Nepal Orthopedic Association Journal
https://doi.org/10.59173/noaj.20251102g

ORIGINAL ARTICLE

A Comparative Study of Magnetic Resonance Imaging and Arthroscopy in ACL and Meniscal Injuries

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ABSTRACT

BACKGROUND
Magnetic Resonance Imaging (MRI) has emerged as the primary diagnostic tool for assessing ligamentous and meniscal injuries of the knee. This study aimed to evaluate the accuracy of MRI findings compared to arthroscopy, considered the gold standard, in diagnosing knee injuries.

METHODS
A total of 83 patients presenting with knee injuries underwent clinical examination, MRI, and subsequent arthroscopy at our hospital. The arthroscopic findings were compared with MRI results, and statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) version 26. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy were calculated. A p-value of ≤0.05 was considered statistically significant.

RESULTS
In this study, the sensitivity of MRI for detecting anterior cruciate ligament (ACL) tears was 96.6%, while it was 98% for medial meniscus (MM) tears and 81% for lateral meniscus (LM) tears. The specificity for ACL, MM, and LM tears was 92%, 81.8%, and 96.8%, respectively. The diagnostic accuracy for ACL, MM, and LM tears was 95.2%, 91.56%, and 92.8%, respectively.

CONCLUSION
This study demonstrated the high sensitivity and specificity of MRI in diagnosing ACL and meniscal tears. The findings support the routine use of MRI in diagnosing these injuries of the knee, especially when combined with a thorough clinical history and examination. MRI exhibits high accuracy in detecting meniscal and ACL tears, making it a valuable screening tool for therapeutic arthroscopy.

KEYWORDS
Anterior cruciate ligament; Arthroscopy; Magnetic resonance imaging; Meniscus

INTRODUCTION

In contemporary times, knee joint injuries are frequently encountered, often stemming from road traffic accidents and sports activities.[1] However, diagnosing meniscal and anterior cruciate ligament (ACL) tears through clinical tests presents challenges, particularly in eliciting objective signs, especially in acute and sub-acute presentations.[2]

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Magnetic resonance imaging (MRI) serves as a pivotal diagnostic tool for assessing internal knee derangements, with arthroscopy serving as the gold standard. It is routinely employed to support the diagnosis of meniscal or cruciate ligament injuries before considering routine arthroscopic procedures.[3] MRIs have limitations in sensitivity and specificity, especially for certain types of meniscal tears and partial ACL tears.[4,5]

The aim of this study was to evaluate the radiological and arthroscopic findings of anterior cruciate and meniscal injuries and compare the findings obtained through these two methods. By comparing MRI and arthroscopic findings, this study sought to enhance the understanding of the diagnostic accuracy of MRI in detecting knee injuries.

METHODS

This prospective descriptive observational study was conducted in the Department of Orthopedics and Trauma Surgery at the Institute of Medicine (IOM), Tribhuvan University Teaching Hospital, over an 18-month period from January 2019 to July 2020, following ethical approval from the Institutional Review Committee (IRC) of IOM. The study included patients clinically and MRI diagnosed with either ACL or meniscal tear or both, with a history of injury, who subsequently underwent arthroscopy and necessary knee procedures.

A total of 83 patients meeting the inclusion criteria were enrolled after obtaining written consent. Inclusion criteria were patients with knee injury having ACL and meniscal injury, patients with the age group 18 to 60 years, patients who have underwent MRI scans, and patients who have underwent arthroscopic surgery.

Exclusion criteria were patients with contraindications to MRI like intracerebral aneurysmal clips, cardiac pacemaker, metallic foreign body in the eye, implants in the middle ear; Patients who had a recent knee injury but who on clinical examination had no instability in any plane and negative McMurray test.

Demographic data, including age, sex, mode, and side of injury, were recorded for each patient. Clinical tests for ACL injury and meniscal tears were performed to confirm the diagnosis, followed by an MRI of the knee and subsequent arthroscopy.

MRI scans were conducted using a 1.5 Tesla machine, which was available in our institute, with standard techniques to visualize the ACL and meniscus and determine the presence or absence of tears. MRI reporting was done by a radiologist and was taken as standard.

Criteria used for ACL tear on MRI

1. Fibre discontinuity
2. Increased signal intensity on T2-weighted or fat-saturated proton density(PD) images
3. Abnormal ACL orientation
4. Empty notch sign

Criteria used for Meniscal tear on MRI

1. High signal intensity within the meniscus that extends to at least one articular surface
2. Distortion of Meniscal Morphology
3. Peripheral irregularity

Arthroscopy was performed within 6 weeks of the MRI. Arthroscopy of the knee was performed to identify pathological lesions and appropriate surgical interventions such as partial/subtotal meniscectomy or repair for meniscal tears, and ACL reconstructions for ACL tears, were carried out based on operative findings. Meniscocapsular and meniscotibial lesions of the medial meniscus which are difficult to reveal by normal probing were performed using pie crusting of the medial collateral ligament and in-depth probing of the meniscus.

Operative findings, including the presence or absence of tears in the ACL and meniscus, were documented in the operation theatre. The collected data was tabulated and analyzed for comparison with MRI findings, and categorized into four groups, to assess diagnostic accuracy and inform treatment decisions. Lysholm Knee Score was used for outcome measures.

Table 1: Contingency table

Test Result	Tear	No tear
Positive	True positive (TP)	False positive (FP)
Negative	False negative (FN)	True negative (TN)

True Positive: MRI diagnosis positive, arthroscopy positive.
True Negative: MRI diagnosis negative, arthroscopy negative.
False Positive: MRI diagnosis positive, arthroscopy negative.
False Negative: MRI diagnosis negative, arthroscopy positive.

The collected data was organized and presented using tables and diagrams. Sensitivity, specificity, predictive values, and accuracy were calculated utilizing the Statistical Package for Social Sciences (SPSS). A significance level of $p < 0.05$ was applied to determine statistical significance. The data underwent analysis to identify any significant correlation between MRI knee findings and arthroscopic observations of ACL and meniscal tears, employing kappa statistics. This statistical approach facilitated the assessment of agreement between the two diagnostic modalities, enhancing the reliability and validity of the study's findings..

RESULTS

In this study comprising 83 patients, the majority were male (72.3%), with a mean age of 31.7 years ± 11.6. Sports-related injuries accounted for the highest proportion (60.2%), followed by road traffic accidents (24.1%) and self-falls (15.7%). Left knee injuries were slightly more prevalent (50.6%) compared to right knee injuries (49.4%).

A significant association was observed between ACL tear detection by MRI and arthroscopy ($P < 0.001$, kappa test value = 0.944). MRI exhibited high sensitivity (96.6%), specificity (92%), positive predictive value (96.6%), negative predictive value (92%), and accuracy (95.2%) in diagnosing ACL tears (Table 2).

Table 2. Comparison of MRI and arthroscopic findings in ACL injuries.

MRI ACL Tear	Arthroscopic ACL Tear		Total
	Yes	No	
Yes	56	2	58
No	2	23	25
Total	58	25	83

Abbreviations: MRI, magnetic resonance imaging; ACL, anterior cruciate ligament.

A significant association was observed between the detection of medial meniscus tears by MRI and arthroscopy ($P < 0.001$, kappa test value = 0.819). The sensitivity of MRI in diagnosing medial meniscus tears was 98%, with a specificity of 81.8%. The positive predictive value (PPV) was 89.1%, the negative predictive value (NPV) was 96.4%, and the accuracy was 91.56% (Table 3).

Table 3. Comparison of MRI and arthroscopic findings in medial meniscal injuries.

MRI MM tear	Arthroscopic MM tear		Total
	Yes	No	
Yes	49	6	55
No	1	27	28
Total	50	33	83

Abbreviations: MRI, magnetic resonance imaging; MM, medial meniscus.

A significant association was observed between the detection of lateral meniscus tears by MRI and arthroscopy ($P < 0.001$, kappa test value = 0.803). The sensitivity of MRI in diagnosing lateral meniscus tears was 81%, with a specificity of 96.8%. The positive predictive value (PPV) was 89.5%, the negative predictive value (NPV) was 93.8%, and the accuracy was 92.8% (Table 4).

Table 4. Comparison of MRI and arthroscopic findings in lateral meniscal injuries.

MRI LM tear	Arthroscopic LM tear		Total
	Yes	No	
Yes	17	2	19
No	4	60	64
Total	21	62	83

Abbreviations: MRI, magnetic resonance imaging; LM, lateral meniscus.

DISCUSSION

MRI of the knee joint is widely acknowledged as a non-invasive and effective alternative to diagnostic arthroscopy. It has become routine practice to utilize MRI scans for confirming diagnoses of ACL or meniscal injuries prior to arthroscopic surgery.[6] MRI offers several advantages over diagnostic arthroscopy, which is currently considered the reference standard for diagnosing internal derangements of the knee.[7,8]

In relation to ACL tears, this study yielded results similar to those of Gopal et al. (Sensitivity 91.3%, Specificity 94.1%, PPV 97.6%, NPV 100%, Accuracy 100%), and Gupta et al. (Sensitivity 91.3%, Specificity 88.2%, PPV 91.3%, NPV 88.2%, Accuracy 90%).[9,10] However, in the studies by Crawford et al. and Behairy et al. reported higher specificity for MRI in diagnosing ACL tears.[6,7]
Regarding MM tears, this study had similar results with the study done by Crawford et al. (Sensitivity 91.4%, Specificity 82%, PPV 83.2%, NPV 90.1%, Accuracy 86.1%) and Bari et al. (Sensitivity 93.54%, Specificity 87.50%, PPV 85.29%, NPV 94.59%, Accuracy 90%).[7,11] However, in the study done by Sharma et al. and Gupta et al., MRI was more specific than sensitive in diagnosing MM tears.[8,10]

Regarding LM, this study has similar results with the study done by Bari et al. (Sensitivity 77.7%, Specificity 81.81%, PPV 72.41%, NPV 85.71%, Accuracy 79%); Crawford et al. (sensitivity 76%, Specificity 93.3%, PPV 80.4%, NPV 91.6%, Accuracy 88.8%); Gupta et al. (Sensitivity 83.3%, Specificity 95.4%, PPV 93.7%, NPV 87.5%, Accuracy 90%); and Sharma et al. (Sensitivity84.6%, Specificity 96.4%, PPV 91.6%, NPV 93.1%, Accuracy 84.6%).[7,8,10,11] No studies had different results compared with this study. MRI was more specific than sensitive in diagnosing LL tears.

In this study, there were two false positive cases, where MRI indicated ACL tears but arthroscopy revealed otherwise. One ACL was found to be normal during arthroscopy, while the other exhibited only mucoid degeneration. These false positives may be attributed to foci of myxoid degeneration and ligamentous laxity, which can mimic tear appearances on MRI.[12] Furthermore, the oblique angle at which the ACL crosses the knee joint may lead to incomplete visualization on MRI, contributing to misinterpretations.[13]
Conversely, we also identified two false negative cases, where MRI results were negative for ACL tears, but arthroscopy revealed tears. One case exhibited a partial tear, while the other had a complete tear. Diagnosing partial tears on MRI, especially in acute cases, can be challenging due to overlying synovial reactions.[14,15] Additionally, MR imaging may miss ruptures near ligament insertions, leading to false negative results.[16] These findings underscore the potential pitfalls of MRI in diagnosing ACL tears, including partial volume artifacts and reparative fibrosis. Awareness of these limitations is crucial for accurate interpretation and clinical decision-making.
This study identified six false positive cases for medial meniscus (MM) tears, where MRI indicated positive findings but arthroscopy did not confirm tears. Among these cases, two exhibited degenerative changes, while the remaining four showed normal findings during arthroscopy. Degenerative changes in the meniscus can present tear-like signals on MRI due to collagen fiber degeneration accompanied by myxoid and eosinophils deposits.[17] These false positives highlight the importance of careful interpretation of MRI findings, particularly in the context of degenerative changes, to avoid misdiagnosis and unnecessary interventions.
This study identified four false negative cases of LM injuries, where MRI results were negative but arthroscopy revealed tears. Two of these cases involved posterior root tears, one was a radial tear, and one was associated with a discoid meniscus. Assessing the posterior root of the lateral meniscus on MRI presents challenges due to various factors, including pulsation artifacts from the popliteal artery and the magic angle effect caused by the slope of the meniscus on the tibial eminence.[16,17]
Moreover, two false positive cases were encountered, where MRI indicated positive findings but arthroscopy did not confirm tears. One case was diagnosed as an anterior horn tear, while the other was a posterior horn tear. The presence of the transverse meniscal ligament at the attachment onto the superior surface of the anterior horn of the lateral meniscus can lead to misinterpretation on MRI, as it often appears as a high signal intensity line. Additionally, anatomical structures such as the popliteal tendon and ligaments of Humphrey and Wrisberg, along with arterial pulsation artifacts,

may also be mistakenly identified as meniscal tears.[17-19] These findings underscore the intricacies involved in interpreting MRI findings of lateral meniscus injuries and emphasize the need for thorough consideration of anatomical variations and potential artifacts to ensure accurate diagnosis and appropriate clinical management.

LIMITATIONS

-MRIs were read by different radiologists, so observer bias.
-Arthroscopies were also not performed by the same orthopedic surgeon.
Orthopedicians had access to MRI scans and reports at the time of arthroscopy, so this was not a double-blinded study.
-Comparison was done in terms of the presence or absence of tears only, comparative findings on location and type of tear were not done.

This study underscores the pivotal role of MRI in diagnosing knee injuries while also highlighting its limitations and potential pitfalls. By comparing our results with previous research, we confirm that MRI is dependable in identifying ACL and meniscal tears, although we need to understand its interpretive challenges better.

CONCLUSION

This study confirms that Magnetic Resonance Imaging (MRI) is a highly effective diagnostic tool for anterior cruciate ligament (ACL) and meniscal injuries, showing high sensitivity, specificity, and accuracy. The strong agreement between MRI and arthroscopic findings highlights MRI's value as a non-invasive method for preoperative assessment. This study supports the routine use of MRI for diagnosing knee injuries, guiding therapeutic decisions, and improving patient outcomes. Future advancements in MRI technology and refinement of clinical protocols are anticipated to further optimize the management of knee pathologies. Overall, these findings advocate for integrating MRI with thorough clinical examinations and patient histories to provide comprehensive and precise diagnoses of knee injuries.

CONFLICT OF INTEREST

None

REFERENCES

1. Kaplan PA, Walker CW, Kilcoyne RF, Brown DE, Tusek D, Dussault RG. Occult fracture patterns of the knee associated with anterior cruciate ligament tears: assessment with MR imaging. Radiology. 1992 Jun;183(3):835-8. https://doi.org/10.1148/radiology.183.3.1584943

2. Gillquist J, Hagberg G, Oretorp N. Arthroscopic visualization of the posteromedial compartment of the knee joint. Orthop Clin North Am. 1979 Jul;10(3):545-7. PMID: 460830.

3. Kulkarni OP, Pundkar GN, Sonar SB. A comparative study of MRI versus arthroscopic findings in ACL and meniscal injuries of the knee. International Journal of Research in Orthopaedics. 2018 Feb 23;4(2):198. https://doi.org/10.18203/issn.2455-4510.IntJResOrthop20180123

4. Sajjanshetty R, Ranjolkar R. MRI vs arthroscopy in the diagnosis of meniscal tears: A comparative study. Indian Journal of Orthopaedics Surgery. 2024 Jun 15;10(2):135–9. https://doi.org/10.18231/j.ijos.2024.023

5. Abd Razak, H.R.B., Sayampanathan, A.A., Koh, T.H.B. and Tan, H.C.A., 2015. Diagnosis of ligamentous and meniscal pathologies in patients with anterior cruciate ligament injury: comparison of magnetic resonance imaging and arthroscopic findings. Annals of translational medicine, 3(17), p.243 . https://doi.org/10.3978/j.issn.2305-5839.2015.10.05

6. Behairy NH, Dorgham MA, Khaled SA. Accuracy of routine magnetic resonance imaging in meniscal and ligamentous injuries of the knee: comparison with arthroscopy. International Orthopaedics. 2008 May 28;33(4):961–7. https://doi.org/10.1007/s00264-008-0580-5

7. Crawford R, Walley G, Bridgman S, Maffulli N. Magnetic resonance imaging versus arthroscopy in the diagnosis of knee pathology, concentrating on meniscal lesions and ACL tears: a systematic review. British Medical Bulletin. 2007 Sep 3;84(1):5–23. https://doi.org/10.1093/bmb/ldm022

8. Sharma UK, Shrestha BK, Rijal S, Bijukachhe B, Barakoti R, Banskota B, Pradhan I, Banskota AK. Clinical, MRI and arthroscopic correlation in internal derangement of knee. Kathmandu Univ Med J (KUMJ). 2011 Jul-Sep;9(35):174-8. https://doi.org/10.3126/kumj.v9i3.6300

9. Gopal K, Sandeep M, Prakash A, Jose A. Correlation between magnetic resonance imaging and arthroscopy in internal derangement of knee. Int J Res Orthop. 2017 May;3(3):476-81. https://doi.org/10.18203/issn.2455-4510.IntJResOrthop20171004

10. Gupta MK, Rauniyar MK, Karn NK, Sah PL, Dhungel K, Ahmad K. MRI evaluation of knee injury with arthroscopic correlation. J Nepal Health Res Counc. 2014 Jan;12(26):63-7. PMID: 25574988

11. Bari V, Murad M. Accuracy of magnetic resonance imaging in the knee. J Coll Physicians Surg Pak. 2003 Jul;13(7):408-11. PMID: 12887845.

12. Riel KA, Reinisch M, Kersting-Sommerhoff B, Hof N, Merl T. 0.2-Tesla magnetic resonance imaging of internal lesions of the knee joint: a prospective arthroscopically controlled clinical study. Knee Surg Sports Traumatol Arthrosc. 1999;7(1):37-41. https://doi.org/10.1007/s001670050118

13.Sharifah MIA, Lee CL, Suraya A, Johan A, Syed AFSK, Tan SP. Accuracy of MRI in the diagnosis of meniscal tears in patients with chronic ACL tears. Knee Surgery, Sports Traumatology, Arthroscopy. 2013 Nov 17;23(3):826–30. https://doi.org/10.1007/s00167-013-2766-7

14. Madhusudhan T, Kumar T, Bastawrous S, Sinha A. Clinical examination, MRI and arthroscopy in meniscal and ligamentous knee Injuries – a prospective study. Journal of Orthopaedic Surgery and Research. 2008 May 19;3(1). https://doi.org/10.1186/1749-799x-3-19

15. Rose NE, Gold SM. A comparison of accuracy between clinical examination and magnetic resonance imaging in the diagnosis of meniscal and anterior cruciate ligament tears. Arthroscopy: The Journal of Arthroscopic & Related Surgery. 1996 Aug;12(4):398–405. https://doi.org/10.1016/s0749-8063(96)90032-8

16. Kim SH, Lee HJ, Jang YH, Chun KJ, Park YB. Diagnostic accuracy of magnetic resonance imaging in the detection of type and location of meniscus tears: comparison with arthroscopic findings. Journal of clinical medicine. 2021 Feb 5;10(4):606. https://doi.org/10.3390/jcm10040606

17. Noble JJ, Hamblen DL. THE PATHOLOGY OF THE DEGENERATE MENISCUS LESION. 1975 May 1;57-B(2):180–6. PMID: 1173585.

18. Noble J, Turner PG. The function, pathology, and surgery of the meniscus. Clin Orthop Relat Res. 1986 Sep;(210):62-8. PMID: 3757377.

19. HOUGH AJ, WEBBER RJ. Pathology of the Meniscus. Clinical Orthopaedics and Related Research. 1990 Mar;&NA;(252):32???40. PMID: 2406071