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Evaluation of Meniscus Tears and Associated Conditions using Magnetic Resonance Imaging without Contrast Agent: A Retrospective Study

Nagwan Elhussein[1*], Amel F. Alzain[2], Ibtisam Abdallah Fadulelmulla[1], Amna Mohamed Ahmed[3], Sara A. Seifeldin[1], Rehab Hussien[1], Awadia Gareeballah[2,4], Sara Ali[5], Mayeen Uddin Khandaker[6,7], Reham Mohamed Taha[8], Zuhal Y. Hamd[9]

[1]*College of Applied Medical Sciences, University of Hail, Hail, Saudi Arabia*
[2]*College of Applied Medical Sciences, Taibah University, Al-Madinah Al-Munawwarrah, Saudi Arabia*
[3]*College of Applied Medical Sciences, King Khalid University, Abha, Saudi Arabia*
[4]*Faculty of Radiological Sciences and Medical Imaging, Alzaiem Alazhari University, Khartoum, Sudan*
[5]*Faculty of Applied Medical Science, Jazan University, Jazan, Saudi Arabia*
[6]*Centre for Applied Physics and Radiation Technologies, School of Engineering and Technology, Sunway University, Bandar Sunway, Malaysia*
[7]*Faculty of Graduate Studies, Daffodil International University, Daffodil Smart City, Birulia, Savar, Dhaka, Bangladesh*
[8]*Al-Ghad College for Applied Medical Sciences, Riyadh, Saudi Arabia*
[9]*College of Health and Rehabilitation Sciences, Princess Nourah bint Abdulrahman University, Riyadh, Saudi Arabia*

Abstract

Background: Meniscus tears are a common knee joint disease. MRI is considered the gold standard for diagnosing knee joint pathology. This study aimed to evaluate meniscus tears and associated conditions using multiplanar MRI.

Methods and Results: A retrospective cross-section study was conducted at King Salman Medical City and involved 115 patients (81 males and 34 females) aged between 10 and 60 years diagnosed with meniscus tears by multiplanar MRI. The research findings indicated that individuals between the ages of 31 and 40, as well as those aged 21-30 and 51-60 years, were the most affected by meniscal tears. Furthermore, males displayed a greater vulnerability to meniscal tears than females, with approximately 70.4% of cases. The medial meniscus was the most prominently affected, accounting for 63.5% of cases, followed by the lateral meniscus (26.1%) and bilateral involvement (23.5%). Among the affected menisci, over half (56.6%) of the cases exhibited transverse tears, while radial and longitudinal tears were less prevalent. Furthermore, complete tears were more prevalent than partial tears, accounting for 68.7% of cases. Most patients were affected by Grade 1 tears, constituting 62.6% of the total sample. The most frequently concomitant feature with meniscus tears was joint effusion (37.4%), followed by osteoarthritis (17.4%) and anterior cruciate ligament tears (15.7%). There was a significant association between the transverse type of meniscal tears and joint effusion (P=0.047).

Conclusion: The research findings imply that, in some clinical situations, MRI without contrast can be a useful and trustworthy method for identifying meniscus tears.**(International Journal of Biomedicine. 2024;14(4):632-639.)**

Keywords: meniscus tear • joint effusion • anterior cruciate ligament • osteoarthritis

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Abbreviations

ACL, anterior cruciate ligament; **OA**, osteoarthritis; **MRI,** magnetic resonance imaging; **MCL**, medial collateral ligament.

Introduction

The articular cartilage and meniscus of the knee joint directly affect its mobility. The meniscus tissues are crescent-shaped structures located between the tibia and femur bones. Their primary function is to alleviate the load on the knee. In the human body, two types of menisci, namely medial and lateral, are present in each knee joint. Tears in the meniscus often lead to deterioration of the cartilage and bones in the knee joint. Additionally, the meniscus plays a crucial role in protecting the joint cartilage by maximizing the contact area within the tibia-femoral joint and minimizing contact stress. Meniscus tears can easily alter the contact mechanism of this joint. Moreover, disruptions in articular cartilage metabolism can occur, increasing the risk of early-onset osteoarthritis. Meniscus tears are particularly discomforting for younger athletes and older individuals.[1] Osteoarthritis (OA) is prevalent among individuals in the middle age group and typically affects those over the age of 65. The knee joints are the areas most commonly affected by this condition; if left undiagnosed in its early stages, the condition progressively worsens and leads to the deterioration of bone structures. One contributing factor to the development of knee osteoarthritis is the presence of tears in the meniscus structures.[1,2]

Meniscus tear patterns include longitudinal vertical tears, which divide the meniscus into inner and outer parts; horizontal tears, which divide the meniscus into upper and lower parts; radial tears, which run straight into the meniscus both perpendicular and parallel to the tibial articular surface; vertical/horizontal flap tears, which are produced when portions of torn menisci become displaced and complex (combination of horizontal, vertical, and radial).[3] Plain radiographs of the knee joint offer slight data about meniscal pathology, and even computed tomography is insufficient to diagnose many internal disorders of this joint. Magnetic resonance imaging (MRI) is the gold standard of imaging modality investigating patients with knee complaints, especially for evaluating sports injuries. MRI explains meniscal anatomy in detail due to its excellent soft tissue contrast, high resolution, ability to visualize very small structures, and multiplanar projection, all of which can offer important benefits over other imaging techniques in the assessment of meniscus tears. [4,5]

This study aimed to evaluate meniscus tears and associated conditions using multiplanar MRI.

Materials and Methods

A retrospective cross-section study was conducted at King Salman Medical City and involved 115 patients (81 males and 34 females) aged between 10 and 60 years diagnosed with meniscus tears by multiplanar MRI. The study recorded the patients' gender, age, clinical history, MRI features of meniscus tear, and associated complications. The data was collected between October 2022 and May 2023. All patients were scanned with a 1.5 tesla GE-signa HdxII machine.

Magnetic Resonance Imaging

Patients signed questionnaires regarding their history of ferromagnetic implants, pacemakers, cochlear implants, and aneurismal clips or history of claustrophobia. All of the patients were examined in a supine position with extended knees with external rotation (5–15). The knee coil was placed over the affected knee joint, and images were obtained in axial, sagittal, and coronal planes with matrix size (516 × 320).

Sequences: Proton Density (PD), weighted fast spin sequence (FSE), images were achieved using repetition time = 3500 ms, echo time = 28 ms, field of view (FOV) = 20, and slice thickness = 4 cm. T1 weighted images, spin sequences (SE), images were obtained using repetition time = 533 ms, echo time = 12 ms, FOV = 20, and slice thickness = 4 cm. T2 weighted images, spin sequences (SE), images were obtained using repetition time = 4000 ms, echo time = 78 ms, FOV = 20, and slice thickness = 4 cm. Short Tau Inversion Recovery (STIR) images were achieved using repetition time = 2500 ms, echo time = 10 ms, inversion time (TI) = 100 ms, and flip angle of 90. T2 weighted fast spin echo sequences images were obtained using repetition time = 4500 ms, echo time = 72 ms, FOV = 20, and slice thickness = 4 cm. Short Tau Inversion Recovery (STIR) and T2 weighted fast spin echo sequences were used to detect pathology (joint effusion, ligament tear, muscle lesion, etc.)

Statistical analysis was performed using the statistical software package SPSS version 26.0 (SPSS Inc, Armonk, NY: IBM Corp). The baseline characteristics were summarized as frequencies and percentages for categorical variables. Group comparisons concerning categorical variables were performed using the chi-square test. A probability value of $P<0.05$ was considered statistically significant.

Results

The research findings indicated that individuals between the ages of 31 and 40, as well as those aged 21-30 and 51-60 years, were the most affected by meniscal tears. Furthermore, males displayed a greater vulnerability to meniscal tears than females, with approximately 70.4% of cases. Moreover, it was noted that approximately 35.7% of meniscal tear incidents were linked to participation in sporting activities (Table 1). The right knee was affected by tears more than the left (49.6 and 40.9%, respectively) (Figure 1).

Table 1.
Demographic characteristics of the study participants and sports activity.

Variable	Frequency	Percent (%)
Age, years		
10-20	5	4.3
21-30	31	27.0
31-40	43	37.4
41-50	12	10.4
51-60	24	20.9
Gender		
Female	34	29.6
Male	81	70.4
Sport activity		
Yes	41	35.7
No	74	64.3

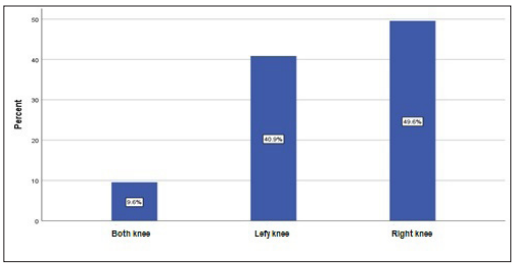

Fig. 1. *Affected knee joints.*

The research findings indicate that the medial meniscus was the most prominently affected, accounting for 63.5% of cases, followed by the lateral meniscus (26.1%) and bilateral involvement (23.5%) (Figure 2). Among the affected menisci, over half of the cases exhibited transverse tears, amounting to 56.6%, while radial and longitudinal tears were less prevalent. Furthermore, complete tears were more prevalent than partial tears, accounting for 68.7% of cases. Most patients were affected by Grade 1 tears, constituting 62.6% of the total sample (Table 2).

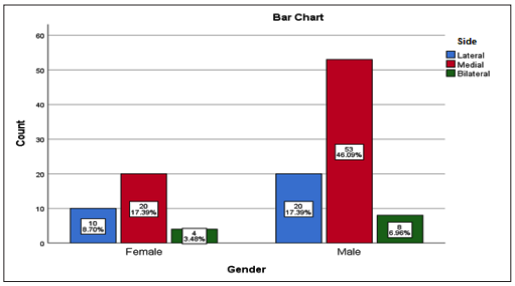

Fig. 2. *The relationship between the side of meniscal tears and gender*

Table 2.

Affected meniscus, type, degree, and grade of tears

MRI findings	Frequency	Percent (%)
Affected meniscus		
Medial	73	63.5
Lateral	30	26.1
Bilateral	12	10.4
Type of tears		
Longitudinal	23	20.0
Transverse	65	56.5
Radial	27	23.5
Degree of tears		
Complete	79	68.7
Partial	36	31.3
Grade of tears		
1	72	62.6
2	17	14.8
3	16	22.6

The most frequently concomitant feature with meniscus tears was joint effusion 37.4%, followed by osteoarthritis, which was present in 17.4% of cases, and anterior cruciate ligament tears in 15.7% of cases (Table 3). The medial meniscus tear was more frequent than the lateral and bilateral in both genders. The medial meniscus tear was more common in males than in females: 65.4% (53/81) versus 58.8% (20/34) (Figure 2).

Table 3.

MRI findings associated with meniscal tears.

MRI finding	Frequency	Percent (%)
Joint effusion	43	37.4
OA	20	17.4
ACL tear	18	15.7
Oedema	16	13.9
Baker's cyst	8	7.0
Ganglion cyst	2	1.74
Bursitis	2	1.74
Meniscal cyst	1	0.87
ACL degeneration	2	1.74
Bone marrow edema	1	0.87
Degenerative changes	1	0.87
Parameniscal cyst	1	0.87
Patellar chondromalacia	1	0.87
Subchondral edema	1	0.87
Synovitis	1	0.87
Fat pad impingement (Hoffa's syndrome)	2	1.74

The study demonstrated that complete tears were the most common type among all age groups, Grades 2 and 3 were more common among sporting participants, and complete tears are the most common in sporting and non-sporting individuals (Figures 3-5).

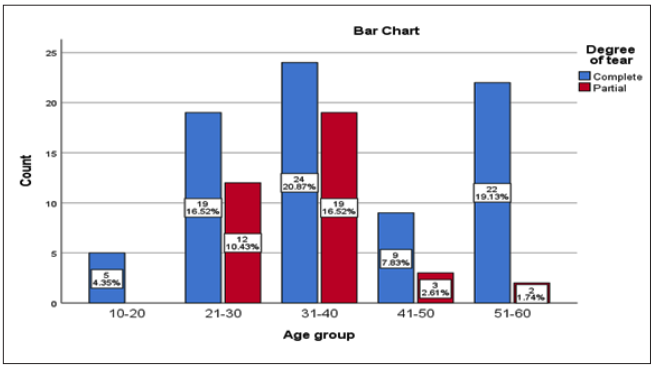

Fig. 3. *The relationship between age group and degree of meniscal tears.*

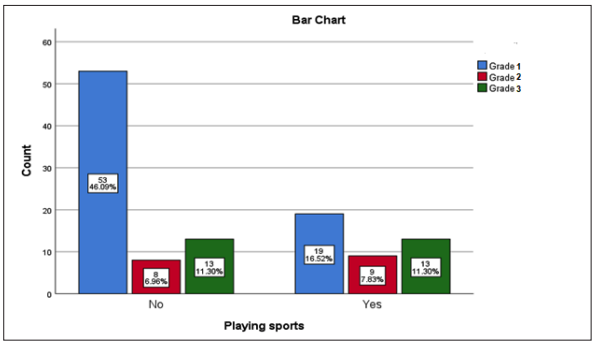

Fig. 4. *The relationship between tear grade and sport activity.*

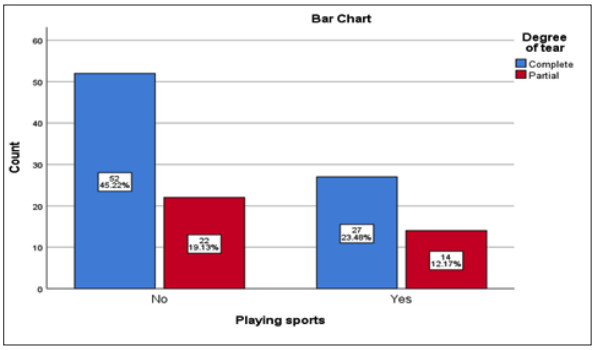

Fig. 5. *The relationship between sports activity and the degree of meniscal tears*

An insignificant relationship was noted between the side and MRI findings associated with meniscal tears (Table 4), but there was a significant association between the transverse type of meniscal tears and joint effusion (P=0.047) (Table 5). The study found that in age group 10-20 years, most types of tears were transverse; in 21-30 years, transverse followed by radial; in 31-40 years, the most common was transverse followed by longitudinal; in 41-50 years, transverse and in 51-60 years of age, transverse followed by radial and longitudinal (Table 6).

Table 4.

Cross tabulation: The relationship between side of tears and MRI findings associated with meniscal tears

Side of tears	Common MRI findings					Total	*P*-value
	ACL tear	Joint effusion	OA	OA, joint effusion	OA, ACL degeneration		
Lateral	5	6	5	1	0	17	0.088
Medial	12	21	11	2	0	46	
Bilateral	1	9	0	0	1	11	
Total	18	36	16	3	1	74	

A series of X-ray (A) and MRI (B) scans of meniscus tears and associated conditions are presented in Figures 6-9.

Table 5.

Cross tabulation: The relationship between type of tears and MRI findings associated with meniscal tears

Type	Common MRI findings					Total	*P*-value
	ACL tears	Joint effusion	OA	OA,joint effusion	OA, ACL degeneration		
Longitudinal	5	5	1	1	0	12	0.047
Transverse	5	27	12	2	1	47	
Radial	8	4	3	0	0	15	
Total	18	36	16	3	1	74	

Table 6.

Cross tabulation: Age groups and types of meniscus tears

Age group	Types of meniscus tears			Total	*P* -value
	Longitudinal	Transverse	Radial		
10-20	0	5	0	5	0.296
21-30	5	15	11	31	
31-40	9	26	8	43	
41-50	3	8	1	12	
51-60	6	11	7	24	
Total	23	65	27	115	

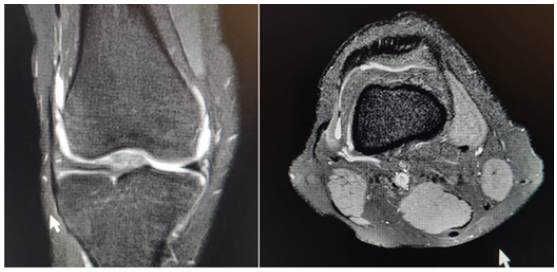

Fig. 6. *A knee joint MRI of a 27-year-old male with a history of trauma. Vertical tear of lateral meniscus with associated entrapment of torn ACL.*

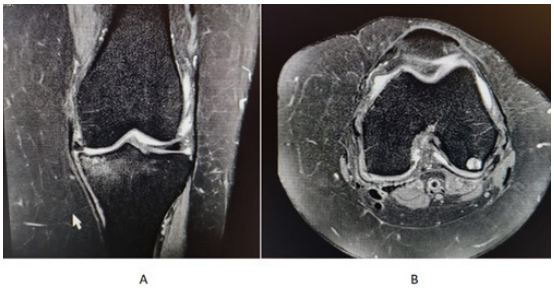

Fig. 7. *A left knee joint MRI of a 54-year-old female presented with pain. Joint effusion associated with a radial tear in the medial meniscus root and OA*

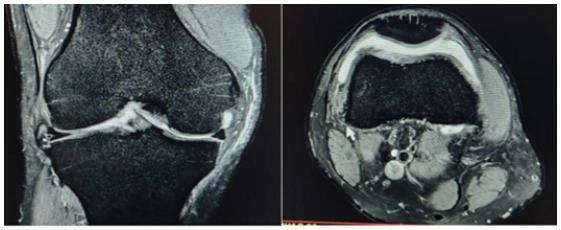

Fig. 8. *A multiplanar MRI of a 40-year-old male presented to the X-ray department with pain in the right knee. Torn lateral and medial meniscus with associated joint effusion.*

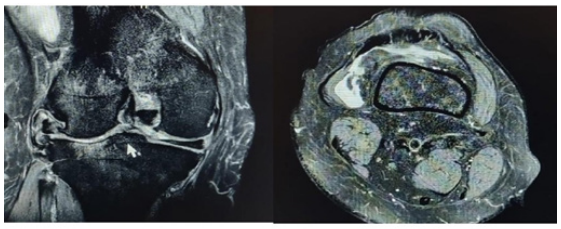

Fig. 9. *A multiplanar MRI of a 37-year-old male presented to the X-ray department with osteoarthritic changes in the right knee. The MRI revealed degenerative torn lateral meniscus, OA and joint effusion, chondromalacia patella (Grade 4).*

Discussion

Meniscus tears are a common knee joint disease; early diagnosis leads to a speedy recovery. MRI is considered the gold standard for diagnosing knee joint pathology, specifically meniscus tears. Several associated bony and ligament injuries accompany meniscus tears. Meniscus tears are one of the major risk factors for the onset and progression of osteoarthritis in the knee, regardless of the type of tear. On the other hand, some patients with osteoarthritis may develop meniscus tears. Studies show that meniscus tears are more common in medial menisci than lateral menisci.[6] Meniscal pathology can be reliably diagnosed with MRI, widely acknowledged in clinical practice. MRI has shown sensitivity and specificity in the 80%–95% range compared to arthroscopic inspection and probing as a reference standard.[7,8]

The incidence of meniscus tear can be attributed to various risk factors. These include carrying heavy weight, participating in sports such as soccer and rugby, experiencing weight-bearing trauma, engaging in swimming, and participating in other sports. Additionally, being overweight, smoking, and consuming alcohol are also risk factors for meniscus tears. It is worth noting that males are more likely to experience knee joint meniscus tears due to sports and activity, while females are more susceptible if they are overweight.[9]

The greater susceptibility of meniscus tears in men is likely because men are more likely to participate in aggressive sports, have an increased risk of injury due to participation in contact sports, and are also involved in industries that require intense physical activity. This aligns with the findings of Lazarova et al.,[4] Tekin et al.,[5] Baker et al.,[10] Mostafa et al.,[11] Umap et al.,[12] Mansori et al.,[13] Coşkun Bilge et al.,[14] and Kluczynski et al.[15] All of these studies show that males are more likely to suffer from meniscus tears.

The mobile lateral meniscus is less susceptible to tears, except in cases of injury to the anterior cruciate ligament (ACL), while the medial meniscus, due to its close connection with the medial collateral ligament, is more susceptible to injury. Literature data have shown that the medial meniscus is injured 2 to 4 times more than the lateral one. Campbell et al.[16] found that the percentage of medial meniscus tears was 66% of all cases. Tekin et al.[5] and Ventura et al.[17] found the medial site was more affected by meniscus tears than the lateral site. However, Umap et al.[12] and Coşkun Bilge et al.[14] mentioned the lateral site was more affected by meniscus tears than the medial site. Ridley et al.[18] found that lateral meniscus tears happen more often in young people, and the incidence of medial meniscus tears increases with age. Çolak et al.[6] also found that men were more likely to suffer from medial tears than women. On the contrary, according to Zhang et al.,[19] meniscus tears are more common in women. Hwang et al.[20] discovered that women are more likely than males to suffer medial meniscus root tears.

In our study, the middle age groups were most affected by meniscus tears. Jerosch et al.[21] found that advanced age was related to significantly higher rates of meniscal injury. The increased rate of meniscal injury with advancing age may result from the natural course of meniscal degeneration with age. As age increases, the cartilage starts to break down and deteriorate. A study conducted by Kobayashi et al.[22] reported that the rates of meniscus tears in men increase in adolescence; for women, the rates of meniscus tears increase when they get older, especially over 70 years old. However, the results of studies are not consistent. Umap et al.[12] and Lazarova et al.[4] reported that the most affected age group with knee joint meniscus tear was 20–30. Ventura et al.[17] mentioned that people over 40 are more susceptible to knee joint meniscus tears. In a study by Mesiha et al.,[23] the histological characteristics of 44 meniscal tears were reviewed, and the authors found decreased intrinsic and perimeniscal cellularity in patients ≥40 years old compared with the control group.

According to the MRI grading of the meniscus tears, Tekin et al.[5] classified them into four grades: Grade 0 has no internal high signal; Grade 1 has a signal intensity that is focal and does not extend to the meniscal surface; Grade 2 has linear signals and does not reach the surface; Grade 3: the signals are also of an internal linear nature that reaches the superior or inferior surface. In this study, the most common grade was Grade 1, like that of Lazarova et al.[4] In studies by Zhang [19] and Ahmed et al.,[24] Grade 2 and Grade 3 were most common, respectively.

In our study, the most common tear pattern was transverse tears, and complete tears are common; this result was inconsistent with a study by Kim et al.,[25] who found the most common type was complex, followed by longitudinal and transverse. Specifically, in patients with an intact ACL, the most common type of rupture was complex rupture (60.5%, 98/162), while in patients with ACL injury, the most

common type of rupture was longitudinal rupture (56.6%, 56/99). MRI accuracy was low for the longitudinal tears of the posterior horn of the medial meniscus in the ACL-injured group.

The data of Mansori et al.[13] disagree with our finding and mention that longitudinal meniscus tears are common in male patients, while transverse meniscus tears are more common in female patients. This result was consistent with Tekin et al.,[5] who found the most common tear type was horizontal. Kim et al.[25] mentioned that longitudinal was the most common meniscus tear type. Ventura et al.[17] reported data similar to our study, which noted that medial meniscus tears were more common and the transverse type was more common than the other.

Patients with meniscal injuries have accelerated cartilage wear, which predisposes them to early degenerative changes and poor long-term function.[26] Meniscal injuries are seen in more than 75% of patients with symptomatic osteoarthritis.[27]

In our study, joint effusion was the most common associated finding with meniscus tear, followed by ACL and OA. Even in patients with no evidence of articular cartilage destruction on MRI, an meniscus tear increased the risk of joint effusion twofold.[28]

Older age at the time of an meniscus tear is associated with the development and progression of osteoarthritis after injury.[29] The results of this study are also consistent with those of Smith et al.,[30] who found that meniscus injury is associated with ACL injury. A study by Venkataraman et al.[31] found that 77.1% of cases of meniscus tear were associated with ACL tears. The anterior cruciate ligament (ACL) is the primary stabilizer of the knee joint; the meniscus is the secondary stabilizer in the anterior-posterior direction. The meniscus becomes the main stabilizer of the knee joint when there is chronic ACL tear or loss of ACL function.[32,33]

In contrast to our finding, in a study by Blankenbaker et al.,[34] medial collateral ligament (MCL) edema was observed in 67% of patients with medial meniscus tears, 35% with lateral meniscus tears, and 100% with meniscal 3 mm or more extrusion. MCL edema can also be observed in patients without intraarticular pathology, recent trauma, or physical examination for abnormality of medial collateral ligaments.

In our study, other MRI findings associated with meniscal tears were edema, Baker's cyst, bursitis, synovitis, and ganglion cyst. Several studies have shown an association between medial meniscal tear and Baker's cyst.[35,36,37] Arthur et al.[35] found that the Baker's cyst was powerfully correlated with a tear in the medial meniscus regardless of other intraarticular abnormalities. Stone et al.[36] reviewed the films of 1760 patients who had MRI scans of the knee joint to assess the most common pathologic changes associated with a Baker's cyst incidental finding. Of the 1760 knees scanned, Baker's cysts were noted in 238. In the 238 knees with Baker's cysts, 111(46.6%) complete meniscal tears and 88 (37.0%) degenerative tears were found. Most tears were found in the posterior horn of the medial meniscus.

In our study, multiplanar reconstruction MRI diagnosed the meniscus tears and assessed the type, location, and associated findings regardless of the patient's complaint. Medial and transverse types were the most common. Osteoarthritis, ACL, edema, joint effusion, and Baker's cyst were all associated conditions accompanying meniscus tears and were evaluated by MRI.

This study had several limitations. First, we could not obtain information about the causes of the meniscus tears. Second, the study did not include some types of meniscus tears, like bucket handle tears and root tears. Finally, we could not compare the MRI results with arthroscopy findings.

Conclusion

This research offers a significant understanding of the diagnostic potential of the MRI technique. The study concluded that the meniscus tear affected males more than females. The medial meniscus tear and transverse types were most common. The middle-aged group was affected by tears more than other age groups studied. The most commonly associated injuries with meniscus tears were ACL tears, osteoarthritis, and accompanying joint effusion, with most of them in the transverse one.

The findings imply that, in some clinical situations, MRI without contrast can be a useful and trustworthy method for identifying meniscus tears, providing a workable substitute for contrast-enhanced imaging. Our study adds to the increasing amount of evidence that supports the use of non-contrast MRI in the assessment of meniscal disease, even if more research is required to confirm our findings and examine the limitations of this methodology. Overall, our study's results aim to optimize diagnostic approaches to assessing knee meniscus injuries.

Competing Interests

The authors declare that they have no competing interests.

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***Corresponding author:** Dr. Nagwan Elhussein, Diagnostic Radiology Department, College of Applied Medical Sciences, University of Hail, Hail, Saudi Arabia**.** E-mail: n.elhussein@uoh.edu.sa*