# MRI versus diagnostic arthroscopy of the knee to evaluate meniscal tears

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**Background**
This study compares between the results of MRI and diagnostic arthroscopy of the knee to evaluate meniscal tears.
**Patients and methods**
A total of 32 patients who had undergone MRI of the knee between March 2018 and May 2020 were selected for the study in whom arthroscopy had also been performed. All knees had been investigated for possible meniscal tears. The MRI results were compared with those of arthroscopy. The arthroscopic results were used as the gold standard to recognize if meniscal tear is present or not. Of the 32 patients, 24 were males and eight were females. The average age was 31 years (range, 22–45 years). Patients who had a discoid lateral meniscus, history of meniscal surgery, or prior surgery on the injured knee were excluded from the study. The sensitivity, specificity, and accuracy were calculated based on arthroscopic findings.
**Results**
The time between MRI and arthroscopy was 7–10 weeks (average, 8 weeks). In certain cases, a difference was noted between the MRI and arthroscopic findings for revealing the meniscal tears. False-positive MRI result was found in one (3.1%) patient and false-negative MRI result was found in five (15.6%) patients. The accuracy of MRI in the evaluation of meniscal tears was 90.58%.
**Conclusions**
MRI is a noninvasive and exceptionally a sensitive method of investigation that may detect early and slight abnormalities within the menisci. However, MRI is not 100% accurate; if MRI result is reported as negative but the patient keeps complaining of continuing symptoms, then arthroscopy should be considered.

**Keywords:**
arthroscopy, knee, meniscus, MRI

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## Introduction

Meniscal injuries are common, and the medial meniscus is more frequently injured than the lateral meniscus. Patients commonly complain of pain and swelling as their principal clinical features. Sometimes, the clinical picture is also confusing, and delay in diagnosis may lead to a worse prognosis. Consequently, further assessment of meniscal tears must be confirmed by MRI or arthroscopy [1,2].

Arthroscopy, through direct visualization and probing of the menisci and anterior cruciate ligament (ACL), allows for consistent assessment of the extent of injury. However, it is invasive and requires an experienced surgeon [3]. Arthroscopy is taken into account as 'the gold standard' for the assessment of knee injuries. Although the total incidence of complications of diagnostic arthroscopy is moderately low, it is an invasive and comparatively expensive procedure and its accuracy is between 35 and 70% [4,5]. Arthroscopy should ideally be performed for treatment purposes only, provided that alternative noninvasive diagnostic techniques, for instance, MRI, are available [6].

MRI is noninvasive and appears to be without risks and does not expose the patient to radiation because MRI does not use ionizing radiation. MRI is a valuable diagnostic tool in identifying radial tears of the posterior horn of the medial meniscus, which are common in elderly patients who also often have osteoarthritis that masks their symptoms, which might be definitely improved after treatment of the tear [1]. MRI is indicated when surgery, like arthroscopy, is being considered.

Several reports have documented that an outsized number of arthroscopic procedures can be avoided if the patients were previously assessed by MRI. MRI is very much indicated in acute injuries of the knee when history and clinical manifestations by orthopedic surgeons demonstrate equivocal results and



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in competitive athletes in whom a direct management is required, as well as in patients who present a high surgical risk [7].

Feller and Webster [8] reported that a negative MRI result is very helpful to avoid a needless diagnostic arthroscopy. However, although MRI has a high sensitivity and specificity for the evaluation of acute knee injury, some reports have documented a high false-positive rate for the detection of the torn menisci [9,10]. Some false-positive MRI reports that have been found within the posterior horn of the medial meniscus are often explained by insufficient visualization of the meniscus at surgery, and tears extending to the inferior surface of the meniscus could also be hard to be visualized and accordingly the assessment of a torn meniscus can be subjective. Consequently, general dependence on MRI to guide management should lead to needless diagnostic arthroscopies. Identification of meniscal tears will be hard to interpret and might be viewer dependent as well as dependent upon the sensitivity of the scanner. Similar difficulties could also be present in clinical examination as well [11].

The aim of the current study was to compare the results between MRI and diagnostic arthroscopy of the knee to diagnose meniscus tears.

## Patients and methods

A total of 32 patients were selected for the study between March 2018 and May 2020 after obtaining an informed written consent from all patients. We prepared for this study after the approval of the local ethical committee. MRI and arthroscopy of the knee were performed for all patients. All knees had been investigated for possible meniscal injury. All MRI scans were assessed by the same radiologist, and all arthroscopies were performed by the same surgeon. The arthroscopic results were used as the gold standard to recognize if meniscal tear is present or not. Patients who had a discoid lateral meniscus, history of meniscal surgery, or prior surgery on the injured knee were excluded from the study.

The records of every patient were independently reviewed. Of the 32 patients, there have been 24 men and eight women, and their average age was 31 years (range, 22–45 years). In all cases, the injuries were unilateral, with 14 affecting the right knee and 18 the left knee. In 10%, there was no history of trauma, and in a further 15%, although the knee had been injured, the character of the injury could not be recalled. A twisting injury was the most typical mechanism of injury within the remaining 75%.

MRI of the affected knee was requested in all patients. Data including patient demographics, period between MRI and arthroscopy, MRI findings, and arthroscopic findings were recorded and analyzed. Demographics of patients are shown in Table 1.

The MRI scans of the all patients were performed by a skilled musculoskeletal radiologist without being given any clinical details of the cases. An area of high signal within the body of a meniscus was regarded as a tear if it extended to one or both articular surfaces or in which distortion of the meniscus, including shortening or blunting, was found. These criteria are considered to be sensitive and specific signs of meniscal tear [12–14]. If the articular surfaces were not reached, the high signal was interpreted as an area of mucoid degeneration [13] and accordingly meniscal findings were classed as torn or not (Fig. 1). Spinal anesthesia was used in all arthroscopic procedures. Standard anterolateral and anteromedial portals were used for the procedure. Details of operative findings were documented, which involved the anatomical structure concerned with the presence or absence of meniscal tear, its location, and further features when available. MRI findings were matched against the arthroscopic findings in each case.

A true-positive result had an abnormal meniscal finding documented by MRI and confirmed at arthroscopy (Fig. 2). A true-negative result had no abnormalities detected by MRI or at arthroscopy. A false-positive result was determined if the MRI documented an abnormality but was not confirmed at arthroscopy (Fig. 3). A false-negative result had a negative MRI report and a positive finding at arthroscopy (Table 2). Correlation of MRI with arthroscopy from the information of 32 patients was expressed as a percentage.

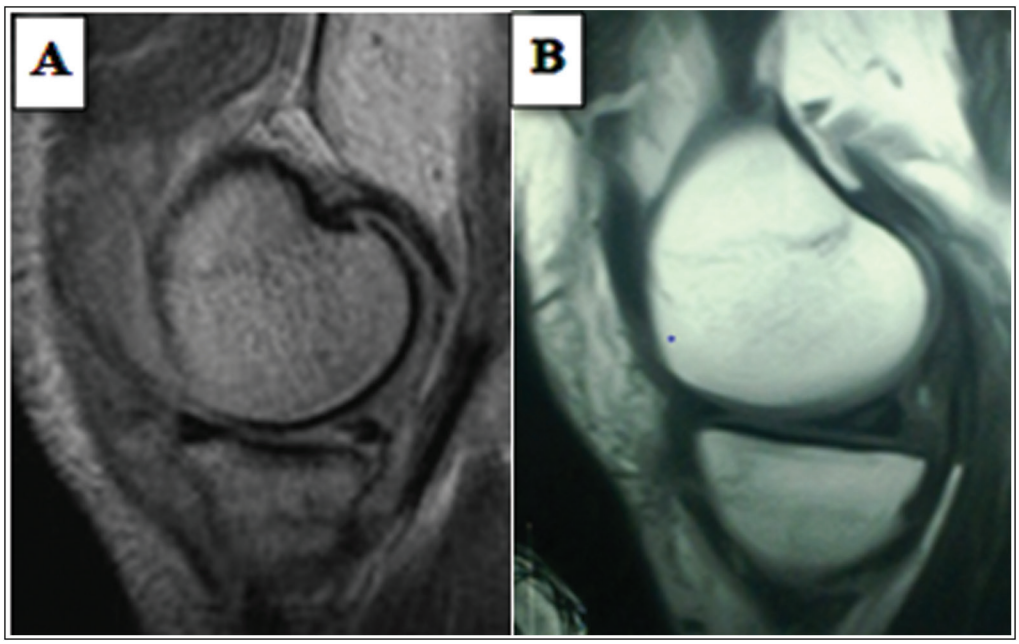
Arthroscopy was considered to be the gold standard for the accuracy of diagnosis of meniscal tears, and to assess the sensitivity, specificity, as well as accuracy of MRI, the arthroscopic results were considered to be the confirmed diagnosis. Sensitivity was determined from the number of true-positive outcomes divided by the sum of the true-positive outcomes and the false-negative outcomes. Specificity was determined from the number of true-negative results divided by the sum of the true-negative outcomes and the false-positive outcomes. Accuracy was determined from the sum of the true-positive and the true-negative outcomes divided by the total number of patients who underwent arthroscopy.

**Table 1 Patient demographics**

| Case | Age (years) | Sex | Side | Duration of symptoms (week) | MRI finding | Arthroscopic finding |
|---|---|---|---|---|---|---|
| 1 | 28 | Male | Left | 7 | Torn MM | Torn MM |
| 2 | 28 | Female | Right | 9 | Torn LM | Torn LM |
| 3 | 27 | Female | Left | 8 | Torn MM | Torn MM |
| 4 | 25 | Male | Left | 7 | Torn MM+ACL | Torn MM+ACL |
| 5 | 27 | Male | Right | 7 | Torn LM | Torn LM |
| 6 | 29 | Female | Left | 7 | Torn MM | Torn MM |
| 7 | 38 | Male | Left | 10 | Torn MM | Torn MM |
| 8 | 22 | Male | Left | 8 | Torn MM | Torn MM |
| 9 | 29 | Female | Right | 8 | Torn MM | Torn MM |
| 10 | 33 | Male | Right | 8 | Torn LM | Torn LM |
| 11 | 35 | Female | Right | 8 | – | Torn MM |
| 12 | 29 | Male | Left | 8 | Torn LM | Torn LM |
| 13 | 28 | Male | Left | 8 | Torn MM | Torn MM |
| 14 | 22 | Male | Right | 8 | Torn ACL | Torn LM+ACL |
| 15 | 35 | Male | Right | 9 | Torn MM | Torn MM |
| 16 | 32 | Male | Left | 8 | Torn MM | Torn MM |
| 17 | 31 | Female | Left | 9 | Torn LM | Torn LM |
| 18 | 37 | Male | Left | 8 | Torn MM | Torn MM |
| 19 | 37 | Male | Right | 8 | Torn ACL | Torn LM+ACL |
| 20 | 24 | Male | Right | 9 | Torn MM+ ACL | Torn MM+ACL |
| 21 | 29 | Male | Left | 7 | Torn MM | Torn MM |
| 22 | 32 | Male | Right | 7 | – | – |
| 23 | 45 | Male | Right | 8 | Torn MM | Torn MM |
| 24 | 34 | Male | Left | 9 | Torn LM | Torn LM |
| 25 | 37 | Female | Right | 8 | – | – |
| 26 | 35 | Male | Left | 8 | Torn MM | Torn MM |
| 27 | 28 | Male | Left | 9 | Torn LM | – |
| 28 | 37 | Female | Right | 7 | Torn MM | Torn MM |
| 29 | 33 | Male | Right | 8 | – | – |
| 30 | 28 | Male | Left | 8 | – | Torn LM |
| 31 | 26 | Male | Left | 8 | Torn MM | Torn MM |
| 32 | 32 | Male | Left | 7 | – | Torn LM |

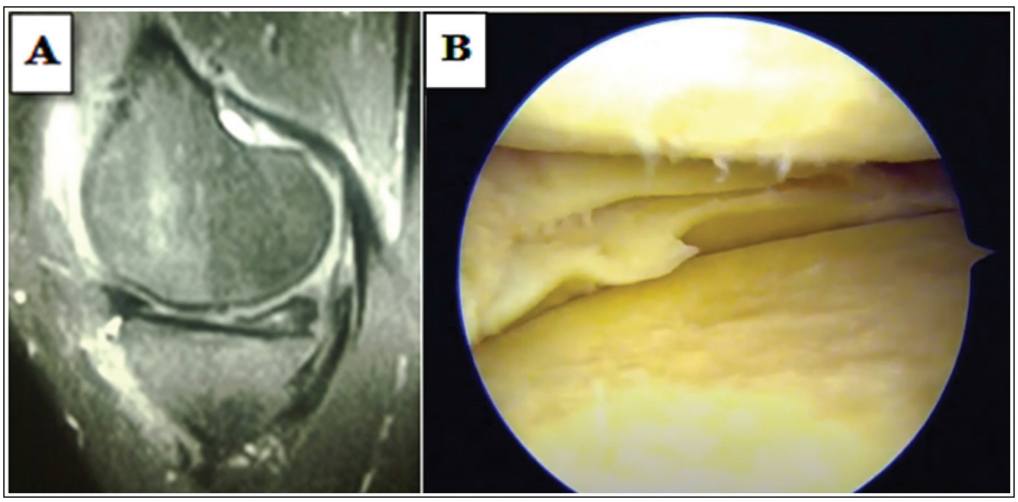
ACL, anterior cruciate ligament; LM, lateral meniscus t; MM, medial meniscus.

**Figure 1**



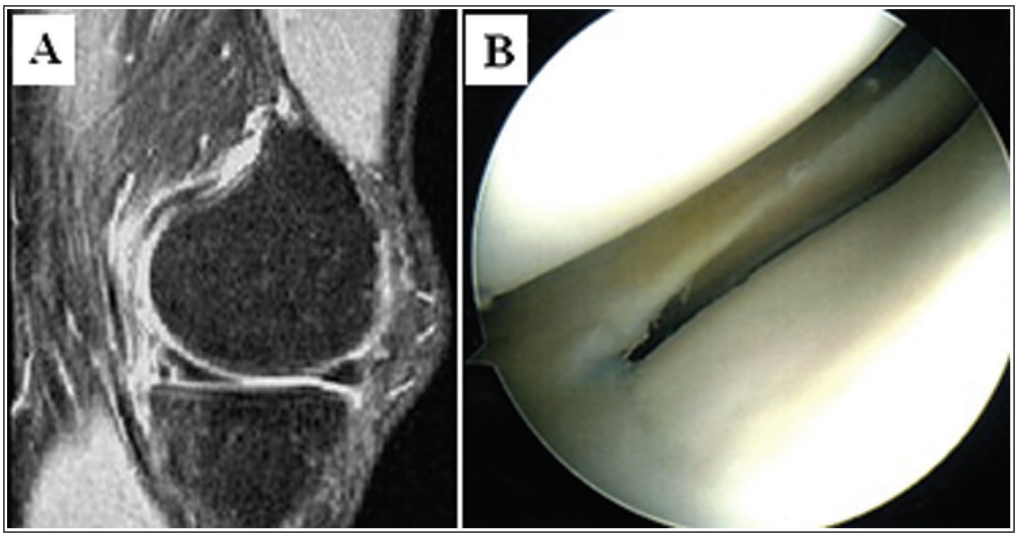

(a) A tear of the posterior horn of the medial meniscus, which appears shortened. (b) If the articular surfaces were not reached, the high signal was interpreted as an area of mucoid degeneration, not a tear.

**Figure 2**




True-positive MRI. (a) A horizontal tear was present in MRI, at the posterior horn of the medial meniscus. (b) The tear was confirmed at arthroscopy.

**Figure 3**




False-positive MRI. Torn posterior horn of the lateral meniscus in MRI (a), whereas the meniscus was found intact on arthroscopy (b).

**Table 2 True-positive and false-positive MRI findings, using arthroscopic finding as the reference data**

| Test | True positive | True negative | False positive | False negative |
|---|---|---|---|---|
| MM MRI finding | 17 | 14 | – | 1 |
| LM MRI finding | 6 | 21 | 1 | 4 |

LM, lateral meniscus; MM, medial meniscus.

## Results

In 24 (75%) of the 32 patients, the indication for arthroscopy was the MRI findings of a torn meniscus. The MRI findings were isolated medial meniscus tears in 15 patients, isolated torn lateral meniscus in seven patients, a combination of tears of the ACL and medial meniscus in two patients, and isolated ACL tears in two patients. The menisci recorded as normal included those that have recognized internal mucoid degeneration on MRI scanning, or fraying on arthroscopic inspection.

In eight (25%) patients, arthroscopy was performed on clinical grounds despite the negative meniscal findings on the MRI. The time between MRI and arthroscopy was 7–10 weeks (average, 8 weeks).

Presenting signs were nonspecific in 11 patients. Pain was the principal complaint in 21 patients. A total of 17 patients had one or more episodes of locking.

The correlations between MRI and arthroscopic diagnoses are given in Tables 3 and 4. Table 5 shows the sensitivity, specificity, and accuracy of MRI.

**Table 3 The MRI and arthroscopic findings for tears of the medial meniscus**

| Findings | MRI findings | Arthroscopic finding |
|---|---|---|
| Normal | 15 | 14 |
| Torn | 17 | 18 |

**Table 4 The MRI and arthroscopic findings for tears of the lateral meniscus**

| Findings | MRI findings | Arthroscopic findings |
|---|---|---|
| Normal | 24 | 2 2 |
| Torn | 7 | 10 |

**Table 5 The sensitivity, specificity, and accuracy of MRI judged against the arthroscopic diagnosis variable**

| Variables | Sensitivity [(*n*/*N*) %] | Specificity [(*n*/*N*) %] | Accuracy [(*n*/*N*) %] |
|---|---|---|---|
| Medial meniscus | 17/18 (94.4) | 14/14 (100) | 31/32 (96.8) |
| Lateral meniscus | 6/10 (60) | 21/22 (95.4) | 27/32 (84.37) |

In definite cases, a difference was obvious between the MRI and arthroscopic findings. False-positive MRI result was found in one (3.1%) patient. A tear was diagnosed on MRI and considered to be present in the posterior horn of the lateral meniscus but was not confirmed at arthroscopy (case no. 27).

For eight patients, arthroscopies were performed on clinical grounds despite the normal appearance of the menisci on MRI. Three of these eight patients had true-negative results, whereas five patients had false-negative meniscal injuries in MRI. The menisci were considered normal on MRI but a tear was detected at subsequent arthroscopies. One patient was noted to have a horizontal cleavage tear of the medial meniscus (case no. 11), two patients had small radial tears in the posterior horn of the lateral meniscus (case no. 30 and 32), and two patients had a combination of ACL and lateral meniscal tears (case no. 14 and 19). These meniscal tears were not demonstrated by MRI but were seen only at arthroscopy.

In four patients, ACL tear was suspected clinically and was confirmed by both MRI and arthroscopy. In knees with a combination of an ACL tear and meniscal tear, the indicative accuracy of the MRI to diagnose meniscal tears reached the level of 100% in medial meniscal injuries, whereas it was 50% in lateral meniscal injuries.

The accuracy of MRI in the identification of medial meniscal tears was 96.8%, whereas it was 84.37% in the identification of lateral meniscal tears, with an average of 90.58% for the whole study.

Arthroscopy was associated with a complication rate of 3.12%. One knee required readmission to hospital for treatment of hemarthrosis.

## Discussion

Arthroscopy provides an accurate diagnosis from 84% to 98.6% of cases and allows treatment of meniscal tears. As a diagnostic method, arthroscopy exposes the patient to discomforts and risks associated with anesthesia and an operation. Arthroscopy has surgical hazards, with a complication rate of 2.5% in arthroscopic meniscal surgery [5], including saphenous and peroneal nerve injuries, deep infections, superficial infections, vascular injuries, and pulmonary embolism. Sometimes, arthroscopy reveals no abnormality or probably insignificant nonpathological lesions, for example, plicae or chondromalacia patellae. This implies that a patient could be exposed to surgical risk with no symptom advantage.

MRI is overused in the assessment of knee disorders and is not a cost-effective method for evaluating knee injuries [9]. However, MRI can identify most internal derangements of the knee efficiently, as it has a greater specificity (i.e. perfectly detects the absence of the knee internal derangement) than sensitivity (i.e. precisely detecting a knee internal derangement). There is greater reliability of a negative MRI result than the reliability of a positive MRI result. Thus, if a patient is given a result of a negative MRI scan, the high specificity and reliability of a negative MRI result of the scan mean that this is likely to be a true negative result [15]. MRI can help to avoid pointless diagnostic arthroscopic surgeries in acute knee injuries, it gives multiplanar images, and it provides images of soft-tissue structures, which other imaging methods cannot. Some patients (1–2%) experience claustrophobia [16,17].

### False-positive and false-negative results

The MRI report guides clinical decision making and has medico-legal consequences. If the surgeon relies exclusively upon the MRI report to decide to go to surgery, false-positive reports may lead to unnecessary arthroscopic procedures [17]. Bright signal in the substance of a meniscus is considered to be a tear if it extended to one or both articular surfaces [14].

The results of the current study show that it is unwise to trust negative MRI reports in the face of high clinical suspicion. In the current study, false-negative MRI was found in five patients. One patient had a horizontal cleavage tear of the medial meniscus, and two of the false-negative MRI examinations failed to delineate small radial tears that were found in the posterior horn

of the lateral meniscus. Only intrameniscal signal was seen, and the posterior horn of the lateral meniscus remains a difficult area for MRI evaluation. Another two patients had a combination of ACL and lateral meniscal tears.

De Smet and Graf [18] explained the low sensitivity of MRI results of meniscal tear based on coexisting ACL abnormality, especially if the tear was affecting the lateral meniscus. This was found true in the current study as two patients with a combination of an ACL and lateral meniscal tears had false-negative results. De Smet and Graf [18] also reviewed a series of 400 MRI scans in patients who had subsequently undergone arthroscopic examination, to detect the possible causes of error in the clarification of MRI scans. They found that the factors that increased the possibility of missing the identification of a meniscal tear on MRI involved the existence of a concomitant torn ACL as well as peripherally located meniscal tears.

False-positive MRI was found in one patient. This discrepancy was an overclarification of the MRI presence of the artifacts of increased signal. Peterfy *et al.* [19] concluded that an increased signal was mainly owing to 'magic-angle' phenomenon and not related to meniscus tear. They also reported increased signal within the medial part of the posterior horn of the lateral meniscus in 74% of the patients. This phenomenon is generally attributable to the orientation of the medial part of the lateral meniscus at an angle of 55° to the static magnetic field producing the artifacts of increased signal and which was not due to meniscus tear. The inner edge of the posterior horn of the lateral meniscus is the classic location for magic angle artifact because of the upsloping nature of this area of the meniscus in many patients. This was found true in the current study, because the only false positive result was found within the posterior horn of the lateral meniscus while the meniscus was found intact at arthroscopy. Generally, other possible explanations of false-positive MRI results are also due to misinterpretation of normal anatomy [20] or inadequate arthroscopic technique. Most tears were diagnosed within the posterior horn of the meniscus where they will be missed by the arthroscopist in 5% of cases. The MRI appearance of a small or deficient meniscus, in a patient who has not had a previous meniscectomy, was in every instance, related to a tear. This MRI finding should then be considered as positive evidence of a torn meniscus and it does not represent a failing of MRI.

In the current study, MRI had a high sensitivity in the medial meniscus, where it was absolutely accurate in detecting a tear in 94.4% of patients, whereas its sensitivity in detecting a torn lateral meniscus was 60%, and medial meniscus injury (64.28%) was found to be more common than lateral meniscus tear (35.7%). This was just like the outcomes of the study of Crawford *et al.* [15].

In only eight out of those 32 patients, arthroscopy was performed on clinical basis after a negative MRI result. This concludes that MRI is a vital investigation before deciding surgery to prevent unnecessary diagnostic arthroscopies in a considerable number of cases. The results of this study reveal that torn menisci can be perfectly diagnosed by MRI and agree with the outcomes of other studies [7,21]. Vincken *et al.* [22] conducted a study to realize the success of MRI in patients with a high clinical suspicion before rushing to arthroscopy of the knee and documented that MRI is a successful imaging modality in the selection of patients for arthroscopy from among an overall public. However, the regular use of MRI to verify the diagnosis is not recommended, because the positive predictive value is low; however, it can be used to exclude pathology, because the negative predictive value is high for a substantial number of the injuries [23].

Recently, Shah *et al.* [24] reported that ISAKOS classification may be greatly valuable in both clinical works during regular MRI findings. The use of this uniform strategy, which has been recently approved precisely, would guarantee a gradual multidisciplinary correspondence and should guide patient treatment and longitudinal assessment for results.

The strengths of the present study are derived from its original prospective and randomized design. However, the present study has some limitations such as the small number of patients. Future studies should examine the correlation between MRI and arthroscopic result in the evaluation of meniscal tears with a larger sample size. All MRI scans were evaluated by the same radiologist. To enhance the accuracy, more testers could have been used and their results compared, but practical restraints did not allow for this.

The accuracy of diagnosis of torn menisci will rely on the superiority of imaging apparatus and on experience and skills of the orthopedic surgeon, the radiologist, and the arthroscopist. The findings of this study reveal the close relationship between MRI and arthroscopic evaluation. The precision of MRI permits alternatives in the decision for arthroscopy among patients who might benefit from it, may be by disposing of the necessity for arthroscopy in one-third to at least one 1/2 of those considered, on clinical grounds, to have meniscal injuries.

Such a decrease in the number of invasive procedures should allow a corresponding decrease in the financial and human resources required for the treatment of knee injuries.

## Conclusions

(1) Although MRI gives a valuable adjunct to the clinical decision-making process, it is neither 100% sensitive nor specific. It is thus important that if an MRI is reported as negative but the patient keeps complaining of constant mechanical symptoms, then arthroscopic evaluation should be considered.
(2) The power of correlation between the results of MRI and arthroscopy confirms the worth of MRI in evaluating internal structures of the knee. However, it is important to think about the economic load of MRI for patients, especially in countries with poor state and poor insurance coverage.

The MRI report is more accurate in the diagnosis of medial meniscal tears than the lateral meniscal tears, especially if lateral meniscal tears are associated with ACL tears.

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**Conflicts of interest**
There are no conflicts of interest.

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