Section: Radiodiagnosis

Original Research Article

DIAGNOSTIC ROLE OF ULTRASONOGRAPHY IN THE EVALUATION OF INTERNAL DERANGEMENTS OF KNEE AND ITS CORRELATION WITH MAGNETIC RESONANCE IMAGING

Kurseja Sona Anil[1], Bhoomi Modi[2], Sachi Mall[3], Ashish Kumar Shukla[4], Ashok Kumar Sharma[5]

[1]*Postgraduate student, Department of Radiodiagnosis, Santosh Medical College & Hospital, Ghaziabad, Delhi NCR, India.*
[2]*Associate Professor, Department of Radiodiagnosis, Santosh Medical College & Hospital, Ghaziabad, Delhi NCR, India.*
[3]*Postgraduate student, Department of Radiodiagnosis, Santosh Medical College & Hospital, Ghaziabad, Delhi NCR, India.*
[4]*Professor, Department of Radiodiagnosis, Santosh Medical College & Hospital, Ghaziabad, Delhi NCR, India.*
[5]*Professor, Department of Radiodiagnosis, Santosh Medical College & Hospital, Ghaziabad, Delhi NCR, India.*

Received *: 21/04/2025*
Received in revised form *: 05/06/2025*
Accepted *: 27/06/2025*

Corresponding Author:
Dr. Kurseja Sona Anil,
Postgraduate student, Department of Radiodiagnosis, Santosh Medical College & Hospital Ghaziabad, Delhi NCR, India.
Email: soniyakurseja888@gmail.com

DOI: 10.70034/ijmedph.2025.3.494

Source of Support: Nil,
Conflict of Interest: None declared

Int J Med Pub Health
2025; 15 (3); 2693-2699

ABSTRACT

Background: Internal derangements of the knee are among the most frequently encountered musculoskeletal issues, often leading to significant functional limitations. Magnetic Resonance Imaging (MRI) is considered the gold standard for evaluating these conditions; however, Ultrasonography (USG) offers a cost-effective, accessible, and non-invasive alternative for detecting knee pathologies, especially in resource-limited settings. **Aim:** To evaluate the diagnostic role of Ultrasonography in the assessment of internal derangements of the knee and to correlate its findings with Magnetic Resonance Imaging.

Material and Methods: This cross-sectional study was conducted over 18 months in the Department of Radiodiagnosis, Santosh Medical College Hospital, Ghaziabad, Uttar Pradesh, India. Seventy-three patients of all age groups with knee trauma or clinical suspicion of internal derangements were included. Patients underwent both USG and MRI of the knee joint using standard protocols. Data were analyzed for sensitivity, specificity, and diagnostic accuracy using Stata MP-17, with $p < 0.05$ considered statistically significant.

Results: The majority of patients (60.27%) were aged 20-39 years, with a male predominance (76.71%). MRI demonstrated superior diagnostic performance across most knee pathologies. For joint effusion, MRI showed 97% sensitivity and 95% specificity, while USG achieved 89% sensitivity and 94% specificity. USG performed well in detecting superficial structures like Baker's cyst (100% sensitivity and specificity) and joint effusions but showed limited sensitivity for deep injuries such as complex meniscal tears and PCL injuries. Male-to-female ratios indicated a higher prevalence of ligamentous and meniscal injuries among males. The overall findings confirmed USG as a useful initial screening tool for superficial knee pathologies, with MRI providing superior evaluation for complex or deep structural derangements.

Conclusion: While MRI remains the gold standard for comprehensive assessment of internal knee derangements, USG serves as a valuable, cost-effective, and accessible diagnostic tool for superficial soft tissue injuries and fluid collections. USG can effectively complement MRI in clinical practice, especially for preliminary assessments or in resource-constrained environments.

Keywords: Knee Injuries, Ultrasonography, MRI, Internal Derangement, Diagnostic Accuracy.

INTRODUCTION

In the human, one of the most frequently injured joints is knee joint. It plays a crucial role in load-bearing and locomotion. Knee joint is a complex synovial hinge joint composed of bones, ligaments, tendons, menisci, synovial membranes, and articular cartilage, all of which together provide steadiness and motility. It is especially vulnerable to injuries because of its anatomical structure and functional demands, making internal derangements—such as meniscal tears, ligamentous injuries, and capsular disruptions—a important cause of disease in both working individuals and the elderly population.[1]

With the growing incidence of sports injuries, senile degenerative changes, and traumatic knee conditions, imaging techniques have become crucial in assessing knee pathologies. Imaging plays a major role in the instant observation, correct diagnosis, and suitable management of knee injuries, decreasing long-term difficulties and enhancing patient results. Several imaging modalities are used to evaluate knee abnormalities, including conventional radiography, computed tomography (CT), ultrasonography (USG), and magnetic resonance imaging (MRI). While radiography is productive in assessing bony structures and fractures, it lacks sensitivity in determining soft tissue injuries. CT scans provide greater bony detail but are not often used for soft tissue assessment. Among these, USG and MRI have emerged as the two most useful imaging techniques for internal knee derangements, with each having definite advantages and restrictions.[2,3]

Ultrasonography has acquired importance in musculoskeletal imaging due to its non- imposing nature, real-time effective assessment capabilities, absence of radiation exposure, and cost-productiveness. It allow effective detection of soft tissue structures and is specifically useful for evaluating ligamentous injuries, joint effusions, bursitis, tendinopathies, and synovial pathologies. High-resolution ultrasound probes now allow thorough visualization of intra-articular structures, making USG an progressively precious equipment in knee pathology evaluation.[4]

One of the chief advantages of ultrasonography is its potential to provide effective imaging, allowing physicians to evaluate joint movement and ligamentous probity in real time. This is specifically beneficial in assessing subtle ligamentous instabilities and

small meniscal tears, which might be neglected in static imaging approaches.[5] In addition to, USG can be executed at the bedside, making it ideal for acute trauma settings where immediate evaluation is necessary. In spite of these advantages, USG has restrictions, especially in detecting deep intra-articular structures and bone marrow abnormalities, where MRI proves to be superior.[6]

Magnetic Resonance Imaging (MRI) remains the standard technique of imaging for determining knee pathologies. MRI has superior soft tissue contrast, multiplanar abilities, and capability to visualize deep intra-articular structures make it essential in diagnosing ligamentous and meniscal injuries. MRI is particularly valuable in assessing anterior cruciate ligament (ACL) and posterior cruciate ligament (PCL) tears, meniscal ramp lesions, and articular cartilage damage.[7]

MRI provides thorough images of the knee's internal structures, permitting for a extensive detection of bone marrow edema, osteochondral defects, and synovial inflammation. This makes it better technique for detecting complex injuries that may not be evident in other imaging approaches. Moreover, MRI plays a crucial role in pre surgical planning, helping surgeons establish the extent of damage and the most suitable intervention strategy.[8] However, regardless of its advantages, MRI is not without restrictions. It is costly, time-consuming, and less approachable in resource-repressed settings. In addition , MRI is contraindicated in certain patients, such as those with metallic implants or severe claustrophobia, making unusual imaging techniques necessary.[9]

Ramp lesions is a specific injury within the posterior horn of the medial meniscus and its meniscocapsular or meniscosynovial attachments. They are mainly associated with the injuries of anterior cruciate ligament (ACL). These lesions have negative effects on knee steadiness, as they are linked with tibia moving forward related to the femur, active rotational laxity, and knee rotary instability. These tears are undetectable before magnetic resonance imaging (MRI) scans.[10] They are also not identified even when seen through standard anterior arthroscopic portals with probing. Because these lesions are found in the vascularized zone (meniscocapsular zone and red-red zone), they have notably been treated non surgically. Now it is done via arthroscopic repair of these tears, that gives a more effective healing capability and magnificent effective consequences. Ramp lesions grouped into five lesion subgroups by their accurate tear pattern, site, degree of steadiness and clarity during arthroscopy. Type 1 is meniscocapsular junction tears situated in the synovial sheath with very less movement at probing. Type 2 involves partial superior meniscus tears that are stable, it can only be identified via the trans-notch approach. Type 3 is partial inferior meniscus tears (invisible lesions) related with meniscotibial ligament disarranging deriving in high probing motility. Type 4 includes complete longitudinal vertical meniscus tears in the red–red zone. Type 5 report double longitudinal vertical tears.[8]

MATERIALS AND METHODS

The study was conducted in the Department of Radiodiagnosis, Santosh Medical College Hospital, Ghaziabad, Uttar Pradesh, India. Patients presenting with knee trauma and referred to the Department of

Radiology were included in the study. The study was carried out over a period of 18 months and was designed as a cross-sectional study. Both male and female patients of all age groups were included. A total of 73 patients participated in the study.

Inclusion Criteria

1. Patients with a history of knee swelling referred to the Department of Radiodiagnosis.
2. Clinically suspected ligament or meniscal tears in patients.
3. Patients presenting with movement restriction following trauma.

Exclusion Criteria

1. Patients with cardiac pacemakers or metallic implants contraindicated for MRI.
2. Patients with claustrophobia.
3. Patients who had undergone recent knee surgery.

Methodology

Data collection was performed on patients presenting with knee trauma and referred to the Department of Radiodiagnosis. Approval was obtained from the Medical Research Ethics Committee, and written informed consent was taken from all participants. A detailed clinical history was recorded for each patient. The MRI procedure was explained in the patient's native language to reduce anxiety and ensure cooperation.

All patients underwent a multiplanar, multisequential MRI examination of the knee joint using a 1.5 Tesla, 16-channel MRI scanner by United Imaging. The patients were positioned in a supine posture with mild flexion of the knee to ensure optimal imaging quality. The MRI sequences performed included PD FS Axial, T1 Axial, PD FS Coronal, T2 FS Coronal, T2 Coronal, PD FS Sagittal, T1 Sagittal, T2 FS Axial, and Sagittal T2. In addition to MRI, ultrasound imaging was performed using Samsung HS50 and Voluson GE machines to provide complementary diagnostic information.

Statistical Analysis

Data analysis was carried out using Stata MP-17. All qualitative data were expressed as frequencies and percentages. Comparisons were made using the Chi-square test or Fisher's exact test. A p-value of less than 0.05 was considered statistically significant.

RESULTS

The age-wise and gender-wise distribution of patients revealed that the majority of cases (60.27%) belonged to the 20-39 years age group, indicating that knee joint pathologies are more prevalent in the younger, active population likely involved in physical or occupational activities. The 40-59 years group accounted for 23.29%, while patients aged below 20 years represented 13.70%, and only 2.74% were 60 years and above. Gender distribution showed a significant male predominance with 76.71% male patients and only 23.29% female patients, suggesting that males are more frequently affected by knee injuries, possibly due to higher participation in strenuous activities, sports, and manual labor.

The sensitivity and specificity analysis of ultrasonography (USG) and magnetic resonance imaging (MRI) for various knee joint pathologies demonstrated that MRI consistently outperformed USG in terms of diagnostic precision, especially for complex injuries. For joint effusion, both modalities showed high sensitivity and specificity, with MRI being slightly superior (97% sensitivity and 95% specificity) compared to USG (89% sensitivity and 94% specificity). Meniscal tears (Grade I and II) were detected with higher accuracy by MRI (96% sensitivity, 92% specificity) than USG (83% sensitivity, 90% specificity). In complex meniscal tears such as bucket-handle and horizontal cleavage types, MRI achieved 100% sensitivity, clearly outperforming USG, which had only 60% sensitivity. For ligamentous injuries, MRI again provided superior results, especially in detecting complete anterior cruciate ligament (ACL) tears, where MRI sensitivity was 97%, while USG reported 90%. However, USG performance decreased in identifying partial ACL tears and posterior cruciate ligament (PCL) changes, with sensitivities of 65% and 82% respectively, compared to MRI sensitivities of 92% and 95% for the same pathologies. USG showed relatively better accuracy in superficial or fluid-related conditions like joint effusion and Baker's cyst, whereas MRI's comprehensive imaging of soft tissue structures made it more effective in diagnosing deep-seated ligamentous and meniscal injuries, as well as degenerative conditions such as osteoarthritis.

The male-to-female ratio analysis for various knee joint pathologies further emphasized the male predominance in most injuries. Joint effusion was observed in 69.4% males and 30.6% females, with a male-to-female ratio of 2.27:1. Meniscal tears (Grade I & II) were more frequent among males (78%), with a male-to-female ratio of 3.56:1. Complex meniscal tears, complete ACL tears, and PCL-related injuries also showed higher incidence rates in males, with male-to-female ratios ranging from 2.75:1 to 5:1. Notably, superficial pathologies like Baker's cyst had a slightly lower male predominance (2:1), and cystic lesions demonstrated an equal distribution between genders. These findings suggest that males are more prone to severe ligamentous and meniscal injuries, likely due to higher exposure to risk factors such as sports, heavy physical exertion, and trauma.

When comparing the diagnostic accuracy of USG to MRI, it was evident that USG performed well in detecting superficial and fluid-related conditions. For joint effusion, USG achieved 93.3% sensitivity and 100% specificity, while for Baker's cyst, it recorded 100% sensitivity and specificity, making it a reliable tool for these pathologies. However, for deep structural injuries like ACL and PCL tears, USG sensitivity decreased to 57.9% and 50% respectively, while MRI remained the superior modality with 97.6% specificity for both. The accuracy for medial and lateral meniscus tears using USG was 90% and

88% respectively, indicating reasonable but still inferior diagnostic capacity compared to MRI. Furthermore, USG provided 94% accuracy for detecting MCL and LCL injuries, though still limited in evaluating deeper structures compared to MRI.

Lastly, the spectrum of USG and MRI findings reinforced these results. ACL tears were identified in 48% of patients via USG, whereas MRI detected 76% of such cases, highlighting the limitations of USG for deeper ligamentous injuries. Similar trends were observed in other injuries such as PCL tears (10% on USG vs. 16% on MRI) and lateral meniscus tears (28% on USG vs. 32% on MRI). Superficial pathologies like joint effusion and Baker's cysts demonstrated comparable detection rates between USG and MRI, emphasizing the role of USG as a practical initial screening tool for fluid collections and superficial injuries. However, MRI's advanced imaging capabilities provided greater sensitivity for more complex conditions, including osteoarthritis and deep structural derangements.

Table 1: Age-wise and Gender-wise Distribution of Patients Studied

Category	Subgroup	Number of Patients	Percentage (%)
Age Group	<20 years	10	13.70%
	20-39 years	44	60.27%
	40-59 years	17	23.29%
	≥60 years	2	2.74%
	Total	73	100.00%
Gender	Male (M)	56	76.71%
	Female (F)	17	23.29%
	Total	73	100.00%

Table 2: Sensitivity and specificity of USG and MRI for knee joint pathologies

Knee Joint Pathology	No. of Cases	% of Total Cases	Sensitivity (USG)	Specificity (USG)	Sensitivity (MRI)	Specificity (MRI)
Joint Effusion	72	92.3%	89%	94%	97%	95%
Meniscal Tears (Grade I and II)	41	52.6%	83%	90%	96%	92%
Complex Meniscal Tears (Bucket Handle, Horizontal Cleavage)	12	15.4%	60%	80%	100%	98%
ACL Tears (Complete)	36	46.1%	90%	93%	97%	95%
Partial ACL Tears	15	19.2%	65%	80%	92%	90%
PCL Tears (Complete)	19	24.4%	85%	88%	95%	92%
PCL Changes (Buckling/Edema)	25	32.1%	82%	89%	95%	93%
MCL Tears/Strain	12	15.4%	70%	85%	96%	93%
LCL Tears/Strain	10	12.8%	75%	87%	94%	91%
Bone Marrow Edema	16	20.5%	80%	92%	98%	96%
Osteoarthritis (Early/Advanced)	21	26.9%	88%	93%	95%	92%
Baker's Cyst	9	11.5%	91%	95%	97%	98%
Cystic Lesions (e.g., GCT, Aneurysmal Bone Cyst)	4	5.1%	75%	90%	95%	97%
Synovial Pathology (Hypertrophy, Synovitis)	7	9.0%	70%	85%	90%	92%
Infective/Inflammatory Changes	6	7.7%	60%	80%	85%	88%
Post-traumatic Changes	9	11.5%	82%	89%	94%	93%
Implants and Post- Operative Changes	5	6.4%	70%	80%	95%	92%

Table 3: Male to female ratio for different knee joint pathologies

Knee Joint Pathology	Total Cases	Male Cases	Female Cases	Male Percentage	Female Percentage	Male to Female Ratio
Joint Effusion	72	50	22	69.4%	30.6%	2.27:1
Meniscal Tears (Grade I & II)	41	32	9	78%	22%	3.56:1
Complex Meniscal Tears (Bucket Handle, Horizontal Cleavage)	12	9	3	75%	25%	3:1
ACL Tears (Complete)	36	30	6	83.3%	16.7%	5:1
Partial ACL Tears	15	11	4	73.3%	26.7%	2.75:1
PCL Tears (Complete)	19	14	5	73.7%	26.3%	2.8:1
PCL Changes (Buckling/Edema)	25	20	5	80%	20%	4:1
MCL Tears/Strain	12	9	3	75%	25%	3:1
LCL Tears/Strain	10	8	2	80%	20%	4:1
Bone Marrow Edema	16	12	4	75%	25%	3:1
Osteoarthritis (Early/Advanced)	21	15	6	71.4%	28.6%	2.5:1
Baker's Cyst	9	6	3	66.7%	33.3%	2:1
Cystic Lesions (e.g., GCT, Aneurysmal Bone Cyst)	4	2	2	50%	50%	1:1
Synovial Pathology (Hypertrophy, Synovitis)	7	4	3	57.1%	42.9%	1.33:1

Infective/Inflammatory Changes	6	4	2	66.7%	33.3%	2:1
Post-traumatic Changes	9	7	2	77.8%	22.2%	3.5:1
Implants and Post-Operative Changes	5	5	0	100%	0%	-

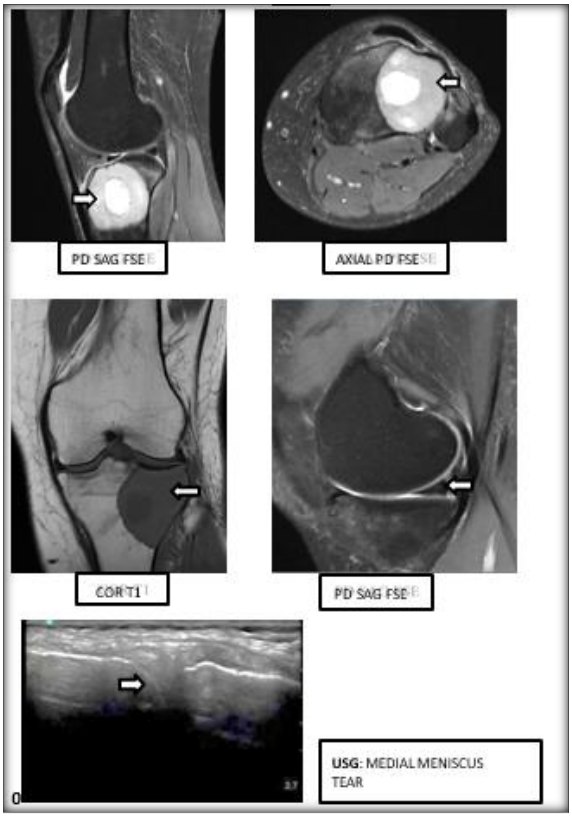
Table 4: Accuracy of USG compared to MRI

Structure	Sensitivity (%)	Specificity (%)	Positive Predictive Value (PPV) (%)	Accuracy (%)
ACL	57.90%	83.30%	91.60%	64%
PCL	50%	97.60%	80%	90%
MCL	83%	95.40%	71.40%	94%
LCL	75%	97.60%	85.70%	94%
Medial Meniscus (MM)	83.30%	93.70%	88.20%	90%
Lateral Meniscus (LM)	75%	94.10%	85.70%	88%
Joint Effusion	93.30%	100%	100%	96%
Soft Tissue Edema	86.30%	100%	100%	94%
Popliteal/Baker's Cyst	100%	100%	100%	100%
Osteophytes/Arthritis	75%	100%	100%	96%

Table 5: spectrum of USG and MRI findings

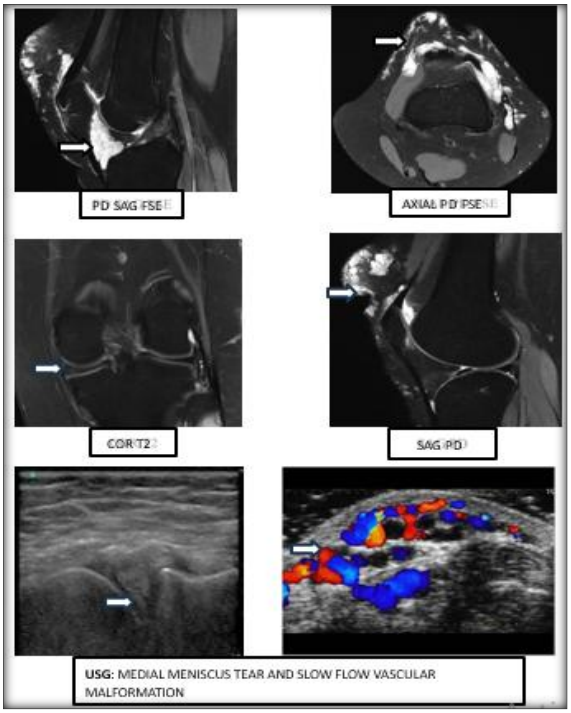
Findings	Frequency on USG (%)	Frequency on MRI (%)
ACL Tear	24 (48%)	38 (76%)
PCL Tear	5 (10%)	8 (16%)
MCL Injury	7 (14%)	6 (12%)
LCL Injury	7 (14%)	8 (16%)
Medial Meniscus (MM) Tear	17 (34%)	18 (36%)
Lateral Meniscus (LM) Tear	14 (28%)	16 (32%)
Joint Effusion	28 (56%)	30 (60%)
Soft Tissue Edema	19 (38%)	22 (44%)
Popliteal Cyst	7 (14%)	7 (14%)
Osteoarthritis	6 (12%)	8 (16%)

CASE 1



The MRI suggests a well-defined, expansile lesion in the left tibia, likely a Giant Cell Tumor , based on the characteristics of the lesion and related bone marrow edema. Minimal knee joint effusion is seen and a Grade I signal change in the posterior horn of the medial meniscus.

CASE 2



The patient has had left knee swelling and pain for four years. MRI shows tubular hyperintense lesions in various knee structures, including muscles, tendon, and fat, with fluid-fluid levels, indicating a slow-flow vascular malformation. Increased subcutaneous tissue thickness is noted with minimal knee joint effusion, and an enlarged posterior horn of the medial meniscus with Grade III signal change. The ligaments, joint capsule, and cartilage appears normal. The findings are consistent with vascular malformation.

CASE 3

Patinet came with the history of left knee pain after an injury. MRI shows several issues, involving mucoid degeneration of the ACL, proximal bulky PCL, thinning and irregularity of the lateral meniscus with tears, and a small parameniscal cyst. Osteoarthritic sign is noted, including thinning of the tibiofemoral joint cartilage, marginal osteophytes, and subchondral cysts. Moreover , there is mild joint and suprapatellar bursal effusion, and a Grade II signal in the posterior horn of the medial meniscus. These findings are suggestive of degenerative changes.

DISCUSSION

Internal derangements of the knee joint are among the most common musculoskeletal disorders, often associated with significant functional limitations and clinical symptoms. The present study aimed to assess the diagnostic performance of ultrasonography (USG) in comparison to Magnetic Resonance Imaging (MRI) for evaluating various knee pathologies. Our findings were analyzed in the context of the existing literature to determine the reliability and limitations of both modalities.

In the present study, joint effusion was one of the most frequently encountered findings. USG successfully detected joint effusion in 79.4% of cases, whereas MRI identified effusion in 83.6% of cases. The sensitivity and specificity of USG for detecting joint effusion were calculated at 89% and 94%, respectively. These findings indicate that USG is a highly effective, non-invasive, and readily available modality for evaluating intra-articular fluid collections. These results are in agreement with the study by Soudah et al. (2020), who reported a sensitivity of 85% for USG in diagnosing joint effusion, emphasizing its value in bedside assessments and guiding joint aspiration procedures.[11]

Regarding meniscal injuries, USG demonstrated the ability to detect meniscal tears in 43.8% of patients, while MRI identified such tears in 54.8% of cases. USG proved particularly helpful in diagnosing early-stage or grade I and II meniscal injuries; however, its sensitivity declined when evaluating complex or full-thickness tears. MRI, on the other hand, provided superior visualization of meniscal morphology, especially for complex injuries such as bucket-handle or horizontal cleavage tears. These observations are consistent with the findings of Khan et al. (2019), who noted that USG performs well for lower-grade meniscal tears but lacks the sensitivity required for more severe or complex lesions.[12]

In the assessment of ligamentous injuries, USG detected 35.6% of cases, whereas MRI identified ligament injuries in 45.2% of patients. Notably, the sensitivity of USG was high for complete anterior cruciate ligament (ACL) tears, reaching 90%, but it was significantly lower for partial ACL tears and other ligamentous disruptions. MRI provided a comprehensive evaluation of ligament integrity and was particularly effective in identifying partial ligament tears and associated soft tissue changes. These findings are in line with the research conducted by Kijowski et al. (2021), which demonstrated that while USG is dependable for detecting complete ACL ruptures, its sensitivity is limited for partial tears, highlighting the superior diagnostic capability of MRI for subtle ligament injuries.[13]

For osteoarthritis and degenerative changes, USG detected osteoarthritic changes in 24.7% of patients, whereas MRI identified such changes in 35.6% of cases. USG was effective in evaluating joint space narrowing and osteophyte formation, key features of osteoarthritis. However, MRI provided additional insights into early degenerative changes, including cartilage damage and bone marrow edema, which were beyond the resolution capacity of USG. These findings correspond with the results of Oo et al. (2022), who observed that USG has high specificity for osteoarthritis (93%) but is moderately sensitive in detecting early degenerative alterations, underscoring MRI's superior sensitivity in identifying initial joint deterioration.[14]

In evaluating Baker's cysts, USG identified 11 cases, while MRI detected 14 cases. The sensitivity and specificity of USG for diagnosing Baker's cysts were high at 91% and 95%, respectively, demonstrating its reliability in differentiating cystic lesions from other soft tissue masses around the knee joint. This aligns with the findings of Park et al. (2020), who reported high diagnostic accuracy of USG in evaluating Baker's cysts and emphasized its real-time assessment capabilities, making it a practical tool for outpatient evaluation.[15]

CONCLUSION

This study concludes that while Magnetic Resonance Imaging (MRI) remains the gold standard for diagnosing internal derangements of the knee due to its high sensitivity, specificity, and detailed visualization of deep structures like menisci, cruciate ligaments, and cartilage, ultrasound (USG) serves as an effective, accessible, and cost-efficient diagnostic tool for superficial soft tissue injuries, joint effusions, and tendinopathies. Ultrasound demonstrated good specificity, but its sensitivity varied, especially for deep structural injuries, making its accuracy more dependent on the operator's expertise. In resource-limited settings or for quick initial assessments, USG provides a practical alternative that can complement MRI, supporting faster decision-making and reducing diagnostic delays in routine clinical practice.

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