

The Accuracy of Ultrasonography in the Diagnosis of Ligamentous and Meniscal Injuries of the Knee among Patients Attending Muhimbili Orthopaedic Institute (MOI)

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Research Article

Keywords: knee injuries, ultrasonography, MRI, meniscal injury, ligamentous injury, Muhimbili Orthopaedic Institute, Tanzania

Posted Date: March 24th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-8916716/v1>

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Additional Declarations: No competing interests reported.

Abstract

Background

Ligamentous and meniscal knee injuries are among the most common conditions managed at MOI and represent a significant burden primarily among the young adult population. Magnetic resonance imaging (MRI) has served as the key diagnostic investigation and basis for management decisions, yet it is expensive and less available in peripheral hospitals. Ultrasonography, which is readily available and affordable, remains underutilised and sonographic patterns of knee trauma in our setting are poorly described. Expanded use of ultrasonography could reduce the number of unnecessary referrals and lower treatment costs.

Methods

This was a prospective descriptive hospital-based cross-sectional study involving 100 consecutive patients with clinically suspected ligamentous and/or meniscal knee injuries referred for MRI at MOI between December 2022 and March 2023. All participants underwent standardised knee ultrasonography before MRI. A structured checklist captured sociodemographic data, clinical presentations, and imaging features. Statistical analysis was performed using SPSS version 23. Descriptive statistics were used for categorical and continuous variables. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy (DA) of ultrasonography were calculated against MRI as the reference standard using 2×2 contingency tables. A p-value < 0.05 was considered statistically significant.

Results

The study included 100 participants with a mean age of 43.88 years (SD ± 13.9); the majority (46%) fell within the 31–50 age group. Gender distribution was nearly equal (52% male). The most common mechanism of injury was falling (45%), followed by sports activities (33%). Medial meniscal injury was most prevalent (57%), followed by lateral meniscal injury (43%). The most frequent ultrasonographic feature was loss of uniform echopattern throughout the meniscus (68% for MM injuries). The sensitivity, specificity, and diagnostic accuracy of ultrasonography were: medial meniscus 90.5%, 70.3%, 83%; lateral meniscus 71.7%, 87.5%, 78%; medial collateral ligament 25%, 100%, 97%; lateral collateral ligament 0%, 100%, 99%; anterior cruciate ligament 14.3%, 100%, 82%; and posterior cruciate ligament 20%, 100%, 96%, respectively.

Conclusions

Ultrasonography demonstrated significant diagnostic agreement with MRI for medial and lateral meniscal injuries, with high sensitivity and specificity. High specificity (100%) was observed for all ligamentous injuries, though sensitivity was limited for collateral and cruciate ligaments, likely due to small sample sizes. Ultrasonography shows promise as a cost-effective, accessible first-line or adjunct imaging tool for knee injury assessment in resource-limited settings.

Background

Knee injuries are among the most common conditions managed in orthopaedic practice, arising from accidents, sports participation, or other trauma. They may be classified as acute if symptoms arise within 30–40 days of the traumatic event, or chronic if symptoms persist beyond that period [1].

The spectrum of knee injuries ranges from minor conditions requiring conservative management such as rest, ice application, immobilisation, and physiotherapy to major injuries necessitating surgical intervention. Left inadequately diagnosed or managed, these injuries may result in diminished physical function or permanent disability [2].

The knee joint depends on a complex interplay of ligamentous and meniscal structures to maintain stability and permit its range of motion. These structures are composed of water and densely-packed collagen fibers orientated parallel to the predominant loading axis. Injury to any ligament, particularly complete disruption, precipitates clinical instability and may secondarily damage the menisci and articular cartilage through altered joint kinematics [3].

Epidemiological patterns of knee injuries vary by age and sex. Young adults particularly males are most commonly affected, typically through outdoor and sporting activities. In older populations, injuries more frequently result from low-energy mechanisms such as falls on level ground, stairs, or ramps [4]. The most frequently injured structure during sports is the anterior cruciate ligament (ACL), commonly accompanied by injury to the posterior cruciate ligament (PCL), medial collateral ligament (MCL), lateral collateral ligament (LCL), and menisci [1]. Long-term consequences of meniscal and ligamentous injuries include osteoarthritis, which typically develops 5–15 years after injury [5].

Imaging is central to the diagnosis of knee injuries and guides management decisions. Plain radiography detects osseous fractures; computed tomography (CT) is useful for subtle fractures; ultrasonography assesses soft tissue structures; and MRI provides a comprehensive evaluation of both soft tissue and osseous structures. Among these, MRI is considered the reference standard for diagnosing ligamentous and meniscal injuries, with reported sensitivity, specificity, and accuracy of approximately 90.9%, 84.6%, and 88.6%, respectively [6].

Despite its diagnostic utility, MRI is expensive, time-consuming, and unavailable in many peripheral hospitals across sub-Saharan Africa. Ultrasonography is widely available, affordable, radiation-free, and can be performed at the bedside, making it particularly suitable for resource-limited settings. However, its role in diagnosing knee ligamentous and meniscal injuries in our setting has not been systematically

evaluated. Establishing the diagnostic performance of ultrasonography against MRI in this context would support its use as an effective screening tool and potentially reduce unnecessary referrals, lowering costs to both the health system and patients [7].

Methods

Study design, setting and participants

This was a prospective, hospital-based, cross-sectional study conducted at the Ultrasonography Unit of the Department of Radiology and Imaging, Muhimbili Orthopaedic Institute (MOI), Dar es Salaam, Tanzania. MOI is a national referral centre for musculoskeletal conditions. The study was conducted from December 2022 to March 2023 and enrolled 100 consecutive participants clinically suspected of ligamentous and/or meniscal knee injuries.

Sample size and sampling

The sample size of 100 participants was determined using a binomial proportion formula, based on a prior estimated sensitivity of 0.75, a precision of 0.1, and a 95% confidence level. Consecutive sampling was applied to all eligible patients referred for knee MRI at MOI during the study period.

Inclusion criteria

All patients referred to MOI for an MRI scan with clinical suspicion of knee injuries, presenting with knee pain, swelling, locking, stiffness, popping sensation, or difficulty walking due to joint instability, were eligible for inclusion.

Exclusion criteria

Patients who were unable to undergo MRI, whose MRI findings were inconclusive, or who declined knee ultrasonography were excluded.

Data collection and imaging protocol

Data collection and imaging protocol

A structured checklist was used to record sociodemographic characteristics, clinical presentations, and imaging findings. All eligible participants underwent standardised B-mode and colour Doppler knee ultrasonography performed by the principal investigator (a radiology resident) prior to MRI. MRI findings were reported by a licensed consultant radiologist. Ultrasonographic and MRI findings were recorded after the principal investigator and the radiologist reached agreement. Ultrasonographic features assessed included: for the menisci, loss of triangular (wedge) shaped appearance, loss of uniform

echopattern, and increased vascularity on colour Doppler; for the collateral ligaments, loss of linear shaped appearance, loss of uniform echopattern, and increased vascularity; and for the cruciate ligaments, inhomogeneous hypoechoic pattern, loss of a sharply defined posterior border, increased vascularity, and for the PCL, increased thickness greater than 10 mm.

Data analysis

All data were entered and analysed using SPSS version 23 (IBM Corp., Armonk, NY, USA). Categorical variables are summarised as frequencies and percentages; continuous variables are presented as means and standard deviations. The diagnostic performance of ultrasonography was assessed against MRI as the reference standard. Sensitivity, specificity, PPV, NPV, and overall diagnostic accuracy were calculated from 2×2 contingency tables for each anatomical structure. A p-value < 0.05 was considered statistically significant.

Ethical considerations

Ethical approval

was granted by the MUHAS Institutional Review Board (reference: MUHAS-REC-01-2023-1498). The study was conducted in accordance with the Declaration of Helsinki. The requirement for individual written informed consent was waived by the IRB, given the prospective observational nature of the study. Permission to collect data was obtained from the Executive Director of MOI. All participant data were anonymised; identifiers were not included in any dataset accessible to the research team. Data were stored securely, and access was restricted to the investigators.

Results

A total of 100 participants met the inclusion criteria and were enrolled. The gender distribution was nearly equal: 52 males (52%) and 48 females (48%) are summarised in Table 1. The mean age was 43.88 years (SD ± 13.9), with the majority (46%) falling within the 31–50 year age group are shown in Fig. 1. The most common mechanism of injury was falling (45%), followed by sports activities (33%) and road traffic accidents.

Table 1
Distribution of participants by gender.

Gender	Number of patients	Percentage (%)
Male	52	52.0
Female	48	48.0
Total	100	100
Source: Author's Work		

Source: Author's Work

Medial meniscal injury was the most prevalent finding on MRI (n = 63; 63%), followed by lateral meniscal injury (n = 60; 60%). ACL injury was identified in 21 participants (21%), MCL injury in 4 (4%), PCL injury in 5 (5%), and LCL injury in 1 (1%). The most frequent ultrasonographic feature was loss of uniform echopattern throughout the meniscus, observed in 68 participants with medial meniscal injury and 46 with lateral meniscal injury. All sonographic features by injury type are summarised in Table 2.

Table 2

The sonographic findings of the patients with a diagnosis of ligamentous and meniscal injuries of the knee

Ultrasonographic features	MM Injury	LM Injury	MCL Injury	LCL Injury	ACL Injury	PCL Injury	Frequency
Loss of a wedge (triangular) shaped appearance	23	16	N/A	N/A	N/A	N/A	39
Loss of uniform echopattern throughout	68	46	N/A	N/A	N/A	N/A	114
Increased vascularity of the meniscus in colour Doppler	1	1	N/A	N/A	N/A	N/A	2
Loss of the linear-shaped appearance of the collateral ligament	N/A	N/A	0	0	N/A	N/A	0
Loss of uniform echopattern throughout the course (collateral)	N/A	N/A	1	0	N/A	N/A	1
Increased vascularity in colour Doppler (collateral)	N/A	N/A	0	0	N/A	N/A	0
Inhomogeneous hypoechoic pattern on the cruciate ligament	N/A	N/A	N/A	N/A	2	0	2
Loss of sharply defined posterior border (cruciate)	N/A	N/A	N/A	N/A	1	0	1
Increased vascularity in the cruciate on colour Doppler	N/A	N/A	N/A	N/A	0	1	1
Increased PCL thickness > 10mm	N/A	N/A	N/A	N/A	N/A	0	0
Source: Author's Work							

Image 1

Left Knee grey-scale (left) and color Doppler (right) ultrasound showing normal triangular (wedge) appearance of the lateral meniscus, homogenous echogenicity and normal vascularity on color doppler (orange arrows).

Image 2

Right Knee gray-scale (left) and color Doppler (right) ultrasound show complete loss of triangular (wedge) shaped appearance of lateral meniscus with loss of uniform echopattern (homogenous echogenicity) throughout the meniscus (green arrows) with normal vascularity.

Image 3

Grey-scale (left) and colour Doppler (right) show abnormal disruption of the triangular (wedge) shaped appearance of the lateral meniscus and abnormal heterogeneous echogenicity (white arrows). No increased vascularity on colour Doppler ultrasound

The diagnostic performance of ultrasonography against MRI as the reference standard is presented in Table 3. Ultrasonography demonstrated the highest sensitivity for medial meniscal injury (90.5%) and the highest specificity (100%) for MCL, LCL, ACL, and PCL injuries. Diagnostic accuracy was highest for LCL injury (99%) and MCL injury (97%), though these results should be interpreted with caution, given the small number of positive cases.

Table 3
Sensitivity, specificity, PPV, NPV, and diagnostic accuracy of ultrasonography versus MRI for each anatomical structure.

USS	MRI	Yes	No	Total	Sensitivity % (95% CI)	Specificity % (95% CI)	PPV %	NPV %	DA %
MM Injury	Yes	57	11	68	90.5	70.3	83.8	81.2	83
	No	6	26	32					
	Total	63	37	100					
LM Injury	Yes	43	5	48	71.7	87.5	89.6	67.3	78
	No	17	35	52					
	Total	60	40	100					
MCL Injury	Yes	1	0	1	25	100	100	97	97
	No	3	96	99					
	Total	4	96	100					
LCL Injury	Yes	0	0	0	0	100	0	99	99
	No	1	99	100					
	Total	1	99	100					
ACL Injury	Yes	3	0	3	14.3	100	100	79	82
	No	18	79	97					
	Total	21	79	100					
PCL Injury	Yes	1	0	1	20	100	100	96	96
	No	4	95	99					
	Total	5	95	100					
Source: Author's Work									

Discussion

This study evaluated the diagnostic accuracy of ultrasonography in detecting ligamentous and meniscal knee injuries compared with MRI as the reference standard, among patients attending a national orthopaedic referral centre in Tanzania.

The mean participant age was 43.88 years, with the 31–50 age group most affected. This is higher than the age groups reported in several European studies for instance, studies from Denmark reported a mean age of 12 years, and studies from South Africa and Sweden reported affected age groups of 18–

21 and 15–24 years, respectively [8, 9]. This difference may reflect the types and patterns of physical activity in our setting, where adult recreational and occupational activities predominate over youth sports. The gender distribution was nearly equal (52% male), consistent with some published reports but differing from studies conducted predominantly in sports-active male populations [3]. The most commonly reported mechanism of injury was falling (45%), followed by sports activities (33%), and road traffic accidents. This contrasts with studies in high-income settings where sports activities, particularly soccer, skiing, and basketball, are the predominant aetiologies [1]. Sports such as skiing are not practised in Tanzania, and competitive youth sports participation patterns differ from those in higher-income settings.

The ultrasonographic features identified in this study are consistent with those described in the established literature [10, 11]. Loss of uniform echopattern throughout the meniscus was the most frequently observed finding (68% for medial meniscal injury and 46% for lateral meniscal injury), followed by loss of the triangular (wedge) shaped appearance. For collateral ligaments, loss of linear appearance and altered echotexture were assessed; and for cruciate ligaments, inhomogeneous hypoechoic signal, loss of a sharply defined posterior border, and increased vascularity on colour Doppler were evaluated.

Ultrasonography showed the highest diagnostic performance for meniscal injuries. For medial meniscal injury, sensitivity was 90.5%, and specificity was 70.3%, yielding an overall diagnostic accuracy of 83%. For lateral meniscal injury, sensitivity was 71.7%, and specificity was 87.5%, with a diagnostic accuracy of 78%. These results are broadly consistent with those reported by Cook et al. and Alizadeh et al. [14, 15], who reported sensitivities and specificities of 91.2%/84.2% and 76.2%/83.3%, respectively, and are superior to those reported by Azzoni et al. [12, 13], who reported sensitivities as low as 60%.

For ligamentous injuries, ultrasonography demonstrated perfect specificity (100%) for MCL, LCL, ACL, and PCL injuries, indicating that when ultrasonography was positive, MRI confirmed the diagnosis in all cases. However, sensitivity was markedly lower: 25% for MCL, 0% for LCL, 14.3% for ACL, and 20% for PCL. These findings should be interpreted with caution, given the small number of MRI-confirmed positive cases for each ligamentous structure (MCL $n = 4$; LCL $n = 1$; ACL $n = 21$; PCL $n = 5$). The low sensitivity likely reflects the inherent limitations of ultrasonography in visualising intra-articular ligaments such as the ACL and PCL, rather than representing the true clinical performance of the modality.

The overall findings support the use of ultrasonography as a first-line or adjunct imaging tool for knee injuries in resource-limited settings such as Tanzania, where access to MRI is restricted. Its availability, low cost, lack of ionising radiation, portability, and compatibility with bedside use make it particularly suited for initial assessment and screening.

This study has several limitations. First, the sample size was modest ($n = 100$), and the number of participants with confirmed ligamentous injuries was small, limiting the precision of sensitivity estimates for these structures. Second, the study was conducted at a single tertiary institution, which may limit generalisability to other settings. Third, as a cross-sectional study, the design did not allow for

assessment of longitudinal outcomes or correlation with arthroscopic findings, which would represent a more definitive reference standard.

Conclusions

Ultrasonography demonstrated clinically meaningful diagnostic agreement with MRI for medial and lateral meniscal knee injuries, with high sensitivity for medial meniscal injury and high specificity across all ligamentous structures. These findings support the use of ultrasonography as a cost-effective and accessible first-line imaging modality for knee injury evaluation in resource-limited settings. Further studies with larger sample sizes are required to validate the sensitivity of ultrasonography for collateral and cruciate ligament injuries specifically.

Abbreviations

ACL

Anterior Cruciate Ligament

CI

Confidence Interval

CT

Computed Tomography

DA

Diagnostic Accuracy

IRB

Institutional Review Board

LCL

Lateral Collateral Ligament

LM

Lateral Meniscus

MCL

Medial Collateral Ligament

MM

Medial Meniscus

MOI

Muhimbili Orthopaedic Institute

MRI

Magnetic Resonance Imaging

MUHAS

Muhimbili University of Health and Allied Sciences

N/A

Not Applicable

NPV

Negative Predictive Value

PCL

Posterior Cruciate Ligament

PPV

Positive Predictive Value

SPSS

Statistical Package for the Social Sciences

USS

Ultrasonography

Declarations

Ethics approval and consent to participate

This study received ethical approval from the Muhimbili University of Health and Allied Sciences Institutional Review Board (MUHAS-REC-01-2023-1498). The study was conducted in accordance with the Declaration of Helsinki. The requirement for individual written informed consent was waived by the IRB, given the observational nature of the study. The Executive Director of MOI granted permission to collect data. All participant data were anonymised and access restricted to the research team.

Consent for publication

Not applicable.

Availability of data and materials

The datasets generated and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

Funding

No funding was received for conducting this study.

Authors' contributions

AMM: conceptualised and designed the study, performed data acquisition and analysis, interpreted the data, and drafted the manuscript. TN and LF: assisted in study design, data interpretation, and critically revised the manuscript for intellectual content. MM: assisted in study design, performed MRI reporting, contributed to data collection and interpretation, and critically revised the manuscript. MJ: contributed to data analysis and critical review of the manuscript. RS: contributed to data analysis and critical review of the manuscript. All authors read and approved the final manuscript.

Acknowledgements

The authors acknowledge the support of all staff members at MOI and the MUHAS Department of Radiology and Imaging. The authors also acknowledge the participants who consented to take part in this research.

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Images

Images are available in the Supplementary Files section.

Figures

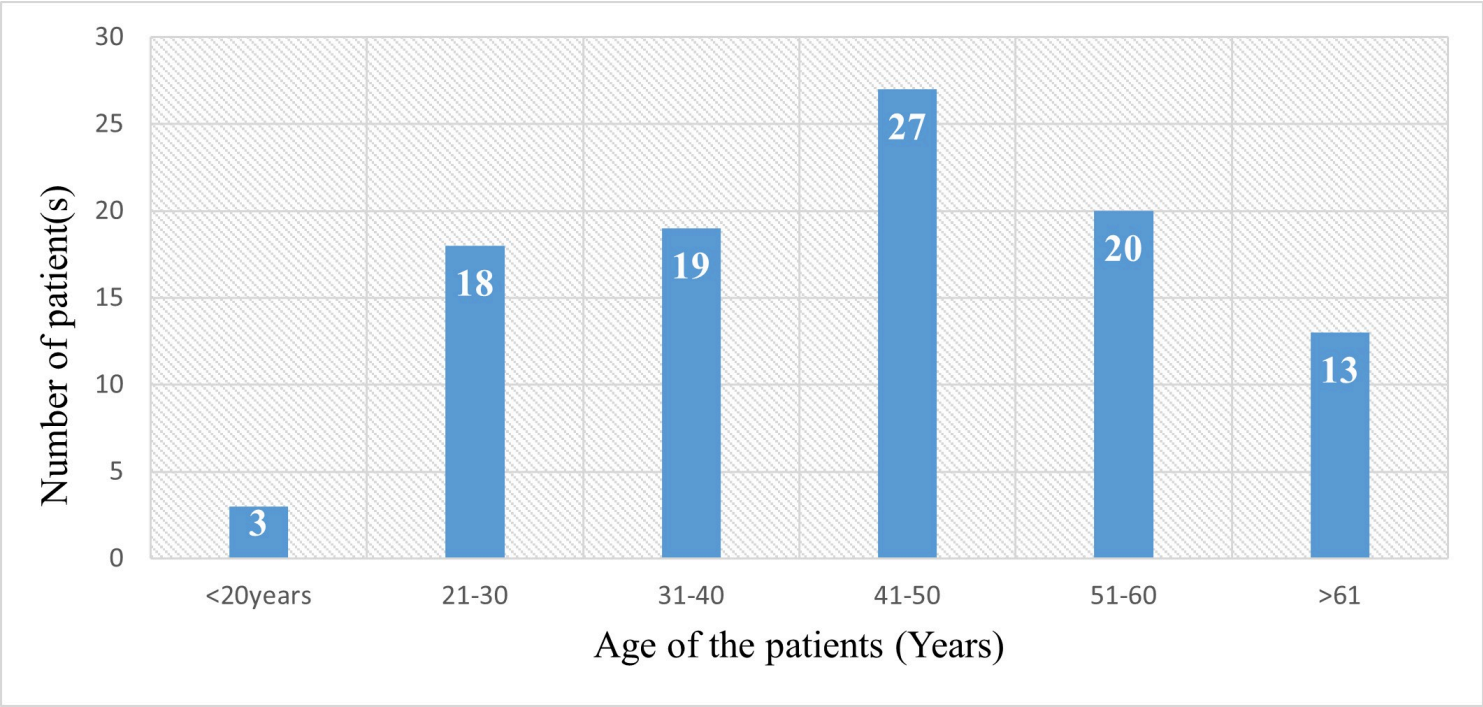


Figure 1

Distribution of patients with a diagnosis of ligamentous and meniscal injuries of the knee by Age.

Supplementary Files

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