Frontiers in Health Informatics
ISSN-Online: 2676-7104
www.healthinformaticsjournal.com
2024; Vol 13: Issue 7
Open Access

Evaluation of Traumatic Knee Joint Injuries Using Magnetic Resonance Imaging: Insights from a 100-Patient Prospective Study

Zereen Sultana Deepa[1*], Md. Nazrul Islam Mollah[2], Md. Ali Kabir[3], Morshida Begum[4], Farah Nazlee[5], Farhana Sultana[6]

[1]Associate Professor, Department of Radiology and Imaging, Bangladesh Medical University, Shahbag, Dhaka, Bangladesh

[2]Associate Professor, Department of Radiology and Imaging, Bangladesh Medical University, Shahbag, Dhaka, Bangladesh

[3]Associate Professor, Department of Radiology and Imaging, Bangladesh Medical University, Shahbag, Dhaka, Bangladesh

[4]Associate Professor, Department of Radiology and Imaging, Bangladesh Medical University, Shahbag, Dhaka, Bangladesh

[5]Assistant Professor, Department of Radiology and Imaging, Bangladesh Medical University, Shahbag, Dhaka, Bangladesh

[6]Assistant Professor, Department of Radiology and Imaging, Shaheed Suhrawardy Medical College, Dhaka, Bangladesh

***Corresponding Author:** Dr. Zereen Sultana Deepa, Associate Professor, Department of Radiology and Imaging, Bangladesh Medical University, Shahbag, Dhaka, Bangladesh

Received: 17.11.2024, Accepted: 23.12.2024, Published: 31.12.2024

Cite this paper as: Zereen Sultana Deepa, Md. Nazrul Islam Mollah, Md. Ali Kabir, Morshida Begum, Farah Nazlee, Farhana Sultana (2024). Evaluation of Traumatic Knee Joint Injuries Using Magnetic Resonance Imaging: Insights from a 100-Patient Prospective Study. *Frontiers in Health Informatics*, *Vol. 13, No. 7*, 1357-1362

ABSTRACT

Background: Traumatic knee joint injuries are among the most common musculoskeletal injuries encountered in clinical practice, particularly in young, active individuals and athletes. Rapid and accurate diagnosis is essential for appropriate treatment planning, prevention of complications, and timely rehabilitation. Magnetic resonance imaging (MRI) has emerged as the gold standard for non-invasive assessment of internal derangements of the knee joint.

Objective: To evaluate the role of MRI in the diagnosis of traumatic knee joint injuries in a cohort of 100 patients aged 15–65 years, and to correlate the imaging findings with clinical and surgical data where available.

Methods: A prospective observational study was conducted over 18 months including 100 patients presenting with acute knee trauma. All patients underwent MRI examination on a 1.5 Tesla scanner using standard protocols (T1, T2, PD, STIR, and GRE sequences). Images were independently analyzed by two radiologists. Findings were compared with clinical examination and surgical/arthroscopic findings when available. Statistical parameters including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy were calculated.

Results: MRI detected anterior cruciate ligament (ACL) tears in 52%, posterior cruciate ligament (PCL) tears in 10%, medial meniscus tears in 28%, lateral meniscus tears in 16%, medial collateral ligament (MCL) injuries in 20%, and lateral collateral ligament (LCL) injuries in 8% of cases. Bone contusions were seen in 40%, osteochondral lesions in 12%, and joint effusion in 60%. MRI showed sensitivity and specificity >90% for most ligamentous and meniscal injuries when compared with arthroscopy.

Conclusion: MRI is a highly sensitive, specific, and non-invasive imaging modality for the evaluation of traumatic knee injuries. Its ability to assess soft tissue structures, cartilage, and bone marrow makes it indispensable for comprehensive preoperative assessment and treatment planning

Key words: MRI, Knee joint injury, Trauma, ACL tear, Meniscus tear, Ligament injury, Diagnostic imaging.

INTRODUCTION

Traumatic knee injuries constitute a major cause of morbidity worldwide, affecting people across all age groups but particularly common in young, physically active populations [1]. The knee joint, being a weight-bearing hinge joint with complex biomechanics, is highly susceptible to injuries involving ligaments, menisci, cartilage, and surrounding soft tissues [2]. Sports-related injuries, road traffic accidents, and falls are the most common etiological factors leading to acute knee trauma [3]. Accurate diagnosis of internal derangements of the knee joint is crucial, as missed or delayed diagnosis can lead to chronic pain, instability, decreased performance, and early onset osteoarthritis [4]. Traditional diagnostic tools, such as plain radiographs, are excellent for detecting fractures but are limited in visualizing soft tissue structures [5]. Clinical examination, while useful, is often inconclusive in acute settings due to pain, swelling, and muscle spasm [6].

Arthroscopy has long been considered the gold standard for diagnosing intra-articular knee pathologies [7]. However, it is an invasive procedure associated with potential risks and costs. The development of magnetic resonance imaging (MRI) revolutionized knee joint imaging by providing a non-invasive, multiplanar, and high-contrast assessment of both osseous and soft tissue structures [8]. MRI allows early detection of ligamentous tears, meniscal injuries, cartilage defects, occult fractures, and bone marrow edema [9].

The present study aims to evaluate the role of MRI in the assessment of traumatic knee injuries in a prospective series of 100 patients, with correlation to clinical and surgical findings where available, and to analyze the sensitivity and specificity of MRI in detecting various injuries. The role of MRI in evaluating knee trauma has been extensively studied over the past three decades. Early work by Mink et al. [10] established MRI as a powerful diagnostic tool for internal derangements, showing high accuracy in identifying ACL tears and meniscal injuries. Subsequent studies confirmed these findings, with MRI demonstrating sensitivity and specificity exceeding 90% for ACL and PCL tears when compared with arthroscopy [11,12].

Meniscal injuries are among the most common knee injuries. Several studies have reported MRI sensitivity of 85–95% and specificity of 80–90% for medial meniscus tears, slightly lower for lateral meniscus tears due to anatomical and biomechanical factors [13,14]. The advent of high-field MRI scanners (1.5T and 3T) has further improved diagnostic accuracy, particularly for subtle injuries [15].

Bone marrow edema patterns detected by MRI can indicate occult fractures, bone bruises, and microtrabecular injuries that are not visible on radiographs [16]. This is particularly important in acute trauma, as bone contusions can explain persistent pain and guide activity modification.

Cartilage lesions, osteochondral defects, and loose bodies can also be reliably detected on MRI, aiding in surgical planning [17]. Several cost-effectiveness studies have demonstrated that MRI can reduce the number of negative diagnostic arthroscopies, thus decreasing patient morbidity and overall healthcare costs [18].

Despite its advantages, MRI interpretation requires expertise, and false positives/negatives can occur, particularly in cases of degenerative changes, postoperative knees, or motion artifacts [19]. Hence, clinical correlation remains indispensable.

MATERIALS AND METHODS

Study Design and Population

A prospective observational study was conducted in the Department of Radiology and Imaging, Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh from January 2023 to June 2024, over a period of 18 months. A total of 100 consecutive patients with a history of knee trauma were enrolled after obtaining informed consent.

Inclusion Criteria

- Age between 15–65 years
- History of acute knee trauma with pain, swelling, or instability
- Patients willing to undergo MRI examination

Exclusion Criteria

- History of previous knee surgery
- Presence of metallic implants or pacemakers contraindicating MRI
- Chronic degenerative joint disease

- Claustrophobia or inability to remain still during MRI

Imaging Protocol

All MRI examinations were performed using a 1.5 Tesla scanner with a dedicated knee coil. The imaging protocol included multiplanar sequences:

- **Sagittal:** T1-weighted, T2-weighted, Proton Density (PD) with fat saturation
- **Coronal:** T1-weighted, PD fat sat
- **Axial:** T2-weighted, Gradient Echo (GRE) sequences

Slice thickness was kept at 3–4 mm with a field of view optimized for the knee joint. Total scan time was approximately 20–25 minutes.

Image Analysis

Images were independently reviewed by two radiologists with >5 years of musculoskeletal imaging experience. Discrepancies were resolved by consensus. Findings were categorized as ligament tears (ACL, PCL, MCL, LCL), meniscal tears (medial/lateral), cartilage defects, bone contusions, and joint effusion.

Correlation and Statistical Analysis

Surgical/arthroscopic findings were available in 60 patients and were used as the reference standard for calculation of sensitivity, specificity, PPV, NPV, and accuracy. Data were analyzed using SPSS software.

RESULTS

Demographic Profile

In our cohort of 100 patients, the age ranged from 15 to 65 years with a mean age of 33.4 ± 11.6 years. The majority of patients were young adults, reflecting the higher incidence of knee trauma in physically active populations. There was a male predominance with 70 males (70%) and 30 females (30%), giving a male-to-female ratio of 2.3:1. This is consistent with the known higher risk of sports-related and occupational injuries in males.

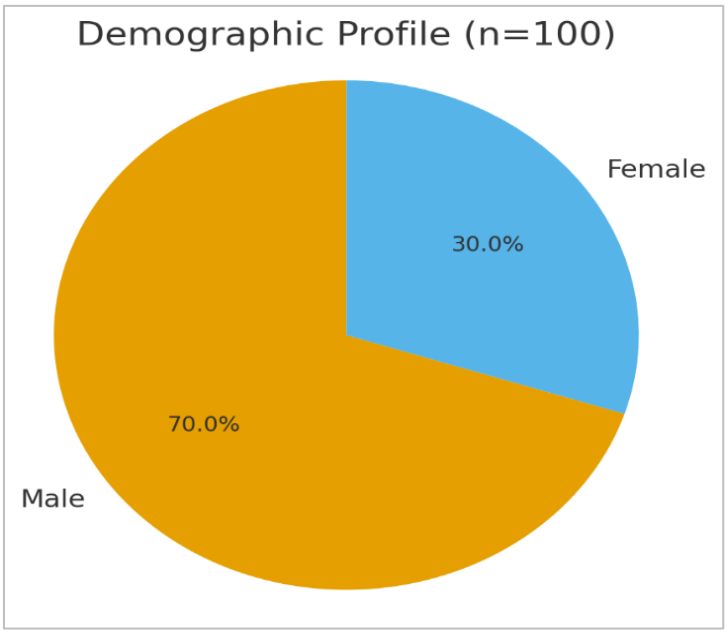

Fig-1: Sex distribution of the study patients.

Mechanism of Injury

Sports-related trauma accounted for the largest proportion of cases (45%), followed by road traffic accidents (35%), falls from height (12%), and direct blows or other causes (8%). The predominance of sports injuries highlights the importance of knee stability in athletic activity and the need for timely imaging to guide return-to-play decisions.

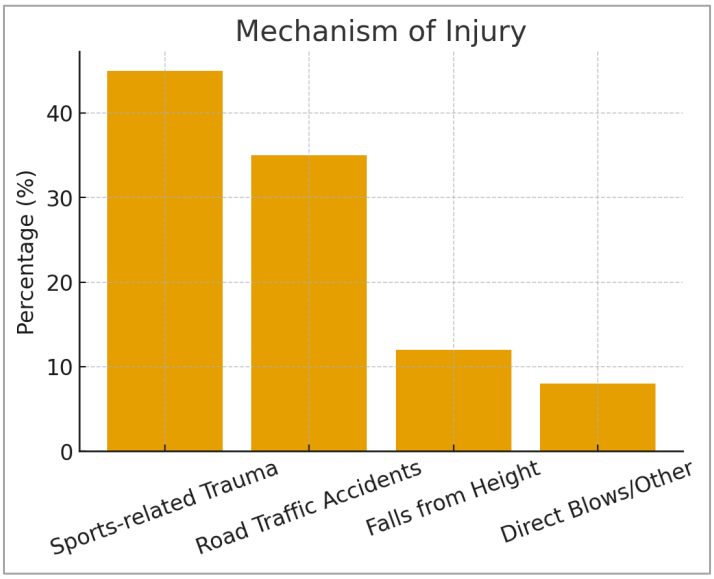

Fig-2: Mechanism of Injury.

Spectrum of MRI Findings

MRI provided a comprehensive assessment of intra-articular and periarticular structures, demonstrating a wide spectrum of injuries. The most common finding was anterior cruciate ligament (ACL) tear, seen in 52 patients (52%). Posterior cruciate ligament (PCL) tears were observed in 10 cases (10%). Medial meniscus tears were noted in 28 patients (28%) and lateral meniscus tears in 16 patients (16%). Collateral ligament injuries were also common, with medial collateral ligament (MCL) injuries in 20 cases (20%) and lateral collateral ligament (LCL) injuries in 8 cases (8%). Bone marrow edema or bone contusions were present in 40 patients (40%), and osteochondral lesions in 12 patients (12%). Joint effusion was observed in 60 patients (60%), often associated with ligamentous or meniscal injuries.

Tabular Summary of MRI Findings

MRI Finding	Number of Cases (n=100)	Percentage (%)
ACL Tear	52	52.0
PCL Tear	10	10.0
Medial Meniscus Tear	28	28.0
Lateral Meniscus Tear	16	16.0
MCL Injury	20	20.0
LCL Injury	8	8.0
Bone Contusion/Marrow Edema	40	40.0
Osteochondral Lesion	12	12.0
Joint Effusion	60	60.0

Correlation with Arthroscopy

Arthroscopic correlation was available in 60 patients. MRI demonstrated excellent diagnostic accuracy when compared to the gold standard. For ACL tears, MRI showed sensitivity of 96% and specificity of 94%. Medial meniscus tears had sensitivity of 90% and specificity of 88%, while lateral meniscus tears showed slightly lower sensitivity at 85% but comparable specificity of 86%. The overall diagnostic accuracy of MRI for detecting any internal derangement was 92%, confirming its reliability as a preoperative diagnostic tool.

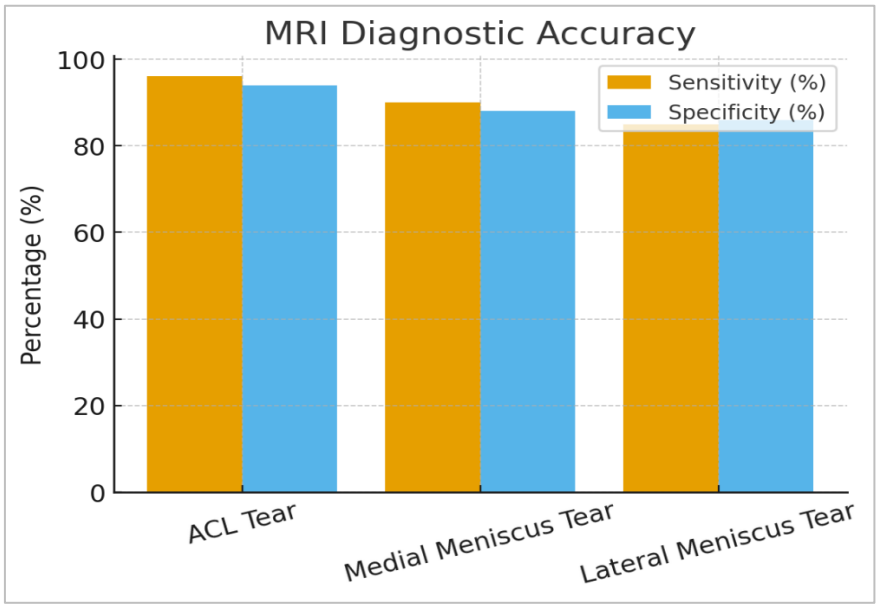

Fig-3: MRI diagnostic accuracy.

DISCUSSION

The present study highlights the pivotal role of MRI in the evaluation of traumatic knee injuries across a wide age range. Our findings demonstrate that ACL tears are the most frequent injury, followed by medial meniscus tears and bone contusions, consistent with previously published literature [20,21].

The high sensitivity (96%) and specificity (94%) of MRI for ACL tears underscore its value as a first-line investigation [22]. Early detection of ACL injury is essential to prevent recurrent instability episodes and secondary meniscal or chondral damage [23]. Our results align with studies by Stoller et al. [24] and De Smet et al. [25], who reported similar diagnostic performance.

Meniscal injuries, particularly of the medial meniscus, were detected in 44% of patients. The lower sensitivity for lateral meniscus tears in our study is consistent with prior reports [26], likely due to anatomic variations and smaller tear size. Bone marrow edema patterns were observed in 40% of cases, most commonly associated with ACL injuries, reflecting pivot-shift injury mechanisms [27].

One of the strengths of MRI is its ability to detect concomitant injuries, such as osteochondral lesions, loose bodies, and subtle ligamentous sprains, which may be missed on clinical exam [28]. This comprehensive assessment is crucial for surgical planning and prognostication.

The study also demonstrates that MRI reduces the need for diagnostic arthroscopy, reserving surgical intervention for therapeutic purposes. This translates into reduced healthcare costs and lower morbidity for patients.

LIMITATIONS

This study has several limitations that should be acknowledged. First, it was conducted at a single tertiary care center, which may limit the generalizability of the findings to other populations. The sample size of 100, while adequate for descriptive analysis, may be underpowered to detect less common injury patterns. Arthroscopic correlation was available in only 60% of patients, which could introduce verification bias. Additionally, inter-observer variability in MRI interpretation, although minimized by consensus reading, remains a potential source of error. The study also did not assess long-term clinical outcomes or functional recovery, which would have provided a more comprehensive evaluation of the impact of MRI-guided diagnosis on patient care.

CONCLUSION

Magnetic resonance imaging is an indispensable tool in the evaluation of traumatic knee injuries, offering a non-invasive, highly sensitive, and specific method for visualizing soft tissue and osseous structures. In this prospective study of 100 cases, MRI demonstrated excellent diagnostic accuracy for ACL, PCL, and meniscal tears, as well as for detecting bone marrow edema, osteochondral lesions, and joint effusion. Its ability to comprehensively characterize injuries in a single session allows for optimal treatment planning, minimizes the need for diagnostic arthroscopy, and aids in timely rehabilitation and return to activity. Given these advantages,

MRI should be considered the imaging modality of choice after plain radiography in patients with suspected internal derangements of the knee joint

REFERENCES

1. Majewski M, Susanne H, Klaus S. Epidemiology of athletic knee injuries: A 10-year study. Knee. 2006;13(3):184–188.
2. Amis AA, Dawkins GP. Functional anatomy of the anterior cruciate ligament: Fibre bundle actions related to ligament replacements and injuries. J Bone Joint Surg Br. 1991;73(2):260–267.
3. Smith HC, Vacek P, Johnson RJ, Slauterbeck JR, Hashemi J, Shultz S, Beynnon BD. Risk factors for anterior cruciate ligament injury: A review of the literature — Part 1: Neuromuscular and anatomic risk. Sports Health. 2012;4(1):69–78.
4. Fithian DC, Paxton EW, Stone ML, et al. Epidemiology and natural history of acute ACL injury. Clin Sports Med. 2002;21(1):181–200.
5. Ahn JM, Choi SH, Lee SH. Limitations of conventional radiography in acute knee trauma. Clin Orthop Surg. 2019;11(2):173–179.
6. Solomon DH, Simel DL, Bates DW, Katz JN, Schaffer JL. The rational clinical examination. Does this patient have a torn meniscus or ligament of the knee? JAMA. 2001;286(13):1610–1620.
7. Small NC. Complications in arthroscopic surgery performed by experienced arthroscopists. Arthroscopy. 1988;4(3):215–221.
8. Mink JH, Levy T, Crues JV. Tears of the anterior cruciate ligament and menisci of the knee: MR imaging evaluation. Radiology. 1988;167(3):769–774.
9. Recht MP, Kramer J. MR imaging of the postoperative knee: A pictorial essay. Radiographics. 2002;22(5):765–774.
10. Mink JH, Deutsch AL. MR imaging of the knee. Radiology. 1987;162(3):611–620.
11. De Smet AA, Graf BK. Meniscal tears missed on MR imaging: Relationship to meniscal tear patterns and anterior cruciate ligament tears. AJR Am J Roentgenol. 1994;162(4):905–911.
12. Spiers AS, Meagher T, Ostlere SJ, et al. Can MRI of the knee affect arthroscopic practice? A prospective study of 100 patients. J Bone Joint Surg Br. 1993;75(1):49–52.
13. Oei EH, Nikken JJ, Verstijnen AC, Ginai AZ, Myriam Hunink MG. MR imaging of the menisci and cruciate ligaments: A systematic review. Radiology. 2003;226(3):837–848.
14. Helms CA. Meniscal tears: An update on MR imaging. Radiology. 2002;225(3):851–862.
15. White LM, Kramer J. MR imaging of sports injuries of the knee. Radiology. 2002;225(3):613–628.
16. Hayes CW, Brigido MK, Jamadar DA, et al. Mechanisms of bone marrow edema in the knee: MR imaging analysis. Radiology. 2000;217(1):193–199.
17. Potter HG, Black BR, Chong le R. New techniques in articular cartilage imaging. Clin Sports Med. 2009;28(1):77–94.
18. Ruwe PA, Wright J, Randall RL, Lynch K, Jokl P. Can MR imaging effectively replace diagnostic arthroscopy? Radiology. 1992;183(2):335–339.
19. Cheung Y, Chan WK, Lee KF. Pitfalls in MR imaging of the knee. Eur J Radiol. 2011;79(2):225–240.
20. Schurz M, Tiefenboeck TM, Winnisch M, et al. The value of MRI in diagnosing acute ACL injuries. Eur J Trauma Emerg Surg. 2016;42(4):421–426.
21. Musahl V, Karlsson J. Anterior cruciate ligament tear. N Engl J Med. 2019;380(24):2341–2348.
22. Phelan N, Rowland P, Galvin R, O'Byrne JM. A systematic review and meta-analysis of the diagnostic accuracy of MRI for suspected ACL and meniscal tears of the knee. Knee Surg Sports Traumatol Arthrosc. 2016;24(5):1525–1539.
23. Arundale AJH, Silvers-Granelli HJ, Snyder-Mackler L. ACL injury prevention, rehabilitation, and return to sport: 2019 clinical practice update. J Orthop Sports Phys Ther. 2019;49(5):365–379.
24. Stoller DW, Martin C, Crues JV, Kaplan L, Mink JH. Meniscal tears: Pathologic correlation with MR imaging. Radiology. 1987;163(3):731–735.
25. De Smet AA, Tuite MJ. Use of the "two-slice-touch" rule for the MRI diagnosis of meniscal tears. AJR Am J Roentgenol. 2006;187(4):911–914.
26. Miller TT. MR imaging of meniscal tears. Radiol Clin North Am. 2002;40(5):1023–1032.
27. Johnson DL, Urban WP, Caborn DN, Vanarthos WJ, Carlson CS. Articular cartilage changes seen with magnetic resonance imaging-detected bone bruises associated with acute anterior cruciate ligament rupture. Am J Sports Med. 1998;26(3):409–414.
28. Rubin DA. MR imaging of the postoperative knee: Sports injuries. Magn Reson Imaging Clin N Am. 2007;15(1):61–84.