ORIGINAL ARTICLE

The Value of High-Resolution Ultrasound in Evaluation of Meniscal and Ligamentous Lesions; A Comparative Study To MRI

Abdulnaby B. Mohamed, Mohamed A. Beleh, Yasser Z. M. Shalaby *

Department of Radiodiagnosis, Faculty of Medicine for Boys, Al-Azhar University, Cairo, Egypt

Abstract

Background: ***In terms of mobility, the knee joint is paramount. Therefore, it is crucial to identify and treat knee pain as soon as possible. Osteoarthritis and meniscus tears are two major knee joint problems.***

Aim and objectives: ***An evaluation of high-resolution ultrasonography's diagnostic capacity for ligamental and meniscal lesions can be conducted prospectively by comparing the results of the two imaging modalities with those of magnetic resonance imaging (MRI).***

Subjects and methods: ***Participants' ages ranged from fifteen to fifty years old, and the study included sixty total participants: forty-five men and fifteen girls. These individuals were seen at Al-Hussain University Hospital's orthopedic outpatient clinic and radiology department.***

Results: ***Finding meniscal and ligament problems is made easier with high-resolution ultrasonography, according to the study. The ultrasonography demonstrated a sensitivity of 94.7%, specificity of 95.1%, NPV of 97.5%, and PPV of 90% for meniscal injuries, respectively. When it came to damage to the medial collateral ligament, the ultrasonography had a sensitivity of 100%, specificity of 96.2%, NPV of 100%, and PPV of 80%. Values were 100%, 100%, 96.4%, and 71.3% for lateral collateral ligament injuries, respectively.***

Conclusion: ***High-resolution ultrasound has demonstrated high accuracy in detecting meniscal and ligament injuries, particularly in young individuals and patients with acute injuries. It shows high sensitivity for detecting injuries to the medial and lateral collateral ligaments and acceptable sensitivity for anterior cruciate ligament injuries.***

Keywords: Ultrasound; MRI; Meniscal and Ligamentous Lesions

1. Introduction

Because of the biomechanical role they perform, injuries to the anterior cruciate ligament (ACL) and the posterior cruciate ligament (PCL) are among the most significant types of knee injuries.[1]

Articular cartilage and menisci, especially the medial meniscus, are more likely to sustain damage if an acute ACL rupture goes unnoticed.[2]

Similarly, while conservative treatment is usually the best option for PCL injuries alone, a worse prognosis and improper treatment might result from a failure to diagnose acute disruption of the PCL in combined ACL-PCL injuries.[3] As a result, ACL and PCL tears must be identified promptly and accurately.[1]

MRI is now accepted as the gold standard imaging technique for evaluation of knee ligaments and the internal derangements of menisci, including tears and degeneration. However, MRI is not always available on demand; it does not allow dynamic testing and is a rather lengthy and expensive imaging modality.[1,4]

In light of the latest developments in ultrasonographic technology, the application of this imaging method is believed to be ideal for evaluating ligamental and meniscal lesions of the knee.[1,5]

Accepted 15 June 2025.
Available online 31 July 2025

* Corresponding author at: Radiodiagnosis, Faculty of Medicine for Boys, Al-Azhar University, Cairo, Egypt.
E-mail address: Yassershalabi1987@gmail.com (Y. Z. M. Shalaby).

https://doi.org/10.21608/aimj.2025.446645

Compared with MRI, ultrasonography is inexpensive, can be performed rapidly, is widely available, and is readily acceptable to patients. In addition, it provides a dynamic, real-time assessment as well as an easy side-to-side comparison. Although there have been some studies on the value of ultrasonography in the diagnosis of meniscal and ligamental tears, the sensitivity and specificity of these studies have varied greatly.[1]

This prospective study aimed to assess the diagnostic efficacy of high-resolution ultrasonography for ligamental and meniscal diseases by comparing ultrasonographic and magnetic resonance imaging (MRI) results.

2. Patients and methods

This comparative study included 60-patients, consisting of 45-males and 15-females, ranging in age between 15-50 years. These patients attended the radiology department and the orthopedic outpatient clinic at Al-Hussain University Hospital. The cases were collected between September 2023 and December 2024.

Inclusion criteria:

Patients who have been in a knee injury before, those who have meniscal or ligamental abnormalities and are experiencing either acute or chronic knee pain, those who have either one or both knees affected, those who have intra-articular disease in the knee that needs to be examined or treated using arthroscopic methods, and those whose osteoarthritis is associated with a grade of no more than III on the Kellgren-Lawrence scale

Exclusion criteria:

No magnetic resonance imaging (MRI) will be performed on patients who have: a prior MRI of the examined knee; a history of severe inflammatory disorders or rheumatoid arthritis; claustrophobia; a pacemaker; or any other condition that could be considered a contraindication to MRI.

All patients underwent the following procedures:

Evaluating the patient's medical history, doing a physical exam, using high-resolution ultrasound in real-time, and producing an MRI scan.

An orthopedic surgeon suspected meniscal or ligamental diseases, such as tears or degeneration, and conducted the clinical examination to confirm it. Radiologists who were not privy to each other's findings conducted the US and MRI scans. MRI was conducted first, followed by ultrasound either on the same day or a few days apart. Subsequently, patients were divided into three age groups with intervals of 16.6 years, and the study results were compared among these groups.

High Resolution ultrasonography:

The equipment used was Toshiba Aplio 500 ultrasound scanner, the 7.5 to 12.0 MHz multi-frequency linear probe was used for B mode scanning.

By following the medial aspect of the joint line, the medial collateral ligament (MCL) was located and studied in the coronal plane using a 7.5 MHz linear probe. Most commonly, this was accomplished by aligning the transducer with the knee in the actual coronal plane and then shifting it medially and anteriorly until the thick fibrillar tissue of the MCL was detected. Additionally, the full MCL extent was assessed along the long and short axes.

Turn the transducer to the side and move it laterally in the coronal plane until you find the groove for the popliteal tendon in the lateral femoral condyle. Now, tune the probe to the side. To see the fibular head, use this groove as a marker to secure the transducer's proximal end on the femur and spin the distal end posteriorly. Along this plane, you may see the LCL.

In a supine position with the knee flexed, the patient's medial and lateral menisci were assessed using a transducer placed in a sagittal plane on both sides of the joint.

Using the transducer in the sagittal plane, the patient was investigated while lying on their back with their knees slightly bent. The posterior horns of the medial and lateral menisci were also examined.

Imaging of the anterior horns of the menisci was conducted while the patient was lying down with their knee fully extended and flexed at a range of 30-45 degrees.

A focus adjustment was made to the transducer at the level of the meniscus that was being studied. Dynamic imaging involved gently putting the knee under internal and external varus strains so that the menisci could be better imaged as the patient moved around.

For the purpose of examining the lateral collateral ligament (LCL), the transducer is advanced laterally in the coronal plane, and the probe is adjusted to the lateral side until the groove for the popliteal tendon is located in the lateral femoral condyle. To see the fibular head, use this groove as a marker to secure the transducer's proximal end on the femur and spin the distal end posteriorly. The LCL is located and studied in this plane for its entry into the fibular head, both near and far.

Examining the back of the knee requires lying the patient flat on their back while the knee is bent. Subsequently, the probe is shifted to the actual sagittal plane, which is located in the middle of the back of the knee. To assess the femoral connection of the posterior cruciate ligament, the probe is swept proximally once the tibial attachment has been discovered.

To assess the anterior cruciate ligament (ACL) from the tibial side, one looks at the knee with the knee fully bent. Near the front edge of the tibial plateau, around 1 cm away, is where you'll find the tibial insertion. Sweeping the probe proximally allows for an evaluation of the femoral aspect, including fiber direction and thickness, to the best of our ability.

Ultrasound interpretation of ligaments:

Normal: presence of homogeneously hypoechoic stretched filaments along its course, without any internal heterogeneous echo changes or surrounding edema, suggests that the ligament is intact and not injured. Inflammation.

Torn ligament: hypoechoic clefts extending partially or completely along the ligament, accompanied by global thickening and surrounding tissue edema, can indicate different grades of tears. These are classified as follows: Grade-1 (sprain), Grade-2 (partial tear), and Grade-3 (complete tear).

Damage to the anterior cruciate ligament (ACL) and posterior cruciate ligament (PCL) manifests as heterogeneity in the internal echo structure and the presence of nodules that are hypoechoic or echogenic but do not touch the articular surface.

Ultrasound interpretation of meniscal lesions:

The normal meniscus shape is a triangle, and its echogenicity is uniform throughout. There should be no internal heterogeneous echo alterations or variations.

Degeneration of the meniscus: A lack of internal echo homogeneity, as well as hypoechoic or echogenic spots that are either linear or nodular in shape and do not involve the articular surface.

Tears in the meniscus can manifest as abrupt changes in the shape of the meniscus or as blunting of its medial surfaces, as well as as linear or echogenic clefts that go all the way to or through the meniscus itself.

Magnetic resonance image (MRI):

In every instance, a 1.5 T MRI with a knee coil was conducted using a Philips Achieva or Intera scanner. The settings used were as follows: a field of vision ranging from 12 to 16 cm, a matrix of 256 to 192 or 512 to 224, and a slice gap of 4 mm. For each knee, the results from the ultrasonographic exam were compared to those from the magnetic resonance imaging (MRI) scan. The inspection typically lasted around twenty minutes.

MRI ligamental interpretation:

A grading system was used to assess changes in signal intensity in the ACL, PCL, MCL, and LCL in order to detect degeneration and tears. Different kinds and degrees of ligament damage might be distinguished using this system's ability to categorize injuries according to the detected changes in signal intensity. Injuries to the two cruciate ligaments are often categorized as follows: Strain (Grade 1), Tear (Grade 2), and Full Tear (Grade 3)

MRI meniscal interpretation:

In order to detect degeneration and tears, a grading system was used to evaluate the changes in signal intensity of the anterior horns, posterior horns, and meniscal bodies. Here was the grading system: Depending on the severity, the menisci may undergo nodular or punctate signal changes in Grade 1, which do not extend to the articular surfaces. In Grade 2, the changes are more linear in nature and do not reach the articular surfaces either. In Grade 3, the changes are either nodular or linear in nature and extend to at least one articular surface..

The grading system was used to classify meniscal lesions.:

Grade-1 and/or Grade-2 signal alterations indicate meniscal degeneration, whilst Grade-3 signal changes indicate meniscal tears, whereas a homogeneous signal indicates normality.

Statistical Analysis:

SPSS 25 was used to examine data. Qualitative data were frequency and percentage. Quantitative data were presented as mean±standard deviation (Mean±SD). In a discrete set of numbers, the mean is the total of the values divided by their number. Standard deviation (SD): measures value dispersion. A low SD implies that the values are near to the established mean, while a high SD indicates a broader range.

For probability (P-value), P-value < 0.05 was considered significant, P-value < 0.001 was extremely significant, and P-value > 0.05 was inconsequential.

Sensitivity: likelihood of a positive test when the disease is present. Specificity: chance of a negative test result without sickness. Positive predictive value is the likelihood of disease when the test is positive. The probability that the disease is absent when the test is negative is the negative predictive value. The US and MRI agreement on ACL, MENISCI, MCL, PCL, and LCL diagnosis was measured using the Kappa test(k). Interpretation of Kappa: $K<0.2$ indicates low agreement, $K=0.2\text{-}0.4$ acceptable, $K=0.4\text{-}0.6$ moderate, $K=0.6\text{-}0.8$ good, and $K=0.8\text{-}1.0$ very good.

3. Results

Table 1. An explanation of the demographic information for each patient under study

		ALL PATIENTS (N=60)	
SEX	Males	45	75.0%
	Females	15	25.0%
AGE	Mean±SD	32.4±11.4	
	Min-max	15-50	

As regard sex, there were 45-males(75%) and 15-females(25%) in all studied patients. As regard Age, the mean was(32.4±11.4) years and ranged between 15-50 years in all studied patients, (table 1; figures 1&2).

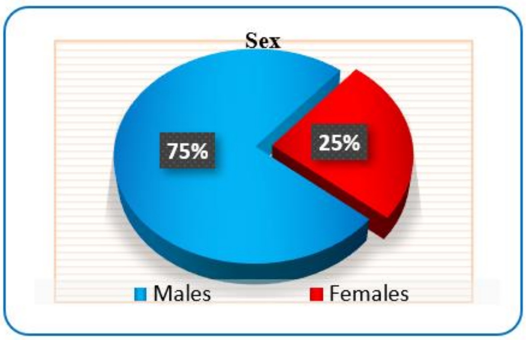

Figure 1. Sex description for each patient under study.

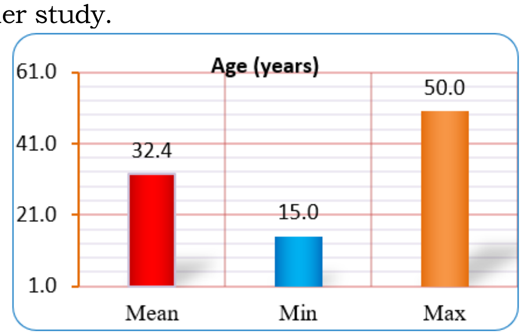

Figure 2. Age description for each patient under study.

Table 2. Statistical agreement of US with MRI in diagnosis of ACL in all studied patients.

ACL		MRI				K	P-VALUE
		Positive		Negative			
US	Positive	10	16.7%	4	6.7%	0.75	<0.001 HS
	Negative	1	1.7%	45	75.0%		

DIAGNOSTIC PERFORMANCE OF US IN DIAGNOSIS OF ACL							
TRUE POSITIVE		False positive		False negative		True negative	
10	16.7%	4	6.7%	1	1.7%	45	75.0%

K:Kappa test of agreement. A p-value of less than 0.001 is regarded as very significant.

All patients in the study had a high statistically significant (P<0.001) good agreement (k=0.75) between the US and MRI in diagnosing ACL. Ten patients (16.7%) had true positive results, four patients (6.7%) had false positive results, one patient had a false negative result (1.7%), and forty-five patients (75%), (table 2; figure 3).

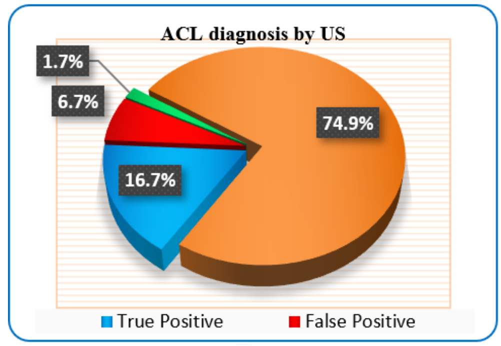

Figure 3. Description of diagnostic performance of US in diagnosis of ACL when compared with MRI in all studied patients.

Table 3. Statistical agreement of US with MRI in diagnosis of MENISCI in all studied patients.

MENISCI		MRI				K	P-VALUE
		Positive		Negative			
US	Positive	18	30.0%	2	3.3%	0.89	<0.001 HS
	Negative	1	1.7%	39	65.0%		

DIAGNOSTIC PERFORMANCE OF US IN DIAGNOSIS OF MENISCI							
TRUE POSITIVE		False positive		False negative		True negative	
18	30.0%	2	3.3%	1	1.7%	39	65.0%

K:Kappa agreement test. HS:p-value<0.001 is considered highly significant.

Excellent agreement (k=0.89) between US and MRI in diagnosing MENISCI in all patients under study, with a high statistical significance (P<0.001). In the United States, 18 patients (30%) had real positive results, 2 patients (3.3%) had false positive results, 1 patient (1.7%) had false negative results, and 39 patients (65%) had true negative results, (table 3;figure 4).

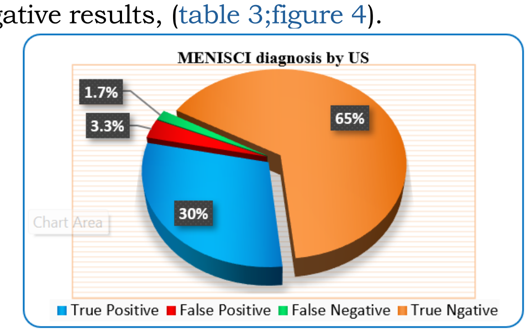

Figure 4. Description of diagnostic performance of US in diagnosis of MENISCI when compared with MRI in all studied patients.

Table 4. Statistical agreement of US with MRI in diagnosis of MCL in all studied patients

MCL		MRI				K	P-VALUE
		Positive		Negative			
US	Positive	8	13.3%	2	3.3%	0.87	<0.001 HS
	Negative	0	0.0%	50	83.3%		

DIAGNOSTIC PERFORMANCE OF US IN DIAGNOSIS OF MCL							
TRUE POSITIVE		False positive		False negative		True negative	
8	13.3%	2	3.3%	0	0.0%	50	83.3%

K:Kappa agreement test. HS:p-value<0.001 is considered highly significant.

Excellent agreement (k=0.87) between US and MRI in diagnosing MCL in all patients under study, with a high statistical significance (P<0.001). Eight patients (13.3%) had true positive results, two patients (3.3%) had false positive results, zero patients (0%), and fifty patients (83.3%) had true negative results,(table 4;figure 5).

Figure 5. Description of diagnostic performance of US in diagnosis of MCL when compared with MRI in all studied patients.

Table 5. Statistical agreement of US with MRI in diagnosis of PCL in all studied patients

PCL		MRI				K	P-VALUE
		Positive		Negative			
US	Positive	6	10.0%	2	3.3%	0.61	<0.001 HS
	Negative	4	6.7%	48	80.0%		
DIAGNOSTIC PERFORMANCE OF US IN DIAGNOSIS OF PCL							
TRUE POSITIVE		False positive		False negative		True negative	
6	10.0%	2	3.3%	4	6.7%	48	80.0%

K:Kappa agreement test. HS:p-value<0.001 is considered highly significant.

All patients in the study had a high statistically significant (P<0.001) good agreement (k=0.61) between the US and MRI in diagnosing PCL. Six patients (10%) had true positive results, two patients (3.3%) had false positive results, four patients (6.7%) had false negative results, and forty-eight patients (80%) had true negative results, (table 5;figure 6).

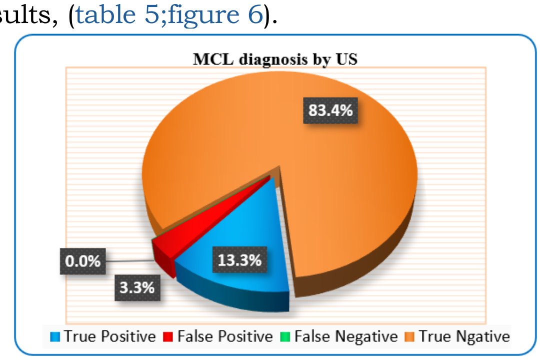

Figure 6. Description of diagnostic performance of US in diagnosis of PCL when compared with MRI in all studied patients.

Case presentation:

Case one:

Thirty years-old male patient presenting with right knee pain for 2-years, the pain started after a history of trauma, its confined to lateral side with small swelling felt on the same side of the knee, he is complaining of intermittent joint swelling also.

Ultrasound Images: Anterior horn of lateral meniscus

Findings:

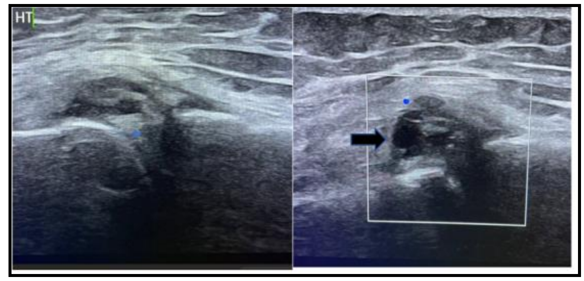

Figure 7. Ultrasound findings: A well-defined small cystic lesion(black arrow) measuring about 6x3 mm is seen lying above the anterior horn lateral meniscus with posterior acoustic enhancement, the lateral meniscus itself showing a horizontal cleft like hypoechoic lesion extending through anterior horn reaching the femoral articular surface(blue arrow). Findings suggestive of horizontal tear with overlying Parameniscal cyst.

MRI:

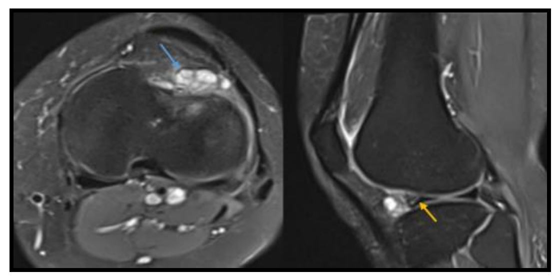

Figure 8. MRI findings: Lateral meniscal tear involving anterior horn and the(Yellow arrow), with small lateral Parameniscal cyst(blue arrow).

CASE Two:

A 27 years-old male patient presented with persistent left knee pain and instability; the patient has history of sport injury with fall on flexed knee 1-year ago.

Ultrasound Images: Posterior cruciate ligament.

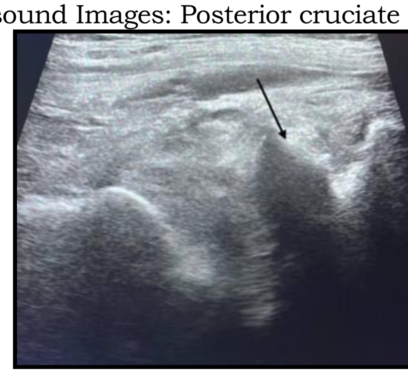

Figure 9. Ultrasound Findings the posterior cruciate avulsed bony fragment with shadowing (black arrow), picture suggestive of PCL avulsion fracture.

MRI Images:

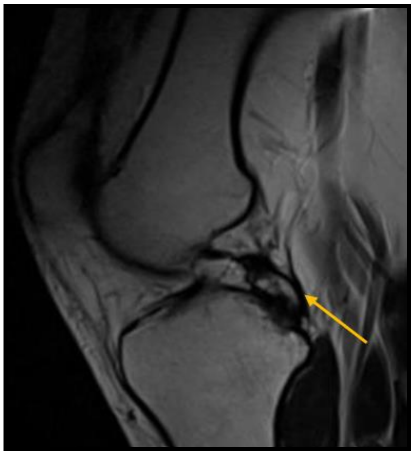

Figure 10. MRI Findings: the posterior cruciate ligament distal bony avulsion is noted attached to relatively small sized ligament(Yellow arrow), picture matching with chronic PCL bony avulsion.

4. Discussion

Knee injuries frequently happen during regular sports activity and are frequently brought up in emergency rooms.[6]

Because of its biomechanical function, ACL and PCL injuries are significant among other knee injuries.[6]

If you miss a sudden ACL tear, you could end up hurting the menisci, especially the medial meniscus, and the articular cartilage.[2]

As regard the detection of anterior cruciate ligament injury, our study revealed that ultrasonography possesses of a sensitivity of 90.9% specificity of 91.8% with PPV=71.5% and NPV=97.8%. A negative likelihood ratio of 0.4 and a positive likelihood ratio of 4.8 were calculated.

Regarding posterior cruciate ligament injury, our study revealed that ultrasonography possesses of a sensitivity of 60% specificity of 96% with PPV=75 and NPV=92.3. A negative likelihood ratio of 0.4 and a positive likelihood ratio of 15.2 were calculated.

As regard medial collateral ligament injury, our study revealed that ultrasonography possesses of a sensitivity of 100% specificity of 96.2% with PPV=80 and NPV=100. The positive likelihood ratio was 26.5 while the negative likelihood ratio was 0.06.

As regard lateral collateral ligament injury, our study revealed that ultrasonography possesses of a sensitivity of 100% specificity of 96.4% with PPV=71.3 and NPV=100. Relative to the negative likelihood ratio of0.06, the positive likelihood ratio was 27.5.

As regards the detection of meniscal tear, our study revealed that ultrasonography possesses a sensitivity of 94.7% specificity of 92.8% with PPV=85.7 and NPV=97.5. The positive likelihood ratio was 13.2 while the negative likelihood ratio was 0.06.

Kumar et al.,[7] The study found that out of 130 patients, 81.65% had their ACL tears diagnosed accurately using USG, while 89% had them diagnosed correctly using other methods. At 97.8%, the test had a high positive predictive value, whereas at 44%, it had a low negative predictive value.

Regarding the MCL, the study by Sarath Raj et al.,[8] the study found to have an accuracy rate of 99%, a specificity rate of 100%, a PPV of 50%, and an NPV of 100%; the experiment also comprised 110 patients. In this respect, our research reveals comparable parameters.

In the context of tear morphology, Akatsu et al.,[9] hypothesized that while ultrasonography might be helpful for screening for meniscal tears, it wouldn't be enough to just detect their shape. Similarly, our investigation didn't find a single bucket handle tear or any of the four root tears that were identified by MRI, but in two cases, we did find meniscal extrusion, which is indicative of a root tear.

Thus, it is necessary to exercise caution when utilizing ultrasound to ascertain surgical indications or to predict the type of surgical operation; this caution is also advised when using MRI for diagnosis.

Still another investigation by Wareluk et al.,[10] reported that ultrasound had a superior specificity for lateral meniscal tears and a higher sensitivity for diagnosing medial meniscal tears.

Our study showed agreement with most of the recent studies that ultrasound have high sensitivity in detection of meniscal tear, all of them ranged between 85-90%, but the specificity showed great discrepancy in those studies and ranged from 63% up to 85%. As a result, It seems that ultrasonography can be helpful for screening meniscal tears, but it doesn't seem to be enough for detecting the morphology of these tears.

In comparing our study with the extant body of literature, it becomes apparent that ultrasonography(USG) stands as a dependable modality for the imaging of knee injuries, demonstrating commendable sensitivity, specificity, NPV, PPV, and accuracy. Nevertheless, MRI continues to be lauded as the gold standard for such diagnostic purposes. Some investigations have shown that ultrasonography for knee evaluations could be significantly improved by combining dynamic evaluations with static imaging.

4. Conclusion

Especially in younger patients and those with more recent injuries, high-resolution ultrasound has shown a high degree of accuracy in identifying meniscal and ligament damage. Its sensitivity for lateral and medial collateral ligament injuries is high, and its sensitivity for anterior cruciate ligament injuries is fair.

Unfortunately, it isn't very good in spotting tears in the posterior cruciate ligament. Ultrasound may not be able to fully replace magnetic resonance imaging (MRI) in most diagnostic contexts, although it can be a useful tool for initial case evaluation in some situations.

Also, unlike MRI, which can be expensive, ultrasound can often provide a diagnosis the very same day, relieving patients of some of the stress and anxiety that comes with waiting.

Disclosure

The authors have no financial interest to declare in relation to the content of this article.

Authorship

All authors have a substantial contribution to the article

Funding

No Funds : Yes

Conflicts of interest

There are no conflicts of interest.

References

1. Lee SH, Yun SJ. Efficiency of knee ultrasound for diagnosing anterior cruciate ligament and posterior cruciate ligament injuries: a systematic review and meta-analysis. Skeletal Radiol.2019;48(10):1599-1610.
2. Parwaiz H, Teo AQ, Servant C. Anterior cruciate ligament injury:A persistently difficult diagnosis.Knee. 2016;23(1):116-120.
3. LaPrade CM, Civitarese DM, Rasmussen MT, et al. Emerging Updates on the Posterior Cruciate Ligament:A Review of the Current Literature. Am J Sports Med.2015;43(12):3077-3092.
4. Anatolia AM. The role of ultrasound in the diagnosis of meniscal tears and degeneration compared to MRI and arthroscopy. Acta Med Anatol.2014;2(3):80-7.
5. Dai H, Huang ZG, Chen ZJ, et al. Diagnostic accuracy of ultrasonography in assessing meniscal injury: meta-analysis of prospective studies.J Orthop Sci.2015;20(4):675-681.
6. Knutson T, Bothwell J, Durbin R. Evaluation and management of traumatic knee injuries in the emergency department. Emerg Med Clin North Am.2015;33(2):345-362.
7. Kumar S, Kumar A, Kumar S, et al. Functional Ultrasonography in Diagnosing Anterior Cruciate Ligament Injury as Compared to Magnetic Resonance Imaging. Indian J Orthop.2018;52(6):638-644.
8. Vs SR, Jinu CK. Diagnostic Accuracy of Ultrasound in the Evaluation of Collateral Ligaments and Meniscal Injuries of Knee in Comparison with Magnetic Resonance Imaging. RGUHS Journal of Medical Sciences.2024;14(1).
9. Akatsu Y, Yamaguchi S, Mukoyama S, et al. Accuracy of high-resolution ultrasound in the detection of meniscal tears and determination of the visible area of menisci.J Bone Joint Surg Am.2015;97(10):799-806.
10. Wareluk P, Szopinski KT. Value of modern sonography in the assessment of meniscal lesions. Eur J Radiol.2012;81(9):2366-2369.