

The Role of MRI in the Diagnosis of Intra Articular Knee Derangement: a Prospective Study

ORIGINAL

Abstract

Background: Magnetic resonance imaging (MRI) has several advantages compared with other modalities in evaluating internal derangement of the knee & it has practically replaced conventional arthrography in the evaluation of menisci & cruciate ligaments as it is non invasive, painless and give excellent soft tissue contrast.

Objective: To assess the role of MRI in internal derangement of the knee.

Methods: Thirty patients with suspected internal derangement of the knee were subjected to a dedicated MR knee study and correlated knee arthroscopy and surgery. MRI of the knee was performed in closed magnet (1.5 Tesla, Seimens). Arthroscopy was done within two months of MR examination and was considered gold standard for the internal derangement of the knee.

Results: The sensitivity, specificity, diagnostic accuracy of MRI were 94.1%, 84.6% and 90% respectively for medial meniscal tear; 71.4%, 95.6% and 90% respectively for lateral meniscal tear and 85.7%, 91.3% and 90% respectively for anterior cruciate ligament tear.

Conclusion: MRI represents the optimal imaging tool in the evaluation of internal knee derangement as it showed high sensitivity, specificity, diagnostic accuracy for meniscal and cruciate ligament injury, in addition to associated derangement like articular cartilage damage and synovial effusion.

Introduction

The knee is a complex structure and one of the most stressed joints in the body. It is a large joint, vital for movement, and susceptible to injury. Knee injuries represent roughly 6% of all acute injuries

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treated at emergency department and approximately one-third of these have been reported to be sports related [1]. The principal intra articular structures in knee are the two menisci, the two cruciate ligaments, and the two collateral ligaments. The injury to these intra articular structures is generally termed as "Internal derangement of knee" which was first coined by British surgeon leeds William Hey in 1784 [2]. Although clinical

examination is most important for the diagnosis of ligament injury, painful stress examinations are not always accurate in the acute phase of the injury. For that reason, magnetic resonance imaging (MRI) is indicated for early diagnosis of the acutely injured knee [3]. While the use of arthrography and arthroscopy improves the accuracy of the diagnosis, both are invasive and can cause complications. MRI scanning has often been con-

Figure 1: Knee MRI image show grade I meniscal injury which appear as single round or punctate high signal focus (arrow) within meniscal substance.



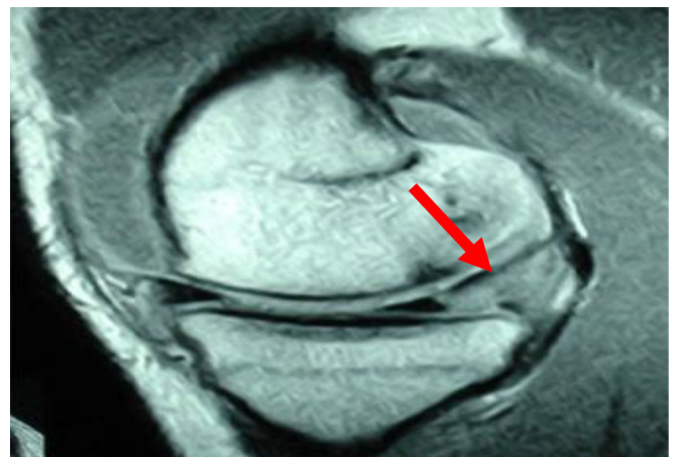
Figure 2: Knee MRI image show grade II meniscal injury which appear as linear high signal focus (arrow) with meniscal substance that does not abut the articular surface.



Figure 3: Knee MRI image show grade III meniscal injury which appear as linear hyperintense signal (arrow) with meniscal substance that communicating with the inferior articular surface.



Figure 4: Knee MRI image show grade IV meniscal injury which appear as meniscal fragmentation (arrow).



sidered as an alternative to diagnostic arthroscopy in evaluating internal architecture of the knee as it is non invasive, painless and provides excellent soft tissue contrast [4] .

Meniscal tear and degeneration are manifested as increased signal intensity on T1 & T2 weighted images within the substance of meniscus. Meniscal abnormalities on MRI have been classified by grading system [5, 6] into 4 grades as in figures 1-4. Clinical significant of intra meniscal signal uncertain, it likely that MRI is more sensitive than arthroscopy and the decision to perform menisc-

tomy currently is based exclusively on the presence of a surface tear.

The normal anterior cruciate ligament (ACL) should have a taut, low to intermediate signal intensity with continuous fibres in all planes and sequences. Tears of ACL typically occur in the middle portion of the ligament. The diagnosis of ACL tear is made on MRI by either Identifying disruption of the ligament along its normal course (**figure 5**) or as a focus of increased signal intensity within the substance of the ligament often best seen by T2-weighted image [7-11].

Tears of the posterior cruciate ligament (PCL) are diagnosed by disruption along the course of the ligament or by areas of increased signal intensity within the substance of the ligament. Most of PCL tears involve the mid substance of the ligament [12, 13].

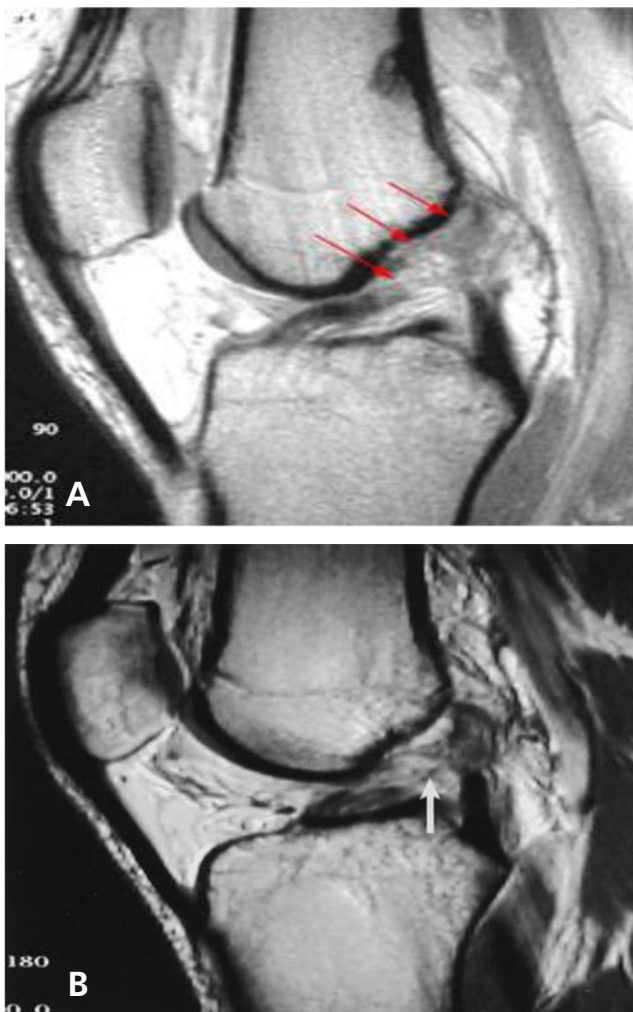
Aim of the study

To assess the role of MRI in the evaluation of intra-articular knee derangement.

Patients and Methods

This prospective study was conducted at MRI unit-department of radiology in Al-kindy teaching hospital during the period from April 2015 to March 2016. We studied 30 patients who were referred from orthopedic department with suspected intra-articular derangement (meniscal and or ligamenteous tear). Patients with prior arthroscopy or surgical intervention or with known joint disease like neoplasm, inflammatory or infectious disorder were excluded from the study. MR scan were performed on all patients included in this study using a Siemens 1.5 Tesla MR machine. The following images were obtained for all patients: T1-weighted images in the sagittal plane, T2-weighted images in the sagittal and coronal plane, T2-SPiR in the sagittal and coronal plane. All images were interpreted by two qualified radiologists for any intra articular lesions and

Figure 5: Knee MRI images a) partial tear of ACL appear as increased signal intensity and irregularity of its fibers (red arrows). b) complete tear of ACL appear as disruption along its fibers (white arrow).



any associated finding like joint effusion & marrow hyperemia. The results of the MRI were compared to the knee arthroscopy and/or surgery (which were considered final diagnosis & gold standard in all cases) done to the patient later on and the analysis for the data was done using SPSS program version 19 results; description of quantitative variables as mean and range, description of qualitative variables as number and percentage

Sensitivity: true positive/true positive + false negative = ability of the test to detect positive cases.

Specificity: true negative/true negative + false positive: ability of the test to exclude negative cases.

PPV (positive predictive value): true positive/true positive + false positive = % of true positive cases to all positive.

NPV: true negative/true negative + false negative = % of the true negative to all negative cases.

Accuracy: true positive + true negative/total.

Results

The average age of the population studied was 33 years. The age group 20-39 years is being the most referred to the clinic; because of their marked daily & athletic activities. High male preponderance noted and this may probably reflect the out patient population (**figure 6**).

The study included thirty patients complaining of internal knee derangement, 3 patients (10%) were with normal MRI findings, 18 patients (60%) had medial meniscus injuries, 6 patients (20%) had lateral meniscus injuries, 8 patients (26.6%) had ACL injuries, no patients had PCL injuries, and 3 patients (10%) had pleural effusion (**figure 7**).

Most medial meniscus tears are noted in the posterior horn while most lateral meniscus tears are noted in the anterior horn (**figure 8**).

With regards to tears of medial meniscus, comparison of the findings of magnetic resonance imaging with those of arthroscopy revealed that sensitivity was 94.1%, specificity was 84.6%, PPV was 88.8%,

Figure 6: Age distribution of study population.

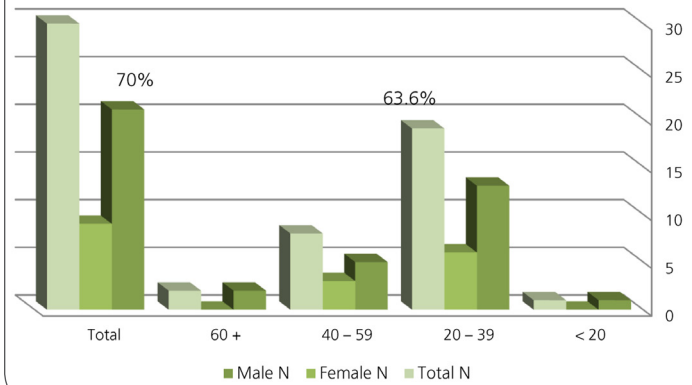


Figure 7: MRI findings in 30 patients with internal knee derangement.

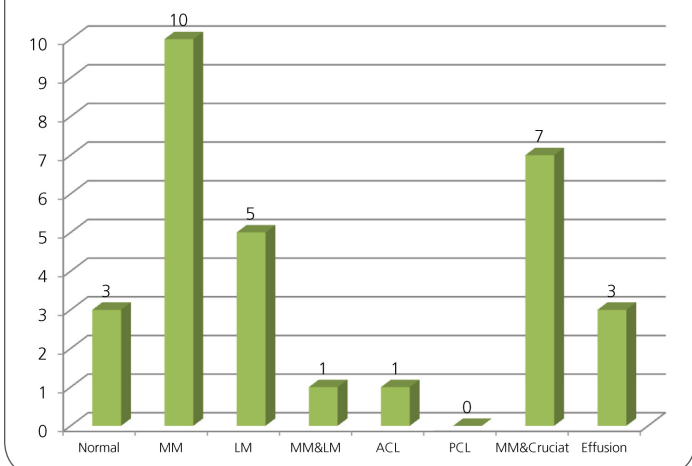
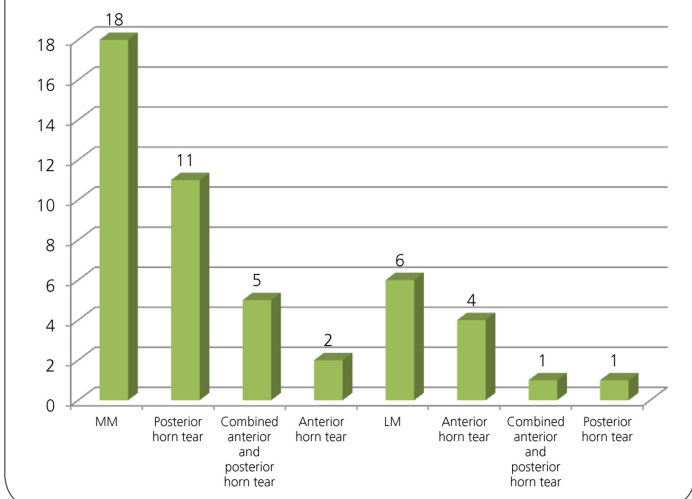


Figure 8: Distribution of different types tear according to their site in final diagnosis.



NPV was 91.6% and accuracy was 90% respectively (**Table 1**). For the lateral meniscus, sensitivity was 71.4%, specificity was 95.6%, PPV was 83.3%, NPV was 91.6% and accuracy was 90% respectively (**Table 2**). For the anterior cruciate ligament, sensitivity was 85.7%, specificity was 91.3%, PPV was 75%, NPV was 95.4% and accuracy was 90% respectively (**Table 3**).

Table 1. Index values of MRI findings for medial meniscus injuries.

Statistic	Value (%)
Sensitivity	94.1
Specificity	84.6
PPV	88.8
NPV	91.6
Accuracy	90

PPV: positive predictive value, NPV: negative predictive value.

Table 2. Index values of MRI findings for lateral meniscus injuries.

Statistic	Value (%)
Sensitivity	71.4
Specificity	95.6
PPV	83.3
NPV	91.6
Accuracy	90

PPV: positive predictive value, NPV: negative predictive value.

Table 3. Index values of MRI findings for ACL tears.

Statistic	Value (%)
Sensitivity	85.7
Specificity	91.3
PPV	75
NPV	95.4
Accuracy	90

PPV: positive predictive value, NPV: negative predictive value.

Discussion

MRI of the knee has become a dependable device in the depiction of knee injuries. Injuries to menisci and cruciate ligaments can be detected on MRI with a high degree of sensitivity and specificity, but accuracy of MRI decreases in patients with multiple injuries [14]. Although arthroscopy has been regarded the gold standard in diagnosis of meniscal and ligament injuries, MRI remains a reliable, non-invasive tool, which can reduce the use of diagnostic arthroscopy.

Zairul-Nizam et al. studied patients with knee injuries and concluded that the MRI is very sensitive in diagnosing meniscus and ligamentous injuries [15]. However, in other studies there were inconsistent findings, Madhusudhan et al. in the UK studied 109 injured knees. In their study, the physical examinations, with the exception of meniscus tears, were superior to MRI results [16]. In a study in Mashhad on 92 patients with knee injuries, Mazlomy et al. noted similar results and reported a high accuracy for clinical examinations [17]. Behairy et al. is an Egyptian study of 70 patients that noted high diagnostic accuracy of both physical examination and MRI, and in most cases, only small differences existed between the two methods, which was also confirmed in a study by Thomas et al. [5, 18]. Major causes for the differences in the results were related to different skill levels of staff involved in MRI interpretation, arthroscopy and clinical examination. The difference in technique used for the MRI is of importance. Studies have shown that if the examination is performed by a skilled technician, the results will be accurate [19].

In our study, MRI showed that the sensitivity of medial meniscal injury was 94.1% with false positive results in 2 patients (11%) and false negative results in 1 patient (5.5%) of the medial meniscal injuries and these results in agreement with Kuikka et al. and Ramnath et al. which reported sensitivity of MRI of 91.7% [20, 21].

There are several explanations for the misleading results of MRI regarding the menisci. These pitfalls in interpreting meniscal tear includes: some of false positive MRI findings were in fact false negative arthroscopic results, some of these tears detected on MRI were intrameniscal tears that did not communicate with arthroscopic visible meniscal surface. Delay between MRI and arthroscopy or surgery also result in false positive MRI diagnosis if the delay is being long enough to allow the meniscus to heal, that's to say some false positive results may reflect healed tear.

Mackenzie et al. summarized the four most common reasons for false positive diagnosis; wrong diagnosis due to variable anatomic structures, overestimation of pathology countered as meniscus tear (for example chondral injuries that mimic meniscus tears), false negative arthroscopic findings and tears within the meniscus without expansion to the articular surface [22]. Jee et al. concluded that MRI in the presence of ACL tears has lower sensitivity for detecting meniscal tears due to missed lateral meniscal tear, and this may represent one of the causes of the misinterpretation of meniscal injures in this study [23]. MRI specificity for medial meniscal injury in this study was 84.6% which agrees with the study of Kuikka et al. and Ramnath et al. which reported 87.1% specificity [20, 21].

In this study we noted that the posterior horn of medial meniscus is most frequently involved and this may be attributable to its anatomical arrangement and being less mobile than the lateral one.

The sensitivity and specificity for ACL injuries in this study were 85.7% and 91.3% respectively, which agree with Khanda et al. as they observed in their study sensitivity and specificity for ACL injuries of 86.67% and 91.43%, respectively [24]. Rayan et al. presented similar results, as they report 81% sensitivity for ACL injuries [25]. This low sensitivity probably secondary to the criteria used by radiologist and orthopedic surgeon to distinguish between

normal, partially, & completely ruptured ACL. MRI finding of an ACL tear apart from abnormalities of ACL proper are termed secondary signs, sensitivity of these signs are limited thus the absence of these signs are not exclude ACL disruption, consequently these signs may allow confident diagnosis with high specificity for ACL injury, these include bone bruises and osteochondral fractures, anterior translocation of tibia, anterior tibial spine fractures and their associated bone bruises, so these signs might lower sensitivity of MRI for ACL tears.

Regarding the PCL, Witonski and Vaz et al. reported that both the sensitivity and specificity of MRI in making the diagnosis of PCL tears were 100% [26, 27]. In our study we evaluated no PCL injuries as these not encountered during the study period and this was one of the limitations in this study.

Some authors reported that specific imaging sequences improve the sensitivity and specificity for detecting meniscal and ligamentous tears [28]. In our work, we noted that T2-SPIR sequence was the best to detect meniscal tear.

The value of our work was that we studied the accuracy of MRI and its agreement with arthroscopy and surgery as it is actually done without using a specific imaging protocol. Despite the fact that this study has a limitation in terms of the small number of patients, we believe that the groups studied are representative of the population normally attending the orthopedics clinics and this study could become a baseline and give guidance for further studies.

Conclusion

MRI is non invasive imaging technique and has been shown highly accurate in the diagnosis of tears of the menisci and cruciate ligaments, making diagnostic arthroscopy unnecessary in most patients.

Familiarity with normal knee joint anatomy and common imaging pitfalls reduces but does not completely eliminate MRI imaging interpretation errors

so more experience is needed for MRI observer to avoid the error in the diagnosis.

MRI proved to give good results in the diagnosis of tear in the posterior horn of the meniscus, which might create difficulties in diagnostic arthroscopy.

Abbreviations

MRI: Magnetic Resonance Imaging

ACL: Anterior Cruciate Ligament

PCL: Posterior Cruciate Ligament

SPIR: Spectral Presaturation with Inversion Recovery

PPV: Positive Predictive Value

NPV: Negative Predictive Value

MM: Medial meniscus

LM: Lateral Meniscus

Authors' contributions

Q. Hassan reporting the study. M. Aledani conducting the study. Q. Hassan proof of the study design, statistical analysis and reviewing the manuscript. M. Aledani study design, statistical analysis, and writing the manuscript. Both authors read and approved the final manuscript.

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Competing interests

The authors declare that they have no competing interests.

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Ethical approval

The study was approved by the local ethical committee in alkindy college of medicine (Medical Research Council Scientific and Research Committee).

Informed consent was obtained from all patients for being included in the study.

References

1. Frobell RB, Lohmander LS, Roos HP. Acute rotational trauma to the knee: Poor agreement between clinical assessment and magnetic resonance imaging findings. *Scand J Med Sci Sports*. 2007; 17:109-14.
2. Manoj MK, Brijesh Ray RS, Jose Francis. P Correlation between MRI and arthroscopic findings in injuries of knee joint. *Kerala Journal of Orthopaedics*. 2014; 27: 18-21.
3. Otani T, Matsumoto H, Suda Y, Niki Y, Jinnouchi M. Proper use of MR imaging in internal derangement of the knee (orthopedic surgeon's view). *Semin Musculoskelet Radiol* 2001; 5:143-5.
4. Edwin H. G. Oei, Msc, Jeroen J. Nikken, MD, Antonia C. M. Verstijnen, Msc, Abida Z. Ginai, MD, PhD and M.G. Myriam Hunink, MD, PhD: MR imaging of the menisci and cruciate Ligaments: A systematic review. *Radiology* 2003; 226:837-48.
5. Behairy NH, Dorgham MA, Khaled SA. Accuracy of routine magnetic resonance imaging in meniscal and ligamentous injuries of the knee: comparison with arthroscopy. *Int Orthop*. 2009; 33: 961-67.
6. Nikolaou VS, Chronopoulos E, Savvidou C, et al. MRI efficacy in diagnosing internal lesions of the knee: a retrospective analysis. *J Trauma Manag Outcomes*. 2008; 2:4.
7. Lee JK, Yao L, Phelps CT, Wirth CR, Czajka J, Lozman. Anterior cruciate ligament tears: MR imaging compared with arthroscopy and clinical tests. *J Radiology*. 1988; 166:861-4.
8. Mink JH, Levy T, Crues JV. Tears of the anterior cruciate ligament and menisci of the knee: MR imaging evaluation. *3rd Radiology*. 1988; 167:769-74.
9. Robertson PL, Schweitzer ME, Bartolozzi AR, Ugoni. Anterior cruciate ligament tears: evaluation of multiple signs with MR imaging. *Radiology*. 1994; 193:829-34.
10. Van Dyck P, Vanhoenacker FM, Gielen JL, Dossche L, Van Gestel J, Wouters K, Parizel PM. Three tesla magnetic resonance imaging of the anterior cruciate ligament of the knee: can we differentiate complete from partial tears? *Skeletal Radiol*. 2011; 40:701-7.
11. Tung GA, Davis LM, Wiggins ME, Fadale PD. Tears of the anterior cruciate ligament: primary and secondary signs at MR imaging. *Radiology*. 1993; 188:661-7.
12. Rodriguez W, Vinson EN, Helms CA et-al. MRI appearance of posterior cruciate ligament tears. *AJR Am J Roentgenol*. 2008; 191: 1031.
13. Sonin AH, Fitzgerald SW, Hoff FL et-al. MR imaging of the posterior cruciate ligament: normal, abnormal, and associated injury patterns. *Radiographics*. 1995; 15: 551-61.

14. Rubin D.A., Kettering J.M., Towers J.D., et al. MR imaging of knees having isolated and combined ligament injuries. *AJR Am J Roentgenol.* 1998; 171: 1207-13.
15. Zairul-Nizam Z.F., Hyzan M.Y., Gobinder S., Razak M.A. The role of preoperative magnetic resonance imaging in internal derangement of the knee. *Med J Malaysia.* 2000; 5: 433-8.
16. Madhusudhan T., Kumar T., Bastawrous S., Sinha A. Clinical examination, MRI and arthroscopy in meniscus and ligamentous knee injuries – a prospective study. *J Orthop Surg.* 2008; 3: 19.
17. Mazlomy M., Makhmalbaf H., Kashani omidi F., Mahvalati sadri A. Comparison of clinical findings with arthroscopic findings in knee intra-articular injuries. *Med J Mashhad Univ Med Sci.* 2007; 49: 421-6.
18. Thomas S., Pullagura M., Robinson E., Cohen A., Banaszkiwicz P. The value of magnetic resonance imaging in our current management of ACL and meniscus injuries. *Knee Surg Sports Traumatol Arthrosc.* 2007; 15: 533-6.
19. Peleg B., Ely S., Hagai A., Nachman A., Arbel R. Accuracy of magnetic resonance imaging of the knee and unjustified surgery. *Clin Orthop Relat Res.* 2006; 447: 100-4.
20. Kuikka P.I., Sillanpää P., Mattila V.M., et al. Magnetic resonance imaging in acute traumatic and chronic meniscal tears of the knee: a diagnostic accuracy study in young adults. *Am J Sports Med.* 2009; 37: 1003-80.
21. Ramnath R.R., Magee T., Wasudev N., Murrah R. Accuracy of 3-T MRI using fast spin-echo technique to detect meniscal tears of the knee. *AJR Am J Roentgenol.* 2006; 187: 221-5.
22. Mackenzie R., Palmer C.R., Lomas D.J., Dixon A.K. Magnetic resonance imaging of the knee: diagnostic performance studies. *Clin Radiol.* 1996; 51: 251-7.
23. Jee W.H., McCauley T.R., Kim J.M., et al. Meniscal tear configurations: categorization with MR imaging. *AJR Am J Roentgenol.* 2003; 180: 93-7.
24. Khanda G.E., Akhtar W., Ahsan H., Ahmad N. Assessment of menisci and ligamentous injuries of the knee on magnetic resonance imaging: correlation with arthroscopy. *J Pak Med Assoc.* 2008; 58: 537-40.
25. Rayan F., Bhonsle S., Shukla D.D. Clinical, MRI, and arthroscopic correlation in meniscal and anterior cruciate ligament injuries. *Int Orthop.* 2009; 33: 129-32.
26. Witonski D. Acute traumatic hemarthrosis of the adult's knee—a diagnostic options in arthroscopic era. Literature review. *Chir Narzadow Ruchu Ortop Pol.* 2008; 73: 339-43.
27. Vaz C.E., Camargo O.P., Santana P.J., et al. Accuracy of magnetic resonance in identifying traumatic intraarticular knee lesions. *Clinics (Sao Paulo).* 2005; 60: 445-50.
28. Helms C.A. The meniscus: recent advances in MR imaging of the knee. *AJR Am J Roentgenol.* 2002; 179: 1115-22.

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