

Validity of Magnetic Resonance Imaging in Knee Injuries

Predrag Grubor¹, Amina Asotic², Milan Grubor¹, Mithat Asotic^{3,4}

Clinic of Traumatology, Clinical Centre, University of Banja Luka, Bosnia and Herzegovina¹

School of Medicine University of Travnik, Travnik, Bosnia and Herzegovina²

Faculty of Pharmacy and Dental medicine, University of Travnik, Travnik, Bosnia and Herzegovina³

Cantonal Hospital Travnik, Travnik, Bosnia and Herzegovina⁴

Corresponding author: prof. Predrag Grubor, MD, PhD. No. 20/24, Aleja Svetog Save, 78000 Banja Luka. Bosnia and Herzegovina. Tel: 00 387 51 221 360, E-mail: predraggrubor@gmail.com

Original paper

ABSTRACT

Introduction Knee injuries are common in athletes, recreationists, and other people in their everyday activities. **Objective:** The study is aimed at establishing the validity of clinical findings, MRI and diagnostic arthroscopy of the knee in ACL, PCL, medial or lateral ligament lesions. **Methods:** The prospective research involved 63 inpatients at the Traumatology Clinic in Banja Luka- Niš between 1 January 2011 and 1 June 2012. **Results:** When clinically examining the ACL and

based on the calculated post-test probability amounting to (LR+) = 0.8017, we conclude that there is a considerable probability (80.17%) that a patient with an arthroscopically diagnosed ACL lesion will have the same lesion diagnosed by MRI. The post-test probability following the clinical examination of the medial meniscus and amounting to (LR+) = 0.6943 suggests that there is a considerable probability (69.43%) that an arthroscopically diagnosed lesion of the medial meniscus will also be diagnosed by MRI. On the basis of the clinical examination of the

lateral meniscus in the examined sample and calculated post-test probability amounting to (LR+) = 0.6346, we conclude that there is a considerable difference (63.46%) between the diagnostic arthroscopy and MRI of lateral meniscus lesions. **Conclusion:** Arthroscopic examination of the knee is a more valuable method than diagnosis by MRI and clinical examination for detecting lesions of the ACL, PCL, medial and lateral meniscus. **Key words:** arthroscopy, MRI, reliability, validation.

1. INTRODUCTION

The anatomy of the knee and its functional qualities, activities and the way of living of the modern man have resulted in the knee becoming one of the most vulnerable joints (1). The consequences of knee injuries are extremely severe and very often they require a long, costly and often prognostically dubious treatment (1, 2). Drosos IG. *et al.* found that fresh meniscal injuries in children under the age of 15 made up between 5.0% and 9.0% of all sports injuries (3). Meniscal injuries are commonly sustained in professional and recreational sporting activities, but also in everyday activities. Meniscal lesions usually require surgical treatment if they give rise to a decrease in physical ability. Arthroscopic treatment of meniscal injuries is one of the most frequently performed orthopaedic surgeries (1).

Hede A. *et al.* found that the average annual incidence of meniscal

injuries per 10000 inhabitants of Copenhagen amounted to 9.0 in men and 4.2 in women (4). Due to the well-known anatomical and functional relations, the data says that injuries to the medial meniscus are much more common than those to the lateral meniscus. Caillet R. stated that the ratio of medial meniscus injuries to lateral meniscus injuries stood at 1:3 (5). Drosos IG. *et al.* came to the conclusion that in almost one third of patients knee injuries were sustained during everyday activities not related to sport(3).

Injuries to the anterior cruciate ligament most commonly occur during sporting activities, when straining the knee, with no contact with other players, due to awkward landings and changes of direction, in unprepared senior basketball, football and handball players (6).

A great number of expert analyses have shown that partial ruptures of the anterior cruciate ligament (ACL)

are very common in fresh knee injuries with haemarthrosis. Liljedahl SO. *et al.* were among the first to describe partial ruptures. In 48 fresh ACL ruptures they found 35 (72%) complete and 13 (27.0%) partial ruptures (7). By arthroscopic analysis of 83 patients with fresh injuries and haemarthrosis in 85 knees, Paulos L., *et al.* found fresh ACL ruptures in 72% of cases: partial and complete ruptures in 28.0% and 44.0% of patients, respectively (8).

Clinical examinations are used to diagnose knee injuries, with some of them having become standard clinical tests for particular injuries a long time ago. X-ray, arthrographic, scintigraphic, ultrasound examinations hold their place in diagnosing knee injuries, but they are losing precedence to computerised tomography (CT), magnetic resonance imaging (MRI) and arthroscopy (9). Following a clinical examination suggesting a knee ligament lesion, the most commonly recommended method is a

non-invasive MRI method not using ionising radiation, providing a superior soft-tissue contrast resolution, possibility to perform multiplanar imaging of periarticular soft tissue, ligaments, tendons and articular cartilage. MRI diagnosis is used to determine if it is a ligament or meniscal lesion and to indicate arthroscopy as the diagnostic and therapeutic method to be used (1).

2. OBJECTIVE

The study is aimed at examining the reliability and validity of diagnosing a knee injury using magnetic resonance imaging in comparison with the arthroscopic finding of the same knee in the examined sample. The monitored lesions affected the following: anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), medial meniscus (MM) and lateral meniscus (ML).

3. MATERIAL AND METHODS

The series comprises a prospective study involving 63 patients (13 women and 50 men), 36.7 years of age on average, treated at the Traumatology Clinic in Banja Luka and Travnik in the period between 1 January 2011 and 1 June 2012. The youngest patient was 11 and the oldest 69 years old. In 47 (74.6%) patients the injury was sustained during a sporting or recreational activity, while in 16 (25.4%) patients it was a direct trauma. The clinical examination of the tested sample was performed by three experienced orthopaedic surgeons and they referred for MRI. Five radiologists read the MRI of the injured knee.

In order to process the data obtained, we used the validation process in order to assess the validity and reliability of the method compared to the 'gold standard'. We used sensitivity (S_n), specificity (S_p), positive predictive values (PPV) and negative predictive values (NPV) of diagnostic methods, prevalence - pre-test probability (PTP), likelihood ratio (positive (LR+) and negative (LR-)) and post-test probability (PTP).

3.1. Reliability and validity of arthroscopy in comparison with MRI findings – anterior cruciate ligament (ACL)

On the basis of the obtained sen-

sitivity amounting to $S_n = 0.8400$ (84%), we conclude that out of the total number of patients with positive MRI findings 84% have an ACL lesion diagnosed by arthroscopy as well. The result obtained refers to the sample comprising 63 patients and must not be generalised, but it can serve as a good orientation tool.

On the basis of the obtained specificity amounting to $S_p = 0.6842$ (68.42%), we conclude that out of the total number of patients with negative MRI findings for ACL lesions, 68.42% have negative arthroscopic findings as well.

The positive predictive value amounting to $PPV = 0.6364$ (63.64%) suggests that out of the total number of patients with positive arthroscopic findings for ACL lesions 63.64% have ACL lesions in the knees. On the basis of the obtained negative predictive value amounting to $NPV = 0.8667$ (86.67%), we conclude that out of the total number of patients with negative arthroscopic findings 86.67% have an intact ACL, which was confirmed earlier by the performed MRI scan.

On the basis of the obtained prevalence amounting to $P = 0.3968$ (39.68%), it may be concluded that out of the total number of patients 39.68% have an ACL lesion. That is confirmed by the already performed MRI scan.

On the basis of the likelihood ratio for a positive test result amounting to $LR+ = 2.66$, we conclude that patients with ACL lesions diagnosed using the MRI scan are 2.66 times more likely to have positive arthroscopic findings for ACL lesions than patients whose MRI findings did not diagnose lesions.

On the basis of the obtained likelihood ratio for a negative test result amounting to $LR- = 0.2338$, patients with meniscal and ligament lesions with previously performed MRI scans diagnosing ACL lesions are 0.2338 times more likely to have a negative arthroscopic result for ACL lesions.

On the basis of the calculated post-test probability (PTP) following the clinical examination and amounting to $LR+ = 0.8017$ (80.17%), we con-

Contingency table	Finding	Arthroscopic finding		
		Positive	Negative	Total
MRI finding	Positive	21	12	33
	Negative	4	26	30
	Total	25	38	63

Table 1. Contingency table: MRI finding – arthroscopic finding – anterior cruciate ligament (ACL)

Contingency table	Finding	Arthroscopic finding		
		Positive	Negative	Total
MRI finding	Positive	1	3	4
	Negative	0	59	59
	Total	1	62	63

Table 2. Contingency table: MRI finding – arthroscopic finding – posterior cruciate ligament (PCL)

clude that there is a high probability (80.17%) that patients whose arthroscopic findings diagnose ACL lesions have already had MRI findings confirming the same ACL lesion.

On the basis of the post-test probability (PTP) following the arthroscopic examination and amounting to $LR- = 0.2622$ (26.22%), there is a small probability (26.22%) that patients whose arthroscopic findings have not verified ACL lesions actually have ACL lesions. It was diagnosed in the previously performed MRI scan.

3.2. Reliability and validity of arthroscopy in comparison with MRI findings – posterior cruciate ligament (PCL)

On the basis of the obtained sensitivity amounting to $S_n = 1.99$ (100%), we conclude that out of the total number of patients with positive MRI findings 100% have positive arthroscopic findings, i.e. that the capacity of the arthroscopic finding to identify patients with positive MRI findings amounts to 100%. The result obtained refers to the sample comprising 63 patients and must not be generalised, but it can serve as a good orientation tool.

On the basis of the obtained specificity amounting to $S_p = 0.0484$ (4.84%), we conclude that out of the total number of patients with PCL lesions undiagnosed by MRI 4.84% have negative arthroscopic findings as well. The obtained positive predictive value amounting to $PPV = 0.2500$ (25.00%) in the examined sample with positive arthroscopic findings for PCL lesions suggests that 25.00% of patients have PCL

lesions diagnosed by MRI. On the basis of the obtained negative predictive value amounting to NPV = 1.00 (100.00%) in the examined sample where PCL lesions were not diagnosed arthroscopically, we conclude that in 100.00% of cases PCL lesions were not verified by MRI either. The obtained prevalence amounting to P = 0.0159 (1.59%) suggests that out of the total number of patients 1.59% have PCL lesions, and the MRI scan confirmed that.

On the basis of the obtained likelihood ratio for a positive test result amounting to LR+ = 1.0508 in the examined sample, it is 1.0508 times more likely that patients with lesions diagnosed by MRI will have positive arthroscopic findings for PCL lesions than it is for patients who do not have the said lesions diagnosed by either arthroscopy or MRI. The likelihood ratio for a negative test result amounting to LR- = 0.0000 suggests that it is impossible for arthroscopy not to verify PCL lesions in the injured ligaments, irrespective of the fact that MRI can diagnose it.

On the basis of the calculated post-test probability following the clinical examination and amounting to (LR+) = 0.9849 (98.49%) in the examined sample, there is a very high probability (98.49%) that patients whose arthroscopic findings show PCL lesions also have them diagnosed by MRI. On the basis of the calculated post-test probability following the arthroscopy and amounting to (LR-) = 0.0000 (0.00%) in the examined sample, there is no probability (0.00%) that patients whose arthroscopy did not verify PCL lesions have the given lesions.

3.3. Reliability and validity of arthroscopy in comparison with MRI findings – medial meniscus (MM)

On the basis of the obtained sensitivity amounting to $S_n = 0.8519$ (85.19%) in the examined sample, we conclude that 85.19% of patients with positive findings for medial meniscus lesions diagnosed by MRI also have positive arthroscopic findings for lesions in the same meniscus. The result obtained refers to the sample comprising 63 patients and must not

be generalised, but it can serve as a good orientation tool. The specificity amounting to $S_p = 0.5000$ (50.00%) suggests that out of the examined patients with preserved medial menisci diagnosed by MRI 50.00% have injured medial menisci (of different types) diagnosed arthroscopically.

The obtained positive predictive value amounting to PPV = 0.5610 (56.10%) leads to the conclusion that out of the total number of patients with a positive diagnostic arthroscopy of lesions in the medial meniscus 56.10% have them diagnosed by MRI as well. The obtained negative predictive value amounting to NPV = 0.8182 (81.82%) in the examined sample leads to the conclusion that out of the total number of patients with negative arthroscopic findings 81.82% also have undamaged medial menisci diagnosed by MRI. The prevalence amounting to P = 0.4286 (42.86%) suggests that in the examined sample 42.86% of patients have lesions of the medial menisci diagnosed by arthroscopy and MRI. The obtained likelihood ratio for a positive test result amounting to LR+ = 1.7037 in the examined sample suggests that diagnostic arthroscopy of the injured medial meniscus will be more accurate than diagnostic MRI.

On the basis of the obtained likelihood ratio for a negative test result amounting to LR- = 0.2963, we conclude that the likelihood of a patient who has actually sustained a medial meniscus lesion to have a negative arthroscopic result is small (0.2963).

On the basis of the calculated post-test probability following the clinical examination and amounting to (LR+) = 0.6943 (69.43%), we conclude that there is a considerable probability (69.43%) that patients with positive arthroscopic findings for injured medial menisci will also have MRI findings corroborating that. On the basis of the calculated post-test probability following the arthroscopy and amounting to (LR-) = 0.2832 (28.32%) in the examined sample, we conclude that there is a small probability (28.32%) that patients whose arthroscopic findings are negative have lesions of the medial meniscus, despite MRI confirming them.

Contingency table	Finding	Arthroscopic finding		
		Positive	Negative	Total
MRI finding	Positive	23	18	41
	Negative	4	18	22
	Total	27	36	63

Table 3. Contingency table: MRI finding – arthroscopic finding – medial meniscus (MM)

Contingency table	Finding	Arthroscopic finding		
		Positive	Negative	Total
MRI finding	Positive	17	7	24
	Negative	5	34	39
	Total	22	41	63

Table 4. Contingency table: MRI finding – arthroscopic finding – lateral meniscus (ML)

3.4. Reliability and validity of arthroscopy in comparison with MRI findings – lateral meniscus (ML)

The obtained sensitivity amounting to $S_n = 0.7727$ (77.27%) in the examined sample leads to the conclusion that 77.27% of patients who are diagnosed with lesions of the lateral meniscus by MRI also have lesions of the same meniscus confirmed arthroscopically. The result obtained refers to the sample comprising 63 patients and must not be generalised, but it can serve as a good orientation tool. The obtained specificity amounting to $S_p = 0.1707$ (17.07%) suggests that out of the total examined sample of patients with negative MRI findings 17.07% have negative arthroscopic findings as well. The positive predictive value amounting to PPV = 0.7083 (70.83%) suggests that out of the total number of patients with arthroscopically diagnosed lesions of the lateral meniscus 70.83% have lesions of the same meniscus confirmed by MRI as well. The obtained negative predictive value amounting to NPV = 0.8718 (87.18%) suggests that out of the total number of patients with negative arthroscopic findings 87.18% also have negative MRI findings – healthy lateral meniscus.

The obtained prevalence amounting to P = 0.3492 (34.92%) suggests that out of the total examined sample 34.92% have injured lateral menisci diagnosed by both arthroscopy and MRI. On the basis of the obtained likelihood ratio for a positive test result amounting to LR+ = 0.9318 we conclude that patients with positive MRI findings are al-

Diagnostic parameter	Anterior cruciate ligament (ACL)	Posterior cruciate ligament (PCL)	Medial meniscus (MM)	Lateral meniscus (LM)
Sensitivity	0.8400	1.0000	0.8519	0.7727
Specificity	0.6842	0.0484	0.5000	0.1707
Positive predictive value	0.6364	0.2500	0.5610	0.7083
Negative predictive value	0.8667	1.0000	0.8182	0.8718
Prevalence	0.3968	0.0159	0.4286	0.3492
Likelihood ratio for a positive test result	2.6600	1.0508	1.7037	0.9318
Likelihood ratio for a negative test result	0.2338	0.0000	0.2963	1.3312
Post-test probability (LR+)	0.8017	0.9849	0.6943	0.6346
Post-test probability (LR-)	0.2622	0.0000	0.2832	0.7127

Table 5. Visibility, reliability and validity of arthroscopic finding compared to MRI finding (ACL-PCL-MM-LM)

most one time (more precisely 0.9318) more likely to have injured lateral menisci diagnosed arthroscopically than patients with with negative MRI findings.

On the basis of the obtained likelihood ratio for a negative test result amounting to $LR- = 1.3312$ we conclude that patients with verified lesions in the lateral meniscus diagnosed by MRI are one time (more precisely 1.3312) more likely to have negative results of arthroscopy than patients with negative MRI findings.

The results of the comparison (ACL-PCL-MM-LM) between the visibility, reliability and validity of arthroscopic findings and MRI findings are shown in *Table 5*.

4. DISCUSSION

The conditions for preventing knee injuries are created by defining risk factors, etiology and mechanisms of injury. Vladimir Ristic *et al.* conducted a survey of 451 surgically treated patients, out of which number 400 were athletes (65% active, 35% recreational), 29% female and 71% male; 90% were aged under 35(10). In 88% of patients in the examined sample, the cause of injury was a sports trauma (non-contact mechanism in 78%, contact mechanism in 22%). Other injuries occurred while performing everyday activities in 11% of the cases and in traffic traumas in 1% of the cases (10). Among athletes, most reconstructions of the anterior cruciate ligament were performed on football players (48%), then on handball players (22%), basketball players (13%), volleyball players (8%), and martial art athletes (4%), but the greatest incidence of injuries was

among active basketball players (1:91) (10). The following factors did not significantly affect sustaining injuries: type of footwear, warming up, genetic predispositions, and receiving daily therapy (9). Injuries were sustained three times more often in matches, during the middle and final parts of matches and training sessions (79%), due to a landing or change of direction (75%), on dry terrains (79%), in unprepared athletes (62%) (10). By conducting adequate training processes, by educating athletes, improving balance and conscious control of the knee position when standing, running, suddenly changing direction and landing, injuries to the anterior cruciate ligament can be reduced in 40-90% of cases (10).

In his prospective study, Sladjan Timotijevic conducted a clinical and ultrasound examination before an arthroscopic examination on all 198 inpatients (11). The obtained values of sensitivity (91.1%), specificity (80.0%), positive predictive value (83.6%) and negative predictive value (88.9%) of the ultrasound examination of acute lesions of the medial meniscus are lower percentagewise than the values of sensitivity (97.2%), specificity (90.2%), positive predictive value (86.0%) and negative predictive value (98.2%) of the ultrasound examination of chronic lesions of the medial meniscus (11).

By examining online reading materials from 1966 to 2000 and selected papers in order to compare the validity of clinical tests for diagnosing intraarticular lesions with MRI with arthroscopic findings of the knee, Solomon *et al.* (12) obtained the data that the sensitivity of the McMurray

test varied between 29% and 63% and the specificity between 20% and 100% .

In their prospective study covering 213 inpatients with acute knee injuries, Karachalios *et al.* (13) were determining the validity of the McMurray test compared to the arthroscopic finding. The obtained value of this test for the medial meniscus was 48% (13).

In their study, while examining the positive predictive value of the McMurray test in comparison with the arthroscopic finding, Chan *et al.* (14) established that it is lower than 75% (14).

In their study, Gibbs *et al.* (15) state a high value of the ultrasound examination in diagnosing meniscal cysts by comparing those findings with MRI findings. In the course of their research, they came to the conclusion that meniscal cysts are often accompanied by horizontal meniscus lesions (especially on the lateral meniscus), which can be detected by ultrasound. If that is not possible, the authors recommend conducting an MRI examination (13).

5. CONCLUSION

The results of the research show that the arthroscopic examination of the knees is a more reliable method for detecting ACL, PCL, medial and lateral meniscus lesions, compared to MRI diagnosis and clinical examination which have been used in this study.

In the clinical examination of the ACL, and based on the calculated post-test probability amounting to $(LR+) = 0.8017$, we conclude that there is a significant probability (80.17%) that patients with an ACL lesion diagnosed by arthroscopy have the same lesion diagnosed by MRI as well. The calculated post-test probability amounting to $(LR-) = 0.2622$ suggests a low probability (26.22%) of an arthroscopically unverified ACL lesion being diagnosed by MRI.

The calculated post-test probability of the clinical examination of the PCL, $(LR+) = 0.9849$, suggests the existence of a very high probability (98.49%) that an arthroscopically diagnosed ACL lesion will be verified by MRI. The post-test probability fol-

lowing the arthroscopic examination and amounting to $(LR-) = 0.0000$ (0.00%) gives us the right to maintain that there is no probability (0.00%) that a patient with an arthroscopically negative finding has a positive MRI finding.

The post-test probability of the clinical examination of the medial meniscus, $(LR+) = 0.6943$, suggests the existence of a considerable probability (69.43%) that an arthroscopically diagnosed lesion of the medial meniscus is diagnosed by MRI as well. There is a low post-test probability amounting to $(LR-) = 0.2832$ that a patient whose arthroscopic finding is negative has a medial meniscus lesion diagnosed by MRI.

On the basis of the clinical examination of the lateral meniscus in the examined sample and calculated post-test probability amounting to $(LR+) = 0.6346$ (63.4469%), we have come to the conclusion that there is a considerable difference (63.46%) between the diagnostic arthroscopy and MRI diagnosis of lateral meniscus lesions. The obtained post-test probability following the arthroscopic examination amounting to $(LR-) = 0.7127$ suggests the existence of a great probability (71.27%) that diagnosis by MRI will confirm lesions of the lateral menisci in the patients whose arthroscopic findings are negative.

The conclusion is that diagnostic arthroscopy of ACL, PCL, and me-

dial and lateral meniscus injuries is more valid than MRI and clinical examination.

REFERENCES

1. Nikolic D. Povrede meniskoligamentarnog aparata kolena, Beograd, Narodna biblioteka Srbije, 2006.
2. Micheli JL, Foster ET. Acute knee injuries in the immature athlete. In: Heckman Dj (Ed). Instructional course lectures, San Antonio, Texas, American Academy of Orthopaedic Surgeons. 1993; 42: 473-481.
3. Drosolic IG, Pozo LJ. The causes and mechanisms of meniscal injuries in the sporting and non-sporting environment in an unselected population. *The Knee*. 2004; 11(2): 143-149.
4. Hede A, Jensen DB, Blyme P. et al. Epidemiology of meniscal lesions in the knee. *Acta Orthop Scand*. 1990; 615: 435-437.
5. Caillet R. *Knee pain and disability*, sixth edition, Philadelphia, F.A. Davis company, 1976.
6. Krinsky BM, Abdenour ET, Starkey C, Albo AR, Chu AD. Incidence of lateral meniscus injury in professional basketball players. *Am J Sports Med*. 1992; 20(1): 17-19.
7. Liljedahl SO, Lindavall N, Wetterfors J. Early diagnosis and treatment of acute ruptures of the anterior cruciate ligament. *J Bone Joint Surg*. 1999; 47-A(8): 1503-1513.
8. Paulos L, Noyes RF, Malek M. A practical guide to the initial evaluation and treatment of knee ligament injuries. *J Trauma*. 1999; 20(6): 498-506.
9. Sawant M, Murty NA, Ireland J. Valgus knee injuries; evaluation and documentation using a simple technique of stress radiography, *the Knee*. 2009; 11(1): 25-28.
10. Ristic V, Ninkovic S, Harhaji V, Milankov M. Analiza uzorka povredjivanja prednjeg ukrstenog ligamenta kolena, *Med Pregl*. 2010; LXIII (7-8): 541-545.
11. Timotijevic S, Vukasinovic Z, Bascarevic Z. Vrednost klinickog i ultrazvucnog nalaza u odnosu na artroskopski nalaz akutnih povreda medijalnog meniskusa kolena, *BIB-LID*. 2008; 136(1-2): 28-32.
12. Solomon HD, Simel LD, Bates WD, Katz NJ, Schaffer LJ. Does this patient have a torn meniscus or ligament of the knee? *JAMA*. 2009; 286: 1610-1620.
13. Karachalios Th, Hantes M, Zibis HA, Zachos V, Karantanias HA, Malizos NK. Diagnostic accuracy of the new clinical test (the Thessaly test) for early detection of meniscal tears. *JBJS Am*. 2005; 87: 955-962.
14. Chan CFS, Fang D. Arthroscopic correlation of clinical diagnosis of meniscal injuries using the McMurray test. *J Hong Kong Med. Assoc*. 2004; 46(3): 187-189.
15. Gibbs V, Jones A. Sonographic detection of a meniscal cyst. *Radiography*. 2007; 7: 137-141.