Macedonian pharmaceutical bulletin, **70** (2) 3 - 8 (2024)
ISSN: 1857-8969
DOI: 10.33320/maced.pharm.bull.2024.70.02.001
Original scientific paper

Accuracy of Magnetic Resonance Imaging in comparison with Arthroscopic findings for lateral and medial meniscal tears

Hristijan Kostov[1], Elena Kostova[2], Valentin Vejseli[1], Igor Merdzanovski[1]

[1] *University Clinic for Traumatology, Orthopedics, Anesthesia, Reanimation, and Intensive Care and Emergency Medicine, 50th Divizija, 1000 Skopje, Republic of North Macedonia*
[2] *Department of Preclinical and Clinical Pharmacology with Toxicology, Faculty of Medicine, Ss. Cyril and Methodius University, 50th Divizja, 1000 Skopje, Republic of North Macedonia*

Received: September 2024; Accepted: October 2024

Abstract

This study was conducted to analyze the reliability of clinical diagnosis in meniscal tear injuries. From one hundred and three patients with knee problems, arthroscopically in 40 were diagnosed LM (lateral meniscus) tears and in 45 patients MM (medial meniscus) tears. MRI of the knee joint was done before the admission and some of them before the clinical examination.

In this study meniscal tears were clinically diagnosed by positive McMurray and Apley test. At all these patients the clinical diagnosis was confirmed during underwent therapeutic arthroscopic knee surgery. The accuracy, sensitivity and specificity were calculated based on MRI and arthroscopic findings. The accuracy of clinical diagnosis in our study was 70% for LM tears and 63.1% for MM tears.

Our study revealed high sensitivity and specificity and good accuracy for meniscal injuries of knee joint in comparison to arthroscopy. MRI is an appropriate screening tool for therapeutic arthroscopy, making diagnostic arthroscopy unnecessary in most patients. Magnetic resonance imaging is accurate and non-invasive modality for the assessment of meniscal injuries. It can be used as a first line investigation in patients with soft tissue trauma to knee.

Key words: MRI, arthroscopy, meniscus, knee

Introduction

Magnetic resonance imaging (MRI) accurately depicts the anatomy and pathology affecting almost every joint in the body. Because MRI is highly accurate, most leading orthopedic surgeons prefer MRI to arthroscopy (De Smet et al., 2009; Helms, 2002).

MRI is accurate for predicting repairable meniscal tears and sensitive for determining non-repairable tears. A commonly used surgical classification of meniscal tears includes the following types: horizontal, longitudinal, radial, bucket handle, displaced flap and complex (Metcalf & Barrett, 2004).

The meniscus is now known to play an important role in the complex biomechanisms of the knee. For instance, it is involved in joint stability, load sharing and transmission, shock absorption and nutrition and lubrication of the articular cartilage (Johnson et al., 1999). The menisci act as a joint filler, compensating for gross incongruity between femoral and tibial articulating surfaces. The menisci have an important role in load-bearing and scock absoption within the joint. They may also function as secondary stabilizers (particularly in the absence of a

*email: kostovhristijan@yahoo.com

functioning anterior cruciate ligament), have a proprioceptive role and aid in the lubrication and nutrition of the articular cartilage. Errors in diagnosing meniscal tears can be classified as unavoidable (discordance between MRI and arthroscopy), equivocal (interobserver differences in interpretation), or interpretive (normal MRI variants mistaken for meniscal tears).

The advantages of MRI are non-invasive nature, lack of ionizingradiation and its ability to detect non osseous structures such as ligaments, menisci, articular cartilage in multiplanar orientation. Current literature reports 95-100% accuracy of MRI for anterior cruciate ligament tears, 90-95% for MM tears and 85-90% for LM tears (Bari & Murad, 2003; Major et al., 2003).

Determination of the clinical relevance of MRI can be affected by selection bias. Selection criteria for arthroscopy, results of which are used as the reference standard, play a role in most studies and potentially have a major influence on the interpretation of MRI results. MRI has a better soft tissue contrast and multi planar slice capability which has revolutionized and has become the ideal modality for imaging complex anatomy of the knee joint (Kean et al., 1983).

Advanced modality in the management of internal derangement of knee joint is arthroscopy, which can be used in its dual mode, either as diagnostic and/or as therapeutic tool. Arthroscopy offers direct visualization of all intraarticular structures with high diagnostic accuracy, the possibility to examine the stability of the knee under anesthesia and the possibility to perform a therapeutic procedure in the same session (Mink et al., 1998).

The aim of this study was to evaluate diagnostic significance of MRI and arthroscopy findings in lateral and medial meniscal tears.

Material and methods

In our study we involved 103 patients with history of knee injuries who were admitted in the Clinic of Traumatology, Clinical Center-Majka Tereza, Skopje. MRI of the knee joint was done before the admission and some of them before the clinical examination. In this study meniscal tears were clinically diagnosed by positive McMurray and Apley test. It also included other special tests to rule out any other associated structural damage to the knee.

All clinically diagnosed patients underwent diagnostic and therapeutic knee arthroscopy to assess the accuracy of clinical diagnosis after required investigations and consent in the Clinic of Traumatology. However, some patients who had been referred from outside or taken treatment and MRI being done prior to admission in our hospital are considered with same MRI report and not subjected to fresh MRI investigation.

Images of magnetic resonance were performed with 1.0-T system (Philips Medical Systems) at Institute of Radiology in Skopje. The standardized MR imaging protocol consisted of sagittal, coronal and axial sequences, in section thickness of 3-5 mm.

All arthroscopic procedures were performed in a standard manner by experienced arthroscopic surgeon who was blinded to the radiologist's diagnosis, using standard anteromedial and anterolateral portals. Additional portals were used when required. Operative findings were documented in the official patient's document, which included the survey of the entire joint and anatomical structure, lesions involved with the presence or absence of tear, its location, status of the articular cartilage and others. The composite data was tabulated and studied for correlation with MRI findings and grouped into four categories:

-True-positive, if the MRI diagnosis was confirmed by arthroscopic evaluation.

-True-negative, when MRI negative for lesion and confirmed by arthroscopy.

-False-positive, when MRI shows lesion but the arthroscopy was negative

-False-negative, result when arthroscopy was positive but the MRI showed negative finding

Statistical analysis

Statistical analysis was used to calculate the sensitivity, specificity, accuracy, positive predictive value (PPV) and the negative predictive value (NPV), in order to assess the diagnostic significance of the MRI results. Categorical variables were summarized using frequency and were compared using the chi-square or McNemar test as appropriate. *p*-value of less than 0.05 was considered to be statistically significant.

Results and discussion

In the study group of 103 patients, consisted of 82 men (79.62%) and 21 women (20.38%), ($x2=33,79, DF=1, p<0.01$), we found statistical significant difference in distribution of frequencies, dominant male patients. This showed that there was a tendency of males being injured and getting operated at the earlier age. The males average age was 30.26 years, with $SD=10.26$, and females average age was 27.68 years with $SD=12.52$, the Student's t-test for two large unrelated samples showed: $t=0.99, DF=101, p>0.05$, i.e. perceived difference is not statistically significant in average ages between males and females. All patients underwent arthroscopic knee surgery. The average age was 29.7 years (range: 16–58 years) and $SD=10.77$ years. Maximum number of patients (n=34) who suffered knee injuries were in the age group of 21-30 years. The right knee was involved in 56 cases (54.4%) and the left knee in 47 (45.6%). A study done by Avcu et al. (2010) showed males are most likely to suffer knee injuries since they are active in sports and the right knee was more

Table.1 Methods and formulas used to calculate the reliability of clinical diagnosis.

Value	Calculation
Sensitivity	TP/(TP+FN)×100
Specificity	TN/(TN+FP)×100
Positive predictive value (PPV)	TP/(TP+FP)×100
Negative predictive value (NPV)	TN/(TN+FN)×100
Accuracy	TP+TN/TP+TN+FP+FN×100

frequently injured than left (Avcu et al., 2010).

Table 1 shows the methods and formulas used to calculate the reliability of clinical diagnosis. Clinical diagnostic test characteristics are:

- Sensitivity: how good the test is at detecting meniscal tears
- Specificity: how good the test is at identifying normal knee
- Positive predictive value: how often a patient with a positive test has the meniscal tears
- Negative predictive value: how often a patient with a negative test does not have meniscal tears
- Accuracy: proportion of test which correctly identifies meniscal tears

Comparison of the arthroscopic and MRI findings yielded the following results. MRI findings for the LM yielded 19 true-positives (were confirmed on arthroscopy) and 53 true-negatives (without evidence of LM tears) with 10 false positive (were misinterpreteted to have LM tears) and 21 false negative (were not diagnosed clinically) (Table 2), which resulted in 83% sensitivity, 88.37% specificity, 93% positive predictive value, 74.5% negative predictive value and 82.5% accuracy (Table 4).

Table.2 Comparison of the arthroscopic and MRI findings in lateral meniscus tear

	Arthroscopy findings in LM	
	Positive findings	Negative findings
MRI Positive findings	19 (TP)	10 (FP)
MRI Negative findings	21 (FN)	53 (TN)
	40	63

TP(true positive); TN(true negative); FP(false positive); FN(false negative)

Table.3 Comparison of the arthroscopic and MRI findings in medial meniscus tear

	Arthroscopy findings in MM	
	Positive findings	Negative findings
MRI Positive findings	44 (TP)	37 (FP)
MRI Negative findings	1 (FN)	21 (TN)
	45	58

TP(true positive); TN(true negative); FP(false positive); FN(false negative)

Table 4. Lateral and medial meniscus tear findings

Test	LM (%)	MM (%)
Sensitivity	58	98.8
Specificity	89	37.3
Positive predictive value (PPV)	73.4	61.6
Negative predictive value (NPV)	78	96
Accuracy	70	63.1

MRI findings for the MM tears yielded 44 true-positives (were confirmed on arthroscopy) and 21 true-negatives (without evidence of MM tears) with 37 false positive (were misinterpreteted to have MM tears) and 1 false negative (were not diagnosed clinically) (Table 3), which resulted in 83% sensitivity, 88.37% specificity, 93% positive predictive value, 74.5% negative predictive value and 82.5% accuracy (Table 4).

McNemar test showed that $x2=3.226$, $DF=1$, $p>0.05$, i.e. there are no statistical differences in distribution of frequencies in positive and negative findings of LM tears in MRI and arthroscopy or perceived difference is not statistically significant and there is agreement. Contrary, we found statistical significant difference in distribution of frequencies in positive and negative findings of MM tears in MRI and arthroscopy ($x2=32.237$, $DF=1$, $p<0.01$) or perceived difference is statistical significant.

We obtained 58% sensitivity and 89% specificity of MRI with respect to fair correlation with arthroscopy in diagnosing LM tears. Identification of LM tears in our study was presented with 70% accuracy of MRI, PPV was 73,4 % and NPV 78% ranged in good interpretation group (80-90%). For the MM tears in our study we obtained 98.8% sensitivity, 37.3% specificity of MRI correlated with arthroscopy and with 63.1% accuracy of MRI, PPV was 61.6% and NPV 96% was ranged in good interpretation group.

Elvenes and collegues in their study found that sensitivity, specificity, PPV and NPV of MRI for MM were 100%, 77%, 71% and 100%, while the values for LM were 40%, 89%, 33% and 91% respectively (Elvenes et al., 2000). According Major et al., the sensitivity and specificity values for MRI of MM and LM were 92%, 87% and 93%, 95%, respectively. Meta-analysis by Oei et al. (2003) combined 29 studies from 1991 to 2000 that evaluated the validity of MRI with respect to meniscal and cruciate ligament disorders of the knee. The pooled sensitivity of medial and lateral menisci was 93% and 79% while pooled specificities were 88% and 95% respectively. For ACL and PCL tear, pooled sensitivities and specificities were 94%, 91% and 94%, 99% respectively. There is no doubt that the radiologist's experience and training are very important factors in interpretation of MRI.

False positive MRI scans seen in the posterior horn of the MM may reflect an inability to completely visualize the area. The occurrence of the false positive and false negative meniscal tears at MRI imaging has been noted earlier. There are explanations for this apparent discrepancy between findings at MR Imaging and arthroscopy given in following order: misinterpretation of normal anatomy like menisco-femoral ligaments, osteochondral flap avulsion lesions mimic meniscal tears accounting for false positive cases in seven of our patients accounting for 20% incidence which correlates well with the literature, observer dependency of MRI, presence of loose bodies, radial meniscal tears are difficult to visualize on MRI hence; they account for a large number of tears missed by MRI, some false positive findings on MRI can be attributed to inadequate visualization of the meniscus at surgery and to the fact that the diagnosis of a tear can be subjective. False positives MRI scan seen in the posterior horn of the medial meniscus may reflect an inability to completely visualize the area at arthroscopy and tears that extend to the inferior surface of the meniscus may be difficult to see (Kojima et al., 1996).

At the same time, reliable statistical data of the diagnostic value of the MRI are also related to the independent base of reference. Regarding knee MRI, in most of the studies and in our study as well, the base of reference is arthroscopy (Esmaili et al., 2005; Kostov et al., 2014; Navali et al., 2013). This presupposes that arthroscopy is 100% accurate allows for the diagnosis of every possible knee pathology. This is not always the case (Khanda et al., 2008).

Some authors reported that sensitivity of 3D-MR imaging with a standard knee protocol was 86–96% and specificity was 84–94% for diagnosing the medial meniscal tears and they reported 68–86% sensitivity and 92–98% specificity for the lateral meniscal tears (Ohishi et al., 2005; Quinn & Brown, 1991; Rubin & Paletta, 2000; Wolff et al., 2009). With developing advances in MRI systems, technology and RF coils, new sequences are applicable both in the studies and in a daily practice nowadays. High-resolution MRI, using a surface dual-loop coil and specific

sequences, which can be performed on every standard-field-strength MRI scanner, is able to significantly improve diagnostic performance for the detection of a meniscal tear of the knee joint. A meniscal tear was correctly diagnosed in 76% of cases with conventional MRI and in 88% of cases with high-resolution MRI (Nemec et al., 2008). Many studies, however, showed that MRI had a variable accuracy for predicting meniscal tear configuration found at arthroscopy and depend with developing advances in technology of MRI systems.

Arthroscopy is a technically demanding procedure and the results are varying according to surgeon's experience, especially in difficult cases. MRI is the most helpful diagnostic technique. Arthroscopy should be considered a diagnostic help used in conjunctions with a good history, complete physical examination and appropriate radiographs. It should serve as an adjuvant to, not as a replacement for, a thorough clinical evaluation. With increased proficiency in examination of extremities and more accurate adjuvant tests, including MRI, we rarely perform simple "diagnostic arthroscopy." Surgical alternatives are discussed thoroughly with the patient before the procedure, and the definitive surgical procedure is performed at the time of an arthroscopic examination.

Conclusion

Our study revealed not so high sensitivity and specificity and almost very good accuracy for meniscal tears of knee joint in comparison to arthroscopy. Findings of this small scale study of our population are consistent with larger studies in this field. So we have sufficient evidence to conclude that MRI is quite good diagnostic tool of meniscal tears.

MRI is an appropriate screening tool for therapeutic arthroscopy, making diagnostic arthroscopy unnecessary in most patients. Magnetic resonance imaging is accurate and non-invasive modality for the assessment of meniscal injuries.

References

Avcu, S., Altun, E., Akpinar, I., Bulut, M.D., Eresov, K., Biren, T., 2010. Knee joint examinations by magnetic resonance imaging: The correlation of pathology, age, and sex. N. Am. J. Med. Sci, 2(4), 202-204. doi: 10.4297/najms.2010.2202.

Bari, V., Murad, M., 2003. Accuracy of magnetic resonance imaging in the knee. J. Col. Physicians Surg. Pak. 13, 408-411. doi: 10.2214/ajr.180.1.1800017. PMID: 12490470.

De Smet, A.A., Blankenbaker, D.G., Kijowski, R., Graf, B.K., Shinki, K., 2009. MR diagnosis of posterior root tears of the lateral meniscus using arthroscopy as the reference standard. AJR Am. J. Roentgenol, 192(2), 480-486. doi: 10.2214/AJR.08.1300.

Elvenes, J., Jerome, C.P., Reikeras, O., Johansen, O., 2000. MRI as a screening procedure to avoid arthroscopy for meniscal tears. Arch Orthop Trauma Surg, 120(1-2), 14-16. doi: 10.1007/pl00021235.

Esmaili Jah, A.A., Keyhani, S., Zarei, R., Moghaddam, A.K., 2005. Accuracy of MRI in with clinical and arthroscopic findings in ligamentous and meniscal injuries of the knee. Acta Orthop. Belg. 71(2), 189-196.

Helms, C.A., 2002. The meniscus: recent advances in MR imaging of the knee. AJR Am. J. Roentgenol. 179(5), 1115-1122. doi: 10.2214/ajr.179.5.1791115.

Johnson, M.J., Lucas, G.L., Dusek, J.K., 1999. Isolated arthroscopic meniscal repair: a long-term outcome study (more than 10 years). Am. J. Sports Med. 27(1), 44-49. doi: 10.1177/03635465990270011501.

Kean, D.M, Worthington, B.S., Preston, B.J., 1983. Nuclear MRI of knee: examples of qnormal anatomy and pathology. Br. J. Radiol. 56, 355-361. doi: 10.1259/0007-1285-56-666-355.

Khanda, G., Akhtar, W., Ahsan, H., Ahmad, N., 2008. Assessment of menisci and ligamentous injuries of the knee on magnetic resonance imaging: correlation with arthroscopy. J. Pak. Medical Association 58(10), 537-540.

Kojima, K.Y., Demlow, T.A., Szumowski, J., Quinn, F.S., 1996. Coronal fat suppresion fast spin echo images of the knee evaluation of 202 patient with arthroscopic correlation. MRI 14, 1017-1101. doi: 10.1016/s0730-725x(96)00144-0.

Kostov, H., Stojmenski, S., Kostova, E., 2014. Reliability Assessment of Arthroscopic Findings Versus MRI in ACL Injuries of the Knee. Acta Inform. Med. 22(2), 111-114. doi: 10.5455/aim.2014.22.111-114.

Major, N.M., Beard, L.N., Helms, C.A., 2003. Accuracy of MR imaging of the knee in adolescents. AJR Am. J. Roentgenol. 180(1), 17-19.

Metcalf, M.H., Barrett, G.R., 2004. Prospective evaluation of 1485 meniscal tear patterns in patients with stable knees. Am J. Sports Med. 32, 675-680. doi: 10.1177/0095399703258743.

Mink, J.H., Levy, T., Crues, J.V., 1988. Tears of the anterior cruciate ligament and menisci of the knee: MR imaging evaluation. Radiology 167(3), 769-774. doi: 10.1148/radiology.

Navali, A.M., Bazavar, M., Mohseni, M.A., Safari, B., Tabrizi, A., 2013. Arthroscopic evaluation of the accuracy of clinical examination versus MRI in diagnosing meniscus tears and cruciate ligament ruptures. Arch Iran Med. 16(4), 229-232.

Nemec, S.F., Marlovits, S., Trattnig, S., Matzek, W., Mayerhoefer, M.E., Krestan, C.R., 2008. High-resolution magnetic resonance imaging and conventional magnetic resonance imaging on a standard field-strength magnetic resonance system compared to arthroscopy in patients with suspected meniscal tears. Acad. Radiol. 15(7), 928-933. doi: 10.1016/j.acra.2008.02.007.

Oei, E.H., Nikken, J.J., Verstijnen, A.C., Ginai, A.Z., Myriam Hunink, M.G., 2003. MR Imaging of the Menisci and Cruciate Ligaments: A Systematic Review. Radiology 226, 837-848. doi: 10.1148/radiol.2263011892.

Ohishi, T., Takahashi, M., Abe, M., Tsuchikawa, T., Mori, M., Nagano, A., 2005. The use of axial reconstructed images from three-dimensional MRI datasets for morphological diagnosis of meniscal tears of the knee. Arch. Orthop. Trauma Surg. 125(2), 622–627. doi: 10.1007/s00402-004-0792-0.

Quinn, S.F., Brown, T.F., 1991. Meniscal tears diagnosed with MR imaging versus Arthroscopy: How reliable a standard is

arthroscopy? Radiology 181(12), 843–847. doi: 10.1148/radiology.181.3.1947108.

Rubin, D.A., Paletta, G.A., 2000. Current concepts and controversies in meniscal imaging. Magn. Reson. Imaging Clin. N. Am. 8(3), 243–270.

Wolff, A.B., Pesce, L.L., Wu, J.S., Smart, L.R., Medvecky, M.J., Haims, A.H., 2009. Comparison of spin echo T1W sequences versus fast spin-echo proton density weighted sequences for evaluation of meniscal tears at 1.5 T. Skeletal Radiol, 38(1), 21–29. doi: 10.1007/s00256-008-0561-1.

Резиме

Точноста на магнетната резонанца во споредба со артроскопски наоди на латерални и медијални кинења на менискусот

Христијан Костов[1], Елена Костова[2], Валентин Вејсели[1], Игор Мерџановски[1]

[1]*Универзитетска клиника за трауматологија, ортопедски болести анестезија, реанимација, интензивно лекување и ургентен центар. 50 дивизија, 1000 Скопје. Република Северна Македонија*

[2]*Институт за претклиничка и клиничка фармакологија со токсикологија. Медицински факултет. Универзитет „Св. Кирил и Методиј“, 50та дивизија, 1000 Скопје. Република Северна Македонија*

Клучни зборови: МРИ, артроскопија, менискус, колено

Оваа студија беше спроведена за да се анализира веродостојноста на клиничката дијагноза кај повредите на кинење на менискусот. Од сто и тројца пациенти со проблеми со коленото кај 40 им беше артроскопски дијагностицирано кинење на латерален менискус (ЛМ) и на 45 им беше дијагностициран медијален менискус (ММ). Магнетна резонанца на коленовиот зглоб е направена пред приемот, а на некои од пациентите и пред клиничкиот преглед. Во оваа студија, кинењето на менискусот беше клинички дијагностицирани со позитивен тест на McMurray и Apley.

Кај сите овие пациенти клиничката дијагноза беше потврдена при извршена терапевтска артроскопска операција на коленото. Точноста, чувствителноста и специфичноста беа пресметани врз основа на МРИ и артроскопски наоди. Точноста на клиничката дијагноза во нашата студија беше 70% за LM и 63,1% за ММ. Нашата студија откри висока чувствителност и специфичност и добра точност за повредите на менискусот на коленото зглоб во споредба со артроскопијата. МРИ е соодветна алатка за скрининг за терапевтска артроскопија, што ја прави дијагностичката артроскопија непотребна кај повеќето пациенти.

Магнетната резонанца е точен и неинвазивен модалитет за проценка на повредите на менискусот. Може да се користи како испитување од прва линија кај пациенти со траума на меките ткива на коленото.