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2026 Volume 11, Issue 1
Journal of Medicines Development Sciences
ISSN: 2382-6371(Online) ISSN: 2382-6363(Print)

Analysis of the Accuracy of 3.0T Magnetic Resonance in Diagnosing Knee Meniscal Injuries

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Abstract: *Objective:* To analyze the accuracy of 3.0T magnetic resonance in diagnosing knee meniscal injuries. *Methods:* From February 2024 to January 2025, 62 cases of knee meniscal injuries were selected for data analysis in our hospital, and 3.0T magnetic resonance imaging and CT imaging were performed. The gold standard was the results of arthroscopy. *Results:* The gold standard suggested that there were 101 meniscal injuries in the 62 patients in this article, with an incidence rate of 81.45% (101/124). Compared with CT examination, the sensitivity and accuracy of 3.0T magnetic resonance diagnosis were significantly higher, $P < 0.05$, and the contrast specificity was $P > 0.05$. Comparing the severity of meniscal injury diagnosed by the gold standard and 3.0T magnetic resonance imaging, $P > 0.05$. *Conclusion:* The accuracy of 3.0T magnetic resonance in diagnosing knee meniscal injuries is high, significantly higher than that of CT diagnosis, and is worthy of clinical promotion and use.

Keywords: 3.0T magnetic resonance; Knee meniscus injury; Diagnosis; Accuracy

Online publication: March 16, 2026

1. Introduction

Among the joints of the human body, the knee joint bears the largest load and moves most frequently. Its structural stability and functional integrity will have a direct impact on the mobility of the limbs. In the knee joint, the function of the meniscus is to buffer shocks, distribute loads, and stabilize the joint. However, injuries are prone to occur under the influence of sports injuries, degeneration, traumatic impacts and other factors. Knee meniscus injuries are common clinically, especially among middle-aged and elderly people, manual workers, and athletes. The main clinical manifestations are knee joint pain, swelling, snapping, and limited movement [1]. Some patients develop secondary cartilage damage, synovitis, and even joint deformity, which significantly reduces their quality of life. Based on this, the clinic proposes to carry out early and accurate diagnosis for patients, and formulate individualized treatment plans according to the location and degree of meniscal injury to promote the improvement of patient prognosis. Currently, multiple clinical methods can be used to diagnose the condition of patients with knee meniscal injuries. CT examination is cheap and easy to operate. It is widely used in clinical diagnosis of bone structure lesions. However, it has low soft tissue resolution and cannot clearly display meniscal microstructural damage, making it prone to misdiagnosis and missed diagnosis.

Arthroscopy is the "gold standard" for diagnosing meniscal injuries [2]. It can directly observe the morphology of the patient's meniscus and obtain pathological tissue, which has high diagnostic accuracy. However, because the examination is invasive, there is a risk of complications such as infection and bleeding, it is expensive, and the operation is complicated, so it cannot be used for routine screening of patients with knee meniscal injuries. Magnetic resonance imaging (MRI) in clinical research has significant advantages, such as no radiation and high soft tissue resolution. It can be used to diagnose soft tissue injuries [3], especially 3.0T magnetic resonance. Compared with low-field intensity MRI, it has higher spatial resolution and signal-to-noise ratio, and can clearly display the patient's meniscal fiber structure, injury location and range. This article selected 62 patients to analyze the accuracy of 3.0T magnetic resonance in diagnosing knee meniscal injuries.

2. Materials and methods

2.1. Information

From February 2024 to January 2025, 62 cases of knee meniscal injuries were selected for data analysis, including 40/22 men and women, age 20–71 (54.21 ± 11.63) years old, 11 cases of left knee meniscal injury, 12 cases of right knee meniscal injury, and 39 cases of bilateral knee joint injuries.

Inclusion criteria: patients with knee joint pain, swelling, snapping, limited movement, etc., confirmed knee meniscus injury; 3.0T magnetic resonance diagnosis, CT diagnosis, and arthroscopy performed in our hospital; complete examination and clinical data to meet the needs of research data analysis; informed consent, and voluntary participation.

Exclusion criteria: There are other serious joint diseases, such as knee joint tumors, tuberculosis, septic arthritis, etc.; there are contraindications for magnetic resonance examination; there is a history of knee surgery in the past, which will affect the judgment of the examination results.

2.2. Method

3.0T magnetic resonance diagnosis and CT diagnosis are implemented, and the gold standard is the results of arthroscopy.

(1) Magnetic resonance examination: The diagnosis is completed using a Siemens vida3.0T magnetic resonance scanner. The patient is placed in a supine position with the knee joint in a neutral position. Coronal and sagittal scans are mainly carried out. T1WI parameters are TR540ms, TE9ms, field of view 190mm, and slice thickness 4 mm. T2WI parameters are TR3500ms, TE80ms, field of view 160mm, and slice thickness 4 mm. The images were read by 2 professional imaging physicians. Consistent results will be considered as diagnostic results.

(2) CT examination: The medical staff will guide the patient to lie on his back, place a sponge pad in the patient's popliteal fossa, flex the knee joint 8-10°, fix the calf with a strap, open the patient's knee joint gap, and fully flex the contralateral knee joint. Use a CT scanner to scan the patient's tibial plateau to the end of the femur. The tube voltage and tube current are 80 kV / 165 mAs and 140 kV / 55 mAs. The volume scanning mode, pitch, matrix, and rotational speed are 1.2, 520×520, and 1.0 s/r.

2.3. Observation indicators

(1) Statistics of the gold standard number and incidence of meniscal injuries.

(2) Compare the sensitivity, accuracy, and specificity of CT examination and 3.0T magnetic resonance diagnosis.

(3) Compare the severity of meniscal injury diagnosed by gold standard and 3.0T magnetic resonance imaging. The criteria for grade 0-3 are: regular low signal in the knee meniscus, normal signal shadow; dots, high signal shadow; current situation, high signal, not extending to the articular surface; high signal, extending to at least one articular surface, irregular shape, fragmentation, and thinning.

2.4. Statistics

Data calculation was completed with statistical SPSS 28.0 software to mean ± standard deviation (SD) describe measurement data, t test, count data described as %, χ^2 test, $P < 0.05$, statistically significant.

3. Results

The gold standard suggests that among the 124 menisci in the 62 patients in this article, 101 menisci were damaged, and the incidence of meniscal injury was 81.45% (101/124). Compared with CT examination, the sensitivity and accuracy of 3.0T magnetic resonance diagnosis were significantly higher, $P < 0.05$, and the contrast specificity was $P > 0.05$. Comparing the severity of meniscal injury diagnosed by the gold standard and 3.0T magnetic resonance imaging, $P > 0.05$ (**Table 1** and **Table 2**).

Table 1. Comparing the sensitivity, accuracy and specificity (%) of CT examination and 3.0T magnetic resonance diagnosis

Diagnosis	Positive	Gold standard			Sensitivity	Accuracy	Specificity
		Negative	Total				
3.0T magnetic resonance diagnosis	Positive	97	1	98	96.04 (97/101)	95.97 (119/124)	95.65 (22/23)
	Negative	4	22	26			
	Total	101	23	124			
CT examination	Positive	81	2	83	80.20 (81/101)	82.26 (102/124)	91.30 (21/23)
	Negative	20	21	41			
	Total	101	23	124			
χ^2	-	-	-	-	12.1049	12.0114	0.3566
P	-	-	-	-	< 0.05	< 0.05	> 0.05

Table 2. Comparison of meniscal injury severity diagnosed by gold standard and 3.0T magnetic resonance imaging

Group	Level 0	Level 1	Level 2	Level 3
Gold standard (n = 124)	23 (18.55)	57 (45.97)	25 (20.16)	19 (15.32)
3.0T magnetic resonance diagnosis (n = 124)	26 (20.97)	54 (43.55)	23 (18.55)	21 (16.94)
χ^2		0.4481		
P		> 0.05		

4. Discussion

The accuracy of diagnosing knee meniscal injuries will affect patient treatment strategies and prognosis. Among them, the gold standard arthroscopy is invasive, high-cost, and cannot be used in routine clinical applications. CT examination does not have high soft tissue resolution and has limited diagnostic performance. The advantage of 3.0T magnetic resonance is high field strength [4], which can be applied to the diagnosis of soft tissue lesions. This article uses the results of arthroscopy as a comparison to compare the diagnostic performance of 3.0T magnetic resonance and CT examinations. The results of this article are analyzed.

In this study, the gold standard examination results showed that 124 menisci were involved in 62 cases, of which 101

menisci were damaged, with an incidence rate of 81.45%. The results highlighted the urgent need for accurate clinical application of diagnostic technology. In this study, the core results show that the sensitivity (96.04%) and accuracy (95.97%) of 3.0T magnetic resonance in diagnosing knee meniscal injuries are significantly higher than those of CT examination (80.20%, 82.26%), $P < 0.05$, but the specificity of the two (95.65% vs. 91.30%) is compared with $P > 0.05$. At the same time, there is good consistency between the results of 3.0T magnetic resonance diagnosis and the gold standard to determine the severity of meniscal injury ($P > 0.05$). The above results confirm that the application of 3.0T magnetic resonance in the diagnosis of knee meniscal injuries has good diagnostic performance and high overall diagnostic accuracy. In particular, it can significantly improve the sensitivity of injury detection. In this study, the reliability of the conclusion was further strengthened through comparative analysis of a large sample of menisci (124).

An in-depth analysis of the core reason why the diagnostic performance of 3.0T magnetic resonance imaging is better than that of CT examination [5] is because there are essential and obvious differences in the imaging principles between the two. Clinical analysis of CT examination, the imaging principle is the difference in X-ray penetration. Analyzing its advantages, it has higher resolution for high-density tissues such as bones, and can clearly display the integrity of the bony structure of the patient's knee joint. However, the image is not clear when diagnosing fibrocartilaginous soft tissues such as the meniscus, and it cannot accurately identify abnormal signal changes within the patient's meniscus. In this study, the sensitivity of CT examination was 80.20%. The reasons are speculated. The first is that the damage is limited to the interior of the meniscus, which is an early or minor meniscal injury of grade 1 or 2. It does not involve the articular surface. It is difficult for CT examination to capture such subtle structural changes and is prone to missed diagnosis. The second is that meniscal injuries include knee joint effusion and synovial hyperplasia [6], which further reduces the tissue contrast of CT images, interferes with the identification of damage lesions, and reduces the accuracy of diagnosis. In this study, there was no significant difference in specificity between the two, because both can make accurate judgments whether it is an obvious meniscal tear (grade 3 injury) or an undamaged normal meniscus, and the only difference is in identifying critical injuries.

Analysis of the reason why 3.0T magnetic resonance has higher diagnostic sensitivity and accuracy is that higher field strength brings improved imaging quality. Compared with low-field magnetic resonance and CT examination, the application of 3.0T magnetic resonance has higher spatial resolution and signal-to-noise ratio, and can clearly display the meniscal fibrous laminar structure and internal signal changes. In this study, the T1WI sequence can clearly distinguish the boundary between the patient's meniscus and the surrounding soft tissue. The T2WI sequence is sensitive to changes in moisture within the tissue and can accurately capture the increase in water due to fiber tears and inflammatory exudation after the patient's meniscal injury. It presents a characteristic high-signal shadow. The shape and range of this high-signal shadow are directly related to the degree of injury [7] and are the key basis for judging the grade of meniscal injury. For example, 3.0T magnetic resonance can clearly identify punctate high signals of grade 1 injuries and linear high signals of grade 2 injuries. The missed diagnosis rate of early minor injuries is significantly reduced. For grade 3 injuries with penetrating high signals and changes in meniscus shape irregularity, fragmentation, etc., the damage range can be accurately located [8]. In addition, in the study of this article, a 3.0T magnetic resonance examination was performed in the supine position, and the patient was instructed to externally rotate the affected knee 15°. Combined with a special coil for the knee joint, the interference of motion artifacts can be significantly reduced, and the image stability and clarity are significantly improved, so the diagnostic accuracy is high.

In terms of determining the severity of injury, there was no difference between 3.0T magnetic resonance imaging and the gold standard ($P > 0.05$). It has high clinical application value and can be accurately graded. Clinical analysis shows that different grades of injuries require different treatments. Among them, grades 0 and 1 require conservative treatment, grade 2 requires conservative and minimally invasive intervention based on symptoms, and grade 3 requires surgical repair. The precise grading of 3.0T magnetic resonance imaging can help patients scientifically formulate individualized treatment plans to avoid over-treatment or under-treatment. CT examination cannot clearly display the internal signal changes of the meniscus, making it difficult to achieve accurate grading. It can only be used for the preliminary diagnosis of severe tear or

displacement of patients.

From the perspective of clinical application, 3.0T magnetic resonance has no radiation advantages and can be used for routine diagnosis and screening, especially for special groups such as athletes and teenagers, who need repeated reexamination. In addition, it can be used to evaluate other structures of the knee joint, such as the patient's cruciate ligament, collateral ligament, articular cartilage, etc., to achieve a "one-stop" diagnosis. For example, it can be used to clarify the patient's meniscal injury combined with cruciate ligament injury. Multiple examinations are not required, the patient burden is reduced, and the diagnostic efficiency is improved. It should be noted that in this study, 4 cases were missed by 3.0T magnetic resonance imaging. The reasons are as follows: degenerative changes and injuries coexist, which will interfere with judgment. Micro-edge tears overlap with synovial fluid signals, and motion artifacts during the examination will also affect the image quality. At the same time, 3.0T magnetic resonance imaging has problems such as long examination time and high cost. It is not suitable for patients who cannot brake for a long time or are claustrophobic.

5. Conclusion

In summary, the application of 3.0T magnetic resonance in diagnosing knee meniscal injuries has high accuracy and sensitivity, which is significantly higher than CT diagnosis. Compared with the gold standard, the diagnostic results of 3.0T magnetic resonance for the severity of meniscal injuries are comparable, and it is worthy of clinical promotion and use.

Disclosure statement

The author declares no conflict of interest.

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