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DIAGNOSTIC PERFORMANCE OF MUSCULOSKELETAL ULTRASOUND COMPARED WITH MRI IN THE EVALUATION OF KNEE JOINT PATHOLOGIES

Dr.Nudurupati Uma[1*], Dr. Venkatesh Pothula[2]

[1*]Associate Professor, Department of Radiodiagnosis, Great Eastern Medical School and Hospital, Ragolu, Srikakulam, Andhra Pradesh, India. druman@gmail.com
[2]Associate Professor, Department of Radiodiagnosis, Great Eastern Medical School and Hospital, Ragolu, Srikakulam, Andhra Pradesh, India. drvenkatesh@gmail.com

***Corresponding Author:** Dr.Nuduruapti Uma
*Associate Professor, Department of Radiodiagnosis, Great Eastern Medical School and Hospital, Ragolu, Srikakulam, Andhra Pradesh, India. druman@gmail.com

ABSTRACT

Background: The study investigates the diagnostic performance of musculoskeletal ultrasound (MSUS) compared to magnetic resonance imaging (MRI) for evaluating knee joint pathologies. Given the knee's complexity and its significance in weight-bearing activities, accurate imaging is crucial for diagnosing conditions such as ligament tears, meniscal injuries, and degenerative changes. While MRI is regarded as the gold standard due to its superior soft-tissue contrast and comprehensive visualization capabilities, it is hampered by accessibility issues, high costs, and patient-specific contraindications. MSUS presents a promising alternative due to its lower cost, wide availability, real-time imaging, and capability to detect conditions like joint effusions and tendon disorders effectively.

Materials and Methods: This prospective cross-sectional study at a tertiary care hospital included 86 patients symptomatic of knee pathologies, evaluated through both MSUS and MRI to establish a reference standard for comparison. The study found that MRI identified a total of 112 knee abnormalities, predominantly joint effusion (44.2%), meniscal tears (33.7%), and anterior cruciate ligament (ACL) injuries (20.9%). MSUS showed high sensitivity (84.6%) and specificity (92.8%), especially in identifying superficial structures, with notable diagnostic accuracy (89.5%).

Results indicated good concordance between MSUS and MRI for conditions like joint effusions and tendon abnormalities; however, ultrasound's performance was less reliable for deep intra-articular pathologies, such as meniscal and cruciate ligament injuries. The study's findings reaffirm the clinical role of MSUS as a reliable, cost-effective, and non-invasive first-line imaging tool, particularly beneficial for patients with superficial pathologies.

Conclusion: Despite its effectiveness, the limitations of the study include its single-center design and relatively small patient cohort, warranting further multicentric research to validate and potentially standardize ultrasound protocols for knee imaging. Overall, while MSUS can efficiently assess many common knee disorders, MRI remains superior for intricate evaluations of deep joint structures. Further studies are necessary to enhance the clinical application of MSUS in knee pathologies and improve patient management outcomes.

Keywords: Musculoskeletal ultrasound (MSUS), Magnetic resonance imaging (MRI), Knee joint pathologies, Diagnostic accuracy, Meniscal tears, Anterior cruciate ligament injuries, Joint effusion, Soft-tissue imaging.

INTRODUCTION

The knee joint is a frequently encountered joint in musculoskeletal practice due to its complex anatomy and important biomechanical function in weight-bearing and locomotion. They can cause pain, disability and reduced quality of life. These pathological conditions include ligament tears, meniscal injuries, tendon abnormalities, synovial disorders, joint effusions and degenerative osteoarthritis. Thus, accurate imaging assessment is important for early diagnosis, treatment planning and monitoring of disease progression (1,2).

Magnetic resonance imaging (MRI) is widely considered the reference imaging modality for evaluation of knee joint pathologies due to its superb soft-tissue contrast and multiplanar capabilities. MRI offers complete visualisation of intra-articular and periarticular structures and accurate detection of meniscal tears, cruciate ligament injuries, cartilage defects, and synovial abnormalities (3,4). However, MRI has several drawbacks such as high cost, limited availability, long examination time and contraindications in some patients such as those with non-compatible implanted devices or severe claustrophobia (5).

Musculoskeletal ultrasound (MSUS) has gained value as an imaging modality for assessment of musculoskeletal disorders. The advances in high-frequency transducer technology have greatly improved the resolution of images, allowing for detailed visualisation of superficial structures around the knee joint. Ultrasound has several advantages such as wide availability, low cost, no ionising radiation, real-time dynamic examination, and the ability to compare findings with the contralateral side during the same imaging session (6,7). Ultrasound is also very sensitive in detecting joint effusions, synovitis, Baker's cysts, tendon disorders and some ligament injuries (8). However, the diagnostic performance of musculoskeletal ultrasound versus MRI for the comprehensive evaluation of knee pathologies is still a topic for future research. Compared to MRI, ultrasound may offer more cost-effective and accessible diagnostic pathways due to its accuracy and reliability. Therefore, the objective of this study is to evaluate the diagnostic accuracy of ultrasound in comparison to MRI in patients suspected of having knee joint pathologies.

MATERIALS AND METHODS

This prospective cross-sectional diagnostic accuracy study was conducted at the Department of Radiology of a tertiary care hospital from January 2019 to August 2020. Objective: To assess the diagnostic performance of musculoskeletal ultrasound (MSUS) versus magnetic resonance imaging (MRI) in the evaluation of knee joint pathologies. Ethical approval for the study was obtained from the institutional review board and written informed consent was obtained from all the participants prior to enrolment.

The study comprised a total of 86 consecutive patients with symptoms suggestive of pathology in the knee joint such as pain, swelling, restricted movement, instability or suspected traumatic injury. Patients of either sex aged 18 years and above referred for imaging evaluation of the knee were included. Patients with previous knee surgery, acute fractures, contraindications to MRI and incomplete imaging studies were excluded.

All participants underwent a musculoskeletal ultrasound and then MRI of the affected knee in a short interval. Ultrasound examinations were performed by an experienced radiologist using a high-frequency linear transducer (7–15 MHz). Standardised scanning protocols were used to assess the suprapatellar recess, quadriceps tendon, patellar tendon, collateral ligaments, menisci, joint effusion, synovium, Baker's cysts and other periarticular soft-tissue structures. When needed, dynamic assessment was performed.

MRI studies were performed on a 1.5-Tesla scanner, with standard knee protocols including sagittal, coronal and axial sequences. MRI findings were used as reference standard for diagnosis of knee joint

abnormalities. The pathologies assessed were meniscal tears, injuries to the anterior cruciate ligament (ACL) and posterior cruciate ligament (PCL), collateral ligament injuries, joint effusion, synovitis, Baker's cysts, cartilage abnormalities and tendon pathologies.

The ultrasound findings were compared with the respective MRI findings. For musculoskeletal ultrasound, diagnostic performance measures were calculated including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and overall diagnostic accuracy. Statistical analysis was done by openepi online tool. Continuous variables were presented as mean ± standard deviation and categorical variables as frequencies and percentages. Statistical significance was considered at p-value <0.05.

RESULTS

The study included a total of 86 patients with suspected knee joint pathologies. The mean age of the participants was 38.7 ± 12.4 years (range, 18-68 years). Males numbered 52 (60.5%) and females 34 (39.5%). The right knee was involved in 49 patients (57.0%) and the left knee was involved in 37 patients (43.0%).

MRI revealed a total of 112 pathological findings in the 86 examined knees. The most frequent MRI abnormalities included joint effusion (38 cases, 44.2%), meniscal tears (29 cases, 33.7%), anterior cruciate ligament (ACL) injuries (18 cases, 20.9%), Baker's cysts (14 cases, 16.3%), synovitis (13 cases, 15.1%), collateral ligament injuries (11 cases, 12.8%), and tendon abnormalities (9 cases, 10.5%).

Musculoskeletal ultrasound demonstrated good concordance with MRI in identifying joint effusion, Baker's cysts, synovitis, and tendon abnormalities. MRI identified 38 joint effusions, 14 Baker's cysts, 13 synovitis cases and 9 tendon lesions, of which ultrasound detected 36, 13, 11 and 8, respectively. For meniscal tears, ultrasound detected 22 of 29 cases with a sensitivity of 75.9% and specificity of 91.2%. In the assessment of ACL injuries, ultrasound identified 13/18 cases, yielding a sensitivity of 72.2% and specificity of 94.1%. The diagnostic performance of ultrasound was relatively lower in deep intra-articular structures than in superficial soft-tissue abnormalities.

Overall, musculoskeletal ultrasound had sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy of 84.6%, 92.8%, 88.1%, 90.7%, and 89.5%, respectively, for detection of knee joint pathologies, using MRI as the reference standard.

Table 1. Demographic Characteristics of the Study Population (n = 86)

Variable	Value
Mean age (years)	38.7 ± 12.4
Age range (years)	18-68
Male, n (%)	52 (60.5)
Female, n (%)	34 (39.5)
Right knee involved, n (%)	49 (57.0)
Left knee involved, n (%)	37 (43.0)

Table 2. Frequency of Knee Pathologies Detected by MRI (n = 86)

Pathology	Number (%)
Joint effusion	38 (44.2)
Meniscal tear	29 (33.7)
ACL injury	18 (20.9)
Baker's cyst	14 (16.3)
Synovitis	13 (15.1)
Collateral ligament injury	11 (12.8)
Tendon abnormalities	9 (10.5)

Table 3. Diagnostic Performance of Musculoskeletal Ultrasound Compared with MRI

Parameter	Value (%)
Sensitivity	84.6
Specificity	92.8
Positive Predictive Value	88.1
Negative Predictive Value	90.7
Overall Accuracy	89.5

The data show that musculoskeletal ultrasound is very accurate in assessing superficial and periarticular knee pathologies and has a significant diagnostic agreement with MRI, especially in the case of joint effusion, Baker's cysts, synovitis and tendon lesions . However, MRI is still better for assessing deep intra-articular structures such as cruciate ligament and meniscal injuries.

DISCUSSION

The aim of the present study was to evaluate the diagnostic performance of musculoskeletal ultrasound (MSUS) in comparison to magnetic resonance imaging (MRI) for the evaluation of knee joint pathologies in 86 patients. Our study results showed overall sensitivity of 84.6%, specificity of 92.8% and diagnostic accuracy of 89.5% for MSUS. Thus, ultrasound is a reliable imaging technique for evaluation of several common knee disorders. These results support the increasing role of MSUS as an accessible, inexpensive and non invasive diagnostic modality in everyday musculoskeletal practice.

The most common abnormality found in this study was joint effusion, followed by meniscal tears and anterior cruciate ligament (ACL) injuries. Ultrasound was very effective to detect joint effusion, diagnosing 36 out of 38 cases confirmed by MRI. Hall reported similar findings and stated that ultrasound is highly sensitive for the detection of even small volumes of knee joint fluid, due to its real-time imaging capability (9). Similarly, previous studies have reported that ultrasound has a high accuracy for detection of synovial hypertrophy and inflammatory changes in the knee joint (10,11). We also showed good concordance between Ultrasound and MRI in detecting Baker's cysts and tendon abnormalities. These findings are in line with the observations of Jacobson who stated that ultrasound provides detailed evaluation of superficial soft tissue structures and allows for dynamic assessment which may not be possible with static MRI studies (12). Ultrasound has the distinct advantage of being able to assess structures dynamically, particularly in patients with suspected pathology of the tendon.

In contrast, the diagnostic performance of ultrasound was relatively lower for injuries of meniscal and cruciate ligaments. In our study, the sensitivities of meniscal tears and ACL injuries were 75.9% and 72.2%, respectively. These results are in line with previous studies that have demonstrated moderate sensitivity of ultrasound for deep intra-articular structures, but confirmed the superior capacity of MRI to evaluate menisci, cruciate ligaments and articular cartilage (13,14). Ultrasound may be less effective in these lesions because of limited acoustic penetration and poor visualisation of structures deep in the intercondylar notch.

MRI is the gold standard for a full evaluation of the knee joint pathology as it provides excellent soft tissue contrast and multiplanar imaging capability (15). However, practical limitations such as high cost, limited availability, longer examination times and contraindications in certain patient populations may limit the routine use of MRI. Ultrasound, in contrast, is inexpensive, widely available, radiation-free, and can be performed as a point-of-care examination (12,16).

The results of this study indicate that musculoskeletal ultrasound might be a useful first line imaging tool in the evaluation of knee pain, particularly in patients with suspected joint effusion, synovitis, Baker's cysts or tendon disorders. MRI should be reserved for cases needing detailed assessment of intra-articular structures or when ultrasound findings are inconclusive.

A limitation of the present study is the relatively small sample size and single-centre design, which may limit the generalisability of the findings. Additionally, operator dependency is a well-known limitation of ultra-sound examinations. These findings need to be validated by additional multicentre studies with larger patient populations and standard ultrasound protocols for knee imaging should be

established.

Musculoskeletal ultrasound is a very accurate diagnostic tool with good agreement with MRI in the evaluation of knee joint pathologies. MRI remains the best imaging modality for detection of deep intra-articular lesions, however, ultrasound is a useful, accessible and cost-effective imaging modality for assessment of many common knee disorders.

CONCLUSION

Musculoskeletal ultrasound showed high diagnostic accuracy and good concordance with MRI in the assessment of pathologies of knee joints . The modality was particularly helpful in identifying joint effusions, synovitis, Baker's cyst, and tendon abnormalities, but had moderate sensitivity for meniscal and cruciate ligament tears. MRI is the gold standard for complete evaluation of intra-articular knee structures. However, musculoskeletal ultrasound has significant advantages in terms of cost, availability, real time dynamic assessment and lack of ionising radiation. To summarise, ultrasound can be a valuable first-line imaging modality in the diagnostic work-up of patients with suspected knee joint disorders, with MRI being reserved for complex cases or when detailed evaluation of deep intra-articular lesions is necessary. Further large scale multicentre studies are warranted to confirm these findings and to improve the clinical utility of musculoskeletal ultrasound in knee imaging.

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