difference between MRI and the composite test is not statistically significant ($p > 0.05$).

The McMurray's and Thessaly tests once again provide the most accuracy for the lateral meniscus, with 72% and 74% respectively. Additionally, these two tests both have 75% specificity, the highest among all individual tests. The Joint line tenderness, unlike the medial meniscus, showed a higher sensitivity with 73.1%, the same as the McMurray's test, but with a lower 66.7% specificity. The Appley's test also provides sensitivity and specificity at 69.2% and 70% respectively. As a result, we can see that all individual tests showed a more similar result than for the medial meniscus, and there is no statistically significant difference between the tests.

Moreover, when the tests are combined into the composite test, the DOR reached 84, much higher than 5.4 - 8.1 of individual tests ($p < 0.0001$). The sensitivity, specificity, and accuracy are higher as well, with 92.3%, 87.5%, and 90% respectively. This result is better than 88.5%, 87.5%, and 88% of MRI. Nevertheless, the difference between them is not statistically significant. ($p > 0.05$).

4. Discussion

The purpose of this study is to determine the diagnostic value of clinical examinations, both individually and in combination, in correlations to MRI scans, with the goal of improving clinical diagnosis for patients with meniscal injuries in particular, as well as meniscal injuries associated with cruciate ligament knee injuries. In our study, we noticed the McMurray's test and Thessaly test both had a higher accuracy compared to the other two tests.

Table 2
Meniscal injuries found in arthroscopic surgery.

Location	n	%
Medial meniscus	12	24%
Lateral meniscus	18	36%
Both	8	16%
Neither of them	12	24%
Total	50	100%

Over recent years, multiple studies have displayed a noticeable difference in diagnostic results, in regards to the McMurray's test, even though this test is widely used in clinical practice [16]. According to a meta-analysis performed by Wayne H et al. in 2009, the McMurray's test has a sensitivity varied from 29 to 88% and specificity from 50 to 98% [17]. Based on Tables 3, 4, we found that the accuracy of the McMurray's test is higher for the medial meniscus than for the lateral meniscus, 76% and 72%, similar to the results of Pjotr Goossens et al. [12]. However, a research in 2005 by Theofilos Karachalios suggested that the McMurray's test is more accurate for the lateral meniscus [11].

In this very research, the authors introduced the Thessaly test, a clinical test which simulates the pressure applied to the meniscus of the patients. The newly presented test had a relatively high sensitivity, specificity and accuracy (80%, 91%, 90% respectively). However, our study and other published papers do not share the same efficacious results. In 2015, a study by Pjotr Goossens on 589 knees had shown a rather contrasting result of 64%; 53%; 62% respectively [12]. This conflict can be theorized by the fact that the Thessaly test is a subjective test, in which the patient has to actively perform different movements while countering weights. Furthermore, the extension lag also plays an important role in the diagnostic value of this particular test [10], with our research being 20 degrees. Another noticeable detail, in terms of our findings, the Thessaly test shares the highest specificity, both for medial and lateral meniscus, compared to other independent tests, respectively at 76.7% and 75%, yet still lower than most published literature [11,18]. There were also minimal differences, in terms of accuracy between the medial and lateral meniscus (both 74%), comparable to Theofilos Karachalios's results with 94% for medial meniscus and 96% for lateral meniscus [11].

One of the simplest tests to perform is Joint line tenderness, of which our study has recorded the sensitivity, specificity and accuracy of 70%, 53.3% and 60% for the medial meniscus, and 73%, 66.7% and 70% for the lateral meniscus, lower than a research on this specific test by Osman T.E with the accuracy of 74% for the medial meniscus, and 96% for the lateral meniscus [19]. In fact, the DOR of this test for the medial meniscus is considered statistically insignificant ($p = 0.1078$). This decline of accuracy can be explained through several confusing factors, contributing to an indistinguishable pain from parts of the knee, such as the capsular ligament or other soft tissue, along with the research's methodology, where all the patients had an ACL injury, resulting in poor indication of pain location.

Similar to other individual clinical exams, the Apley's test also demonstrated a highly variable value of sensitivity, specificity and accuracy, comparable to different researches [11,20,21]. Our results are consistent with those of Eric J. Hegedus et al.: sensitivity, specificity and accuracy of 60.7%; 70.2%; 69% [13]. Additionally, we have found minimal accuracy differences between the medial and lateral meniscus (68% and 70%) for the Apley's test.

To address the lack of consistency and accuracy among individual clinical exams, we propose a composite test, of which is considered positive if at least two out of four tests were positive. According to Tables 3, 4, the composite test has displayed a remarkable increase, in terms of sensitivity, specificity, accuracy and DOR compared to the four independent tests. As stated by P. Antinolfi et al. in 2017, a composite test of Joint line tenderness, McMurray's test and Apley's test can reach a value of 91%, 87%, 90% for the medial meniscus, and 86%, 90%, 87% for the lateral meniscus, better than MRI scans [14]. While the study proposed that when clinical diagnosis is in favor of a meniscal tear, performing an MRI scan prior to arthroscopic examination is unnecessary, our findings would suggest otherwise. In our research, when put up against MRI, the composite test, although enhanced, still reflects the inconsistency from the individual tests: for the medial meniscus, the composite test recorded a result of 85% for sensitivity; 73% for specificity; 78% for accuracy and 15,58 for DOR, lower than 90%, 83.3%, 86% and 45 of MRI scans, whereas for the lateral meniscus, the composite test had a result of 92.3%, 87.5%, 90%, 84, higher than 88.5%,

Table 3

Number of true positive, false positive, true negative, false-negative cases, sensitivity, specificity, accuracy and Diagnostic odds ratio for medial meniscal tears.

Medial meniscal tears	TP	FP	TN	FN	Sensitivity ^a	Specificity ^a	Accuracy ^a	DOR (p)
Joint line tenderness	14	14	16	6	70% (49.9 - 90)	53.3% (35.5–71.2)	60% (46.42 -73.58)	2.6667 (0.1078)
McMurray's test	16	8	22	4	80% (62.5–97.7)	73.3% (57.5–89.2)	76% (64.16–87.84)	11.2000 (0.0006)
Apley's test	13	9	21	7	65% (44.1–85.9)	70% (53.6–86.4)	68% (55.07–80.93)	4.3333 (0.0172)
Thessaly test	14	7	23	6	70% (49.9–90.1)	76.7% (61.5–91.8)	74% (61.84–86.16)	7.6667 (0.0018)
Composite test	17	8	22	3	85% (69.4 - 100)	73.3% (57.5–89.2)	78.0% (66.52–89.48)	15.5833 (0.0003)
MRI scans	18	5	25	2	90% (76.9 - 100)	83.3% (70–96.7)	86% (76.83–95.62)	45.000 (<0.0001)

^a 95% confidence interval.**Table 4**

Number of true positive, false positive, true negative, false-negative cases, sensitivity, specificity, accuracy and Diagnostic odds ratio for lateral meniscal tears.

Lateral meniscal tears	TP	FP	TN	FN	Sensitivity ^a	Specificity ^a	Accuracy ^a	DOR (p)
Joint line tenderness	19	8	16	7	73% (56.0–90.1)	66.7% (47.8–85.5)	70% (57.3–82.7)	5.4286 (0,0063)
McMurray's test	18	6	18	8	69.2% (51.5–87.0)	75% (57.7–92.3)	72% (59.55–84.45)	6.7500 (0,0026)
Apley's test	18	7	17	8	69.2% (51.5–87.0)	70.8% (52.6–89.0)	70% (57.3–82.7)	5.4643 (0.0060)
Thessaly test	19	6	18	7	73.1% (56.0–90.1)	75% (57.7–92.3)	74% (61.84–86.16)	8.1429 (0.0012)
Composite test	24	3	21	2	92.30% (82.1 - 100)	87.50% (74.3 - 100)	90.00% (81.68–98.32)	84.0000 (<0.0001)
MRI scans	23	3	21	3	88.5% (76.2 - 100)	87.5% (74.3 -100)	88% (78.99–97.01)	53.6667 (<0.0001)

^a 95% confidence interval.

87.55%, 88%, 53.67 of MRI scans. On the other hand, MRI has proven to be a highly reliable diagnostic tool for meniscal tears, through several different researches [7,8]. Besides from detecting meniscal injuries and ACL tears, MRI scans can help locate, classify and grade meniscus lesions, which in turn, can assist the surgeon to predict meniscal repairability, formulate treatment plan and consider surgical procedures [2,8–10]. Based on these grounds, we believe that MRI should still be considered to be the primary diagnostic tool for meniscal injuries, in particular, as well as meniscal injuries associated with cruciate ligament knee injuries.

However, the role of clinical examination in detecting meniscal tears should not be taken lightly. Although the individual tests have exhibited deficiencies, in close examination, combining these tests into a single composite test can greatly enhance the diagnostic value, comparable to MRI scans. Developing countries, particularly Vietnam, where the economy is not as developed as in other parts of the world, need an accurate clinical diagnostic process. And from within this framework, the surgeon can then decide whether to perform an MRI scan, reducing costs for the patients to a certain degree.

Compared to different studies on patients with common meniscus lesions, the results of our patients are lower. This could be explained by the fact that symptoms of torn ACLs may have reduced the sensitivity, specificity, and accuracy of meniscus tears. After this study, a control group study with a larger sample size should be performed, on not just patients undergoing ACL reconstruction but all patients who are at risk of meniscal tear, in order to precisely identify the accuracy of the clinical tests and the composite test, compared to MRI.

5. Conclusion

Individual tests, such as Joint line tenderness, McMurray's test,

Apley's test, and 20 degrees Thessaly test, have shown a rather limited reliability; however, combining these tests into a single composite test can greatly improve diagnostic value, comparable to MRI scans. We believe that a thorough clinical examination, including the composite test, is an essential part of the diagnosis of meniscal injuries in particular, as well as meniscal injuries associated with knee cruciate ligament injuries. However, MRI should remain to be the standard diagnostic tool. When confronted with a patient who is at risk of meniscal tear, a well-trained surgeon should perform a thorough clinical examination, including the composite test, before deciding on MRI scans and, if necessary, arthroscopic procedures. In addition, patients should also be informed in advance about the risk of misdiagnosis and negative arthroscopic surgery.

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Ethical approval

This study, involving human subjects and human data, has been performed in accordance with the Declaration of Helsinki and has been approved by the Ethics Committee at the Hanoi Medical University, Hanoi, Vietnam, in March 2017. Further information and documentation to support this is available to the Editor on request.

Consent

Written informed consent was obtained from the patients alive at the moment of the study for publication of this case report and accompanying images. A copy of the written consent is available for review by

the Editor-in-Chief of this journal on request.

Author contribution

The idea for the manuscript was conceived in Feb 2017 by TDD and was further developed by DTT; TDD, DTT, TTV and BNTD wrote the 1st draft of the manuscript. TDD, SML and TTV have been involved in surgery and data collection, whereas BNTD and HTT performed the statistical analysis. TDD, DTT and SML reviewed the manuscript and were involved in its critical revision before submission. All authors have read and approved the final manuscript.

Research registration

NA.

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TTV, TDD: Writing- Original draft preparation; BNTD and HTT: Data curation and Statistical analysis; TDD: Supervisor, Investigation; SLM: Supervisor; DTT: Revision draft preparation, Conceptualization, Methodology, Investigation. All authors have read and approved the final manuscript.

Declaration of competing interest

We declare that we have no known competing financial interests or personal relationships with anyone that could have appeared to influence the work reported in this paper.

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