

## COMPARATIVE ANALYSES OF DIAGNOSTIC METHODS IN KNEE INJURIES

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**Abstract: Objective:** This study is analyzing the role and significance of the three diagnostic methods (clinical diagnosis, magnetic resonance imaging (MRI) and arthroscopy), in establishing accurate diagnosis in knee injuries. The goal is to determine the diagnostic accuracy of each diagnostic method, using arthroscopy as gold standard.

**Material and Methods:** We examined 70 patients with knee injuries. Clinical diagnosis was established using patient's history and positive clinical tests for meniscal lesions, ACL injury and articular cartilage lesions. All patients underwent MRI on a 1.5 T magnet for MRI diagnosis. This was followed by arthroscopy for making the final diagnosis.

**Results:** We analyzed the results of clinical tests for meniscal, ligamentous and articular cartilage injuries of the patients in both groups. Validity of the clinical tests was compared to the results got from MRI and arthroscopy. Accuracy of clinical diagnosis versus MRI diagnosis for medial (69.6% vs. 68.5%) and lateral (84% vs. 82.6%) meniscal lesions was almost identical. Accuracy of clinical diagnosis compared with the accuracy of MRI diagnosis for ACL injuries was higher (91.3% vs. 81.4%). Accuracy (85.5% vs. 72.8%) of clinical diagnosis versus MRI diagnosis for articular cartilage lesions was better.

**Conclusion:** Affirmation of clinical diagnosis in this study is a result of usage of standard clinical signs and tests which are fundamental in establishing clinical diagnosis of knee injuries. MRI is a diagnostic method which enriches the diagnostic process. Arthroscopy is defined as superior diagnostic method, also a gold standard for comparison of the other two diagnostic methods.

**Key words:** knee injuries, clinical examination, MRI, arthroscopy.

### INTRODUCTION

Diagnosis of knee injuries is established using clinical examinations and magnetic resonance imaging (MRI) of the injured knee. Both methods are used for obtaining necessary data in order to decide whether to perform arthroscopy or not.

Patient's history gives information on the mechanism of the injury, localization of the pain, swelling, limitations etc. Several clinical tests are used for differentiation if there are a meniscal, ligamentous or cartilage injuries (1, 2, 3, 4, 5, 6, 7, 8). Knee injuries are common. They often can be combined and sometimes is difficult to establish a precise clinical diagnosis of the injured tissue (9, 10, 11, 12, 13, 14). MRI is an additional diagnostic method since it offers useful data in the final decision on performing arthroscopy (9). Positive clinical and MRI diagnosis for knee injuries gives us an indication for arthroscopy. Arthroscopy is a gold standard for diagnosis and at the same time it is an operative method used for minimal invasive treatment of the injured knee (10, 15, 16, 17, 18).

### AIM

The aim of this study was to determine the accuracy of clinical and MRI diagnosis in comparison to arthroscopy for detecting knee injuries. It was also our aim to found out whether MRI diagnosis has an impact on the surgeon's decision for the choice of treatment.

### MATERIAL AND METHODS

We have examined 70 patients with knee injuries, 50 (71.4%) of them were male and 20 (28.6%) female, with average age of  $35 \pm 15$  years. Patients with meniscal, ACL or cartilage injury were analysed in this

study. Inclusion criteria were as follows: patients with established clinical diagnosis of knee injury, MRI of the injured knee and arthroscopy.

Patients with acute knee injury, intra-articular fractures, loose bodies, discant osteochondritis, degenerative osteoarthritis and inflammations were excluded from the study.

Clinical diagnosis was established using patient's history and positive clinical tests for meniscal injuries (McMurray and Apley), ACL injury (anterior drawer test, Lachman test and pivot shift test) and articular cartilage injuries (McMurray test for medial and lateral condyl, patella tests). All patients underwent MRI on a 1.5 T magnet for MRI diagnosis. This was followed by arthroscopy for making the final diagnosis. The same surgeon has performed clinical as well as arthroscopic diagnosis of the injured knee.

Clinical and MRI diagnoses were correlated with arthroscopic diagnosis which was used as a gold standard. To determine the credibility of the clinical examinations and MRI, sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy were assessed. We were using statistical program SPSS for Windows for analyzing the data.

## RESULTS

From 70 patients with knee injuries, 55 were with clinical diagnosis of meniscal lesions, 26 were with clinical diagnosis of ACL injury and 51 were with clinical diagnosis of articular cartilage lesion.

### *Meniscal lesions*

Among 55 patients with clinically diagnosed meniscal lesion 44 were with medial meniscal lesion and

11 with lateral meniscal lesion. Arthroscopy confirmed accuracy of clinical diagnosis in 32 patients (72%) or (44 vs. 32) with medial meniscal lesion, and 8 patients (72.7%) or (11 vs. 8) with lateral meniscal lesion. From 56 patients with medial meniscal lesion on MRI, arthroscopy confirmed the diagnosis in 34 patients (60.7%) or (56 vs. 34) and from 10 patients with lateral meniscal lesion arthroscopy confirmed the diagnosis in 6 patients (60%) or (10 vs. 6).

The sensitivity of clinical diagnosis versus MRI diagnosis for medial meniscus (79.9% vs. 79.5%) was identical. The specificity of clinical diagnosis was better in comparison to MRI (58.1% vs 38.1%). Positive predictive values (69.8% vs. 69.6%) and negative predictive values (69.2% vs. 69.2%) for medial meniscus were the same (Table 1).

The sensitivity of clinical diagnosis versus MRI diagnosis for lateral meniscus (50% vs. 40%) was better. The specificity of clinical diagnosis in comparison to MRI (92.7% vs. 92.7%) was identical. Positive predictive values (63.6% vs. 60%) and negative predictive values (87.9% vs. 85.5%) for lateral meniscus were the same.

Diagnostic accuracy of clinical diagnosis was higher in comparison to MRI diagnosis for medial meniscal lesion (69.6% vs. 68.5%) and for lateral meniscal lesion (84% vs. 82.6%) (Table 2).

### *ACL injury*

ACL injury was clinically diagnosed in 26 patients. Arthroscopy confirmed the clinical diagnosis in 25 patients (96.15%). From 26 patients with ACL injury on MRI, arthroscopy confirmed the diagnosis in 22 patients (84.61%).

The sensitivity (83.3% vs. 71%), specificity (97.4% vs. 89.7%), positive predictive values (96.2% vs. 84.6%)

**Table 1.** Statistical methods for medial meniscal lesions

Medial meniscus	McMurray	Apley	ClinicalDg	MRI
Sensitivity (95%CI)	82% (66.6-90.8)	63.1% (49.9-78.8)	79.9% (63.7-88.9)	79.5% (65.9-85.8)
Specificity (95%CI)	58.1% (40.8-73.6%)	62.5% (46.9-78.9)	58.1% (40.8-73,6)	38.1% (25.6-55.4)
PPV (95%CI)	70.5% (55.8-81.8)	66.7% (53.1-82)	69.8% (54.9-81.4)	69.6% (56.7-81.4)
NPV (95%CI)	72% (52.4-85.7%)	60.6% (43.7-75.3)	69.2% (50-83.5)	69.2% (42.4-87.3)
LR+	1.9	1.8	1.9	1.2
LR-	0.3	0.5	0.4	0.4
Diagnostic accuracy	71%	64%	69.6%	68.5%
Area Under Roc curve (95%CI)	0.7 (0.6-0.8)	0.6 (0.5-0.7)	0.7 (0.6-0.8)	0.7 (0.5-0.8)

**Table 2.** Statistical methods for lateral meniscal lesions

Lateral meniscus	McMurray	Apley	ClinicalDg	MRI
Sensitivity (95%CI)	53.3% (30.1-75.2)	50% (26.8-73.2)	50% (26.8-73.2)	40% (19.8-64.3)
Specificity (95%CI)	94.4% (84.9-98.1)	96.4% (87.7-99)	92.7% (82.7-97.1)	92.7% (82.7-97.1)
PPV (95%CI)	72.7% (43.4-90.3)	77.8% (45.3-93.7)	63.6% (35.4-84.8)	60% (33.3-83.2)
NPV (95%CI)	87.9% (77.1-94)	88.3% (77.8-94.2)	87.9% (77.1-94)	85.5% (73.9-91.9)
LR+	9.6	13.7	6.9	5.5
LR-	0.5	0.5	0.5	0.6
Diagnostic accuracy	85.5%	86.9%	84%	82.6%
Area Under Roc curve (95%CI)	0.8 (0.7-0.9)	0.8 (0.6-0.9)	0.8 (0.6-0.9)	0.7 0.5-0.9

Legend: PPV (positive predictive values); NPV (negative predictive values); LR+ (likelihood ratio positive); LR- (likelihood ratio negative); AUC (area under the curve)

**Table 3.** Statistical methods in LCA injuries

LCA	Anterior drawer test	Lachman	Pivot shift	Clinical Dg	MRI
Sensitivity (95%CI)	83.3% (66.4-92.7)	69.4% (51.8-82.7)	56.5% (39.3-72.2)	83.3% (66.4-92.7)	71% (53.4-83.9)
Specificity (95%CI)	97.4% (86.8-99.5)	98.8% (89.1-99.9)	98.8% (89.1-99.9)	97.4% (86.8-99.5)	89.7% (76.4-95.9)
PPV (95%CI)	96.2% (81.1-99.3)	97.7% (81.5-99.8)	97.2% (78.1-99.7)	96.2% (81.1-99.3)	84.6% (66.5-93.8)
NPV (95%CI)	88.4% (75.5-94.9)	80.6% (67.5-89.3)	74.5% (61.4-84.3)	88.4% (75.5-94.9)	79.5% (65.5-88.8)
LR+	32.5	55.5	45.1	32.5	6.9
LR-	0.2	0.3	0.4	0.2	0.3
Diagnostic accuracy	91.3%	86.9%	81.2%	91.3%	81.4%

Legend: PPV (positive predictive values); NPV (negative predictive values); LR+ (likelihood ratio positive); LR- (likelihood ratio negative); AUC (area under the curve)

and negative predictive values (88.4% vs. 79.5%) of clinical diagnosis versus MRI diagnosis for ACL tears were better. Same results were also found for clinical tests (anterior drawer test, Lachman test, pivot shift test). In our study anterior drawer test was superior against the other two tests in diagnosing LCA tears (Table 3).

Diagnostic accuracy of clinical diagnosis was higher in comparison to MRI diagnosis for ACL injuries (91.3% vs. 81.4%) as depicted in Table 3.

#### *Articular cartilage lesions*

We had 51 patients with clinically diagnosed articular cartilage injury. Arthroscopy confirmed the clinical diagnosis in 45 patients (88.23%). From 48 patients

with articular cartilage injury on MRI, arthroscopy confirmed the diagnosis in 39 patients (81.25%).

The sensitivity (91.8% vs. 79.6%), specificity (70% vs. 57.1%), positive predictive values (88.2% vs. 81.3%) and negative predictive values (77.8% vs. 54.5%) of clinical diagnosis versus MRI for cartilage lesions were better. Diagnostic accuracy of clinical diagnosis was higher in comparison to MRI diagnosis for articular cartilage injuries (85.5% vs. 72.8%) as depicted in Table 4.

## DISCUSSION

Analysis of the results in this study corresponds with the results from similar studies exploring this field. The conclusions were identical. Authors point out

**Table 4.** *Statistical methods in articular cartilage injuries*

Articular cartilage	Clinical Dg	MRI
Sensitivity (95%CI)	91.8% (80.8-96.8)	79.6% (66.4-88.5)
Specificity (95%CI)	70% (48.1-85.5)	57.1% (36.5-75.5)
PPV (95%CI)	88.2% (54.8-94.5)	81.3% (68.1-89.8)
NPV (95%CI)	77.8% (54.8-91)	54.5% (34.7-73.1)
LR+	3.1	1.8
LR-	0.1	0.4
Diagnostic accuracy	85.5%	72.8%
AUC (95%CI)	0.8 (0.7-0.9)	0.7 (0.5-0.8)

Legend: PPV (positive predictive values); NPV (negative predictive values); LR+ (likelihood ratio positive); LR- (likelihood ratio negative); AUC (area under the curve)

that clinical examination is more reliable in diagnosing meniscal lesions, ACL tears and articular cartilage lesions, although previously it was assumed that MRI was essential in establishing accurate diagnosis.

In our study sensitivity (79.9% vs. 79.5%), specificity (58.1% vs. 38.1%), PPV (63.6% vs. 60%), NPV (87.9% vs. 85.5%) and accuracy (69.6% vs. 68.5%) of clinical diagnosis versus MRI for medial meniscal lesions were almost identical. Sensitivity (50% vs. 40%), specificity (92.7% vs. 92.7%), PPV (69.8% vs. 69.6%), NPV (69.2% vs. 69.2%) and accuracy (84% vs. 82.6%) of clinical diagnosis versus MRI for lateral meniscal lesions were the same. Rayan et al. analyzed 87 patients with meniscal lesions. They conclude that clinical examination had better sensitivity (86% vs. 76%), specificity (73% vs. 52%) and diagnostic accuracy (79% vs. 63%) in comparison to MRI for diagnosis medial meniscal lesions. In lateral meniscal lesions sensitivity (56% vs. 61%), specificity (95% vs. 92%) and diagnostic accuracy (85% vs. 85%) were almost the same (19).

Rose et al. refer similar results in accuracy between clinical examination and MRI. Diagnostic accuracy for medial meniscal lesions was 82% vs. 75%, and for lateral meniscal lesions 76% vs. 69% (20). Kocabey et al. and Bohnsack et al. stated that clinical examination is as accurate as MRI in the skilled orthopedic surgeon's hands and MRI should be reserved for more complicated and confusing cases (21, 22).

Mohan et al. reported accuracy of clinical diagnosis of 88% for medial meniscal lesions and 92% accuracy for lateral meniscal lesions (23).

Dutka J et al. reported of 113 patients who had better sensitivity of MRI in comparison to clinical examination for medial meniscal tears (88% vs. 65%) and for lateral meniscal tears (44% vs. 38%) (24).

Hardy et al. refer sensitivity, specificity and accuracy of MRI diagnosis (90%, 59%, 76%) in comparison to clinical diagnosis (93%, 55%, 73%) (25).

Miller stated that accuracy of clinical diagnosis of meniscal lesions was 80.7% in comparison with accuracy of MRI diagnosis 73.7% (26).

Some authors analyze only the accuracy of MRI in comparison to arthroscopy. Their results were as follows: Aydingoz et al. report 90% sensitivity of MRI in detection of bucket handle lesions of meniscus. Cellar et al. refer of high sensitivity of MRI (92%) for medial meniscal lesions and 70% sensitivity of MRI for lateral meniscal lesions (27, 28).

In our study the accuracy of clinical diagnosis compared with the accuracy of MRI diagnosis for ACL injuries were higher (91.3% vs. 81.4%). Sensitivity, specificity and accuracy were 83.3%, 97.4%, 91.3% of the anterior drawer test, 69.4%, 98.8%, 86.95% of the Lachman test and 56.5%, 98.8%, 81.16% of the pivot shift test.

Dutka et al. found better sensitivity values of clinical examination for injuries of the anterior cruciate ligament (86%) versus MR sensitivity (80%) (24).

Esmaili Jah et al. reported that clinical examination was accurate in 91.4%, and MRI in 88.5% of anterior cruciate ligament injuries (29).

Analysis of the clinical tests for ACL rupture was made by van Eck CF et al. Sensitivity was 38% and specificity 81% of the anteriordrawertest; sensitivity of the Lachman test was 81% and the specificity 81% and sensitivity of the pivot shift test was 28% and the specificity 81%. The authors concluded that the Lachman test had the highest sensitivity for diagnosing an acute, complete ACL rupture (30).

Jain et al. presented the sensitivity of the anterior drawer test, the Lachman test and the pivot shift test and the results were 89.3%, 78.6% and 75%, respectively (31).

In the study of Kim SJ, Kim HK comprising 147 patients, the anterior drawer test was positive in 79.6%, the Lachman test was positive in 98.6%, and the pivot shift test was positive in 89.8% of patients (32).

Some authors had equal or better results using MRI for diagnosis ACL injuries in comparison with clinical examinations.

Rose et al. obtained similar results in accuracy between clinical examination and MRI. Diagnostic accuracy for ACL tears was 99% vs. 98% (20).

Kocabey et al. stated that the accuracy of the clinical examination and MRI evaluation was equal in diagnosing ACL ruptures (21).

Rayan et al. analyzed 26 patients with ACL injuries. They concluded that clinical examination versus MRI had almost the same sensitivity (77% vs. 81%, respectively), specificity (100% vs. 96%), positive predictive value (100% vs. 81%), negative predictive value (95% vs. 95%), and diagnostic accuracy (93% vs. 96%) (19).

The study of Laoruengthana et al. analyzing 50 patients showed that sensitivity, specificity, accuracy and negative predictive value (NPV) of MRI in detecting the complete tear of the ACL injury were 90.9%, 84.6%, 88.6% and 84.6%, respectively (33).

Ruth Crawford found MRI to be highly accurate in diagnosing anterior cruciate ligament (ACL) tears. It is the most appropriate screening tool before therapeutic arthroscopy. It is preferable to diagnostic arthroscopy in most patients because it avoids the surgical risks of arthroscopy (9).

In our study the sensitivity (83.3% vs. 71%), specificity (97.4% vs. 89.7%), positive predictive values (96.2% vs. 84.6%) and negative predictive values (88.4% vs. 79.5%) of clinical diagnosis of ACL tears were better in comparison to MRI diagnosis. Diagnostic accuracy of clinical diagnosis was higher in comparison to MRI for ACL injuries (91.3% vs. 81.4%) (10).

We have better results for sensitivity (91.8% vs. 79.6%), specificity (70% vs. 57.1%), PPV (88.2% vs. 81.3%), NPV (77.8% vs. 54.5%) and accuracy (85.5% vs. 72.8%) of clinical diagnosis versus MRI for articular cartilage lesions.

Gelb et al. evaluated articular surface damage. They said that the predictive value of positive tests was 100% for clinical assessment and 33% for the magnetic resonance imaging. They conclude that magnetic resonance imaging is overused in the evaluation of knee disorders and not a cost-effective method for evaluating injuries when compared with a skilled examiner (34).

Dutka et al. refer better sensitivity (51% vs. 32%) and specificity (100% vs. 97%) values of clinical examination for chondral injuries versus MRI (24).

Cellar et al. reported that sensitivity, specificity and accuracy of MRI in detecting articular chondral lesions, were 45.87% and 60% (28).

In our study sensitivity (91.8% vs. 79.6%), specificity (70% vs. 57.1%) and accuracy (85.5% vs. 72.8%) of clinical diagnosis versus MRI for cartilage lesions were better. Duc et al. reported MRI sensitivity, specificity, and accuracy for the two readers and the two evaluations ranged from 56% to 66%, 78% to 93% and 71% to 75%, respectively (35).

Friemert et al. said that the role of MRI for the diagnosis of chondral lesions of the knee joint is still unclear. The sensitivity of the method ranges from 15% to 96%. They concluded that MRI is suitable for the exclusion of cartilage lesions (36).

Munk et al. concluded that the clinical relevance of MRI in cartilage lesions was more doubtful. Because of that the combination of clinical and MRI findings would reduce the number of blank arthroscopies to 5%. MRI is a valuable diagnostic tool, but arthroscopy still remains the gold standard for definitive diagnosis (37).

D'Erme et al. reported 81% sensitivity and 61% specificity of MRI diagnosis for cartilage lesions (38).

Kijowski et al. said that sensitivity, specificity, and accuracy of MR imaging for detecting cartilage lesions were 69.3%, 78.0%, and 74.5% (39).

In our study, we have better results for sensitivity (91.8% vs. 79.6%), specificity (70% vs. 57.1%), PPV (88.2% vs. 81.3%), NPV (77.8% vs. 54.5%) and accuracy (85.5% vs. 72.8%) of clinical diagnosis versus MRI for articular cartilage lesions.

Diagnosis of intraarticular lesions of the knee is a complex process, which includes clinical examination and MRI of the injured knee. Sometimes MRI is used more frequently because it is a very precise method for visualization of the soft tissue. Nevertheless, MRI does not diminish the importance of orthopedic clinical examination as an indication for arthroscopy.

The study of Trieshmann et al. shows that MRI of the knee is a valuable tool for augmenting the diagnostic process. It is a cost-effective technique for avoiding unnecessary surgery and affects patient outcome by improving surgical decision (40).

## CONCLUSION

In conclusion, carefully performed clinical examination can give better diagnosis of knee injuries in comparison to MRI diagnosis. Any experienced orthopedic surgeon can trust his/her clinical diagnosis as an indication for arthroscopy followed by surgical treatment. When the clinical diagnosis is established, without any doubts due to positivity of the clinical tests, the MRI is not essential. In suspected cases where there is a dilemma, MRI is very helpful in making decision for arthroscopy.

Diagnostic accuracy of clinical and MRI diagnosis in knee injuries is high. Their reliabilities in diagnosis of meniscal lesions, ACL tears and articular cartilage lesions are evident.

## Abbreviations

**MRI** — magnetic resonance imaging

**ACL** — anterior cruciate ligament

**PPV** — positive predictive value

**NPV** — negative predictive value

**LR+** — likelihood ratio positive

**LR-** — likelihood ratio negative

**AUC** — area under the curve

## Sažetak

## KOMPARATIVNE ANALIZE DIJAGNOSTIČKIH METODA KORIŠĆENIH KOD PACIJENATA SA POVREDOM KOLENA

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**Uvod:** Ova studija analizira ulogu i značaj tri dijagnostičke metode (klinička dijagnoza, magnetna rezonanca (MR) i artroskopija), u postavljanju tačne dijagnoze povrede kolena. Cilj ove studije bio je utvrđivanje tačnosti pojedinačnog dijagnostičkog metoda, koristeći artroskopiju kao zlatni standard.

**Materijal i metode:** Ispitivali smo 70 pacijenata sa povredom kolena. Klinička dijagnoza je postavljena na osnovu istorije bolesti pacijenta i pozitivnih kliničkih testova na povrede meniskusa, ACL i artikularne hrskavice. Svi pacijenti su podvrgnuti MR snimanju na 1.5 T magnetu za MR dijagnozu. Ovo je praćeno artroskopijom, za postavljanje finalne dijagnoze.

**Rezultati:** Analizirali smo rezultate kliničkih testova povreda meniskusa, ligamenata i artikularne hrskavice pacijenata u obe grupe. Validnost kliničkih testova bila je poređena sa rezultatima dobijenim sa MR i artroskopijom. Tačnost kliničke dijagnoze poređena sa

MR dijagnozom za povrede medijalnog lemniskusa (69.6% vs. 68.5%) i lateralnog (84% vs. 82.6%) bila je skoro identična. Tačnost kliničke dijagnoze poređena sa tačnosti MR dijagnoze za ACL povrede bila je viša (91.3% vs. 81.4%). Tačnost kliničke dijagnoze prema MR dijagnozi povrede artikularne hrskavice (85.5% vs. 72.8%) išla je korist kliničkom postavljanju dijagnoze.

**Zaključak:** Potvrđivanje validnosti i značaja kliničke dijagnoze u ovoj studiji je rezultat korišćenja standardnih kliničkih znaka i testova, koji su fundamentalni u postavljanju kliničke dijagnoze povrede kolena. MR je dijagnostička procedura, koja obogaćuje dijagnostički proces. Artroskopija je definisana kao superiorni dijagnostički metod, kao i za zlatni standard, korišćen za upoređivanje tačnosti druga dva dijagnostička metoda.

**Cljučne reči:** povreda kolena, kliničko ispitivanje, magnetna rezonanca, artroskopija.

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