

MRI and US in Evaluation of Non-Osseous Peri-Articular Lesions of the Knee Joint: A Comparative Study

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Abstract

Background: US of the knee is well-suited for evaluation of disease of the knee, particularly in evaluation of injuries of the quadriceps and patellar tendons, injuries of the MCL and LCL, joint effusions and fluid collections around the knee, and guiding percutaneous interventions.

Understanding US technique for complete evaluation of the knee and relevant sonographic anatomy, US appearance of common pathologic conditions, and knowledge of important pitfalls provides another tool for the evaluation of knee pathologic conditions.

Although the cornerstones of imaging evaluation of the knee are radiographs and magnetic resonance (MR) imaging, ultrasonography (US) is less expensive than MR imaging, easily available, comparable accuracy, low cost, high spatial resolution, dynamic imaging, guide percutaneous interventions, direct patient contact, ability to compare with the contralateral knee, evaluating patients with contraindications to MR, and correlating the patient's site of pain to the sonographic findings.

Aim of Study: To detect the role of high resolution ultrasonography as a growing and useful diagnostic tool in the assessment of different non-osseous peri-articular knee pathologies compared to MR imaging.

Patients and Methods: Observational prospective study. The study conducted in Radiology Department at Ain Shams University Hospitals. From April 2021 till October 2021. Patients referred to radiology department for ultrasonography and MRI examination of the knee joint.

Results: This study showed US was 100% sensitive, specific and accurate in detection and anatomical evaluation of the peri articular soft tissue lesions in comparison with MRI and not in correlation with the histopathology.

Conclusion: Ultrasonography is safe, cheap and efficient tool in the evaluation of the peri articular non-osseous knee lesions. At this point in time, we concluded that ultrasonography has an important complementary role with MRI examination in the evaluation of the knee joint different pathologies yet it is operator dependent and needs experience.

Key Words: MRI – US Evaluation – Non-osseous – Peri-Articular – Lesions knee joint.

Introduction

THE knee joint is the most complicated and largest joint in our body. It is also the most vulnerable to injury because of body weight bearing and pressure load while providing flexible movement [1].

Pain and other disorders of the knee are a common presenting complaint in practice. Although plain X-rays and MRI are more important, ultrasonography (US) is of less cost than MR imaging, widely available, and of comparable accuracy in the evaluation of certain pathologic conditions of the knee [2].

The advantages of US include portability, low cost, high resolution, dynamic assessment, and ability to guide percutaneous interventions as aspiration or intra-articular injections. US also allows direct patient contact, and ability to obtain proper relevant history and the ability to compare with the other knee joint. US evaluation of the knee can be targeted to a specific region on the basis of the complaint or be a comprehensive review [3].

US is particularly very efficient for evaluating injuries of the quadriceps and patellar tendons, injuries of the medial and lateral collateral ligaments, joint effusions, and fluid collections around the knee [4].

In-depth appreciation of relevant sonographic anatomy, common pathologic conditions, knowing important pitfalls, and mastering the US technique will allow one to effectively use this powerful tool [5].

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The primary limitation of US of the knee is that it is operator dependent and requires proper training and experience for high quality knee examination. Other limitations of US include incomplete evaluation of the deep structures of the knee, particularly the cruciate ligaments, the majority of the articular cartilage, bone marrow edema and intramedullary bony lesion [5].

MR imaging enables the most comprehensive imaging assessment of the knee joint being nearly the only modality to assess deep structures of the knee joint, performing MR study after knee joint injury will be highly cost-effective [6].

MR imaging of the knee is most commonly performed with 1.5- or 3-T systems and dedicated knee coils. Standard MR studies are typically acquired in three orthogonal planes with a combination of proton density, intermediate-weighted, T1 and T2-weighted pulse sequences with and without fat suppression [7].

Aim of the work:

To detect the role of high resolution ultrasonography as a growing and useful diagnostic tool in the assessment of different non-osseous peri-articular knee pathologies compared to MR imaging.

Patients and Methods

Type of study: Observational prospective study.

Study setting: The study will be conducted in Radiology Department at Ain Shams University Hospitals.

Study period: About six months.

Study population: Patients referred to radiology department for ultrasonography and MRI examination of the knee joint will be included in the study according to the inclusion and exclusion criteria as following:

Inclusion criteria: Any patient complaining of knee pain and/or swelling and Age: 12-70 years old.

Exclusion criteria: Patients with absolute contraindications to MR examination as cardiac pace maker, aneurysmal clipping and claustrophobia and patients with Osseous knee lesions.

Sampling method: Simple random sample of cases referred to radiology department for ultrasonography and MRI examination of the knee joint will be recruited.

Sample size: Was calculated using Pass 11.0 and based on a study carried out by Kim et al., 2016 Soliman, 2020. A total sample size of 50 patient achieves 90% power to detect a change in sensitivity from 0.5 to 0.833 using a two-sided binomial test and 100% power to detect a change in specificity from 0.5 to 0.99 using a two-sided binomial test. The target significance level is 0.05. The actual significance level achieved by the sensitivity test is 0.347 and achieved by the specificity test is 0.0357. The prevalence of the disease is 0.454. Sample size was inflated by 15% to account for attrition problem.

Ethical considerations: Informed written consent will be taken from all participants. Approval was conducted by Ethical Committee in Ain Shams University.

Study procedures: Full history will be taken from our patients including: Age, sex and occupation, regarding the complaint: Onset, course and duration of symptomatology either pain or swelling, history and mode of trauma" if any" and points of maximum pain and tenderness, and any relevant previous surgical history and clinical examination will be done for the patients before doing the MR and US examination. All patients will be subjected to:

Inspection: Skin, for scar or sinuses, swellings, muscle atrophy and shape and symmetry.

Palpation: Determination of the point, of maximum tenderness and assessment of movements (active, and passive).

X-Ray Examination: Will be done for all patients as a basic step to differentiate osseous from non-osseous pathologies as our study will be for non-osseous pathologies.

Ultrasonographic examination: All patients will have standardized ultrasonography of the knee joint with excess gel instead of the gel pad. Linear high frequency probe will be used to perform knee ultrasound examination. The patella will be used as the principle acoustic window and the routine US examination of the knee starts with its anterior aspect, followed by the medial, lateral and posterior aspects in both longitudinal and transverse planes.

The anterior aspect of the knee is best examined with the patient supine with the knee flexed approximately 20°-30° obtained by placing a small pillow beneath the popliteal space. In this position, the anterior aspect of the knee is examined starting from cranial to caudal with careful examination for the following check list: Quadriceps tendon,

supra, medial and lateral patellar recesses, medial and lateral patellar retinacula, patellar tendon and infra and pre patellar bursae.

The medial aspect of the knee joint will be examined with the leg externally rotated with careful examination for the following check list: Medial collateral ligament, medial tibio-femoral joint space, Pes anserinus complex and bursa and AHMM.

The lateral aspect of the knee joint will be examined after asking the patient to rotate the leg internally with careful examination for the following check list from anterior to posterior: Distal aspect of the iliotibial band, lateral tibio-femoral joint space, fibular collateral ligament and AHLM.

The posterior region of the knee joint will be examined after asking the patient to lie prone with the knee extended to examine the following check list: semimembranosus-gastrocnemius bursa, baker cyst if present, intercondylar/ACL cyst, popliteal vessels, biceps femoris tendon and PHMM and PHLM.

Dynamic examination obtained in different degrees knee flexion and extension can be obtained to facilitate the evaluation of normal and pathologic structures.

Power-Doppler imaging will be used to detect tissue hyperemia in cases of tendinopathy, enthesopathy, synovitis, inflammatory conditions and assessment of knee AVM and soft tissue mass lesions.

MRI examination: All patients will have MR imaging of the affected knee joints on a high field-strength scanners.

Technique:

Positioning: The patients will be positioned supine with the affected knee completely or nearly completely extended in the knee coil.

Protocol: The MRI study will include the following pulse sequences: Coronal T1WIs, sagittal T2 WIs, sagittal PD WIs, axial T2WIs, coronal STIR WIs and T1 post contrast (axial, sagittal and coronal planes) if used.

Table (1): MRI sequences parameters.

Parameters	Coronal T1	Sagittal T2	Coronal STIR	Sagittal PD	Axial T2
TR	600	3600	2400	1620	3600
TE	17	100	60	30	100
FOV					
Anterior/posterior	30	30	30	30	20
Right left	35	35	50	35	60
Feet/head	50	50	20	50	40

The following parameters will be applied ; slice thickness 4mm slice gap 4mm, matrix 256/192 or 512/224 and field of view ranged from 12 to 16cm.

Results obtained from the ultrasonographic examination will be compared to those obtained from MR examination for each knee examined.

Other radiological tests will be done as clinically indicated.

Statistical analysis: The collected data will be revised, coded, tabulated and introduced to a PC using statistical package for social science SPSS

(15.0.1 for windows). Results are expressed as mean (as a measure of central tendency) ± standard deviation (as measures of variability) or number (%). Comparison between mean values in the studied groups will be performed using *t*-test. *p*-value ≤0.05 will be considered significant and <0.01 will be considered highly significant.

Results

This study included 50 patients. They included 30 females and 20 males with their ages ranged between 12-70 years, all of them suffering from knee pain and/or swelling.

Table (2): The maximum, minimum, median, mean & standard deviation (SD) of the age.

	Minimum	Maximum	Mean \pm SD
Age	12	70	41.36 \pm 17.64

Table (3): The frequency, percentage & ratio according to sex.

Sex	Frequency	Percentage
Female	30	60
Male	20	40
Total	50	100.0

The frequency and percentage according to sex in the study population are tabulated by a chart where male patients represented 40% while female population represented 60%.

Table (4): The distribution of 91 pathological entities, which were diagnosed by all utilized imaging modalities in 50 knee joints.

Pathological entities	Frequency	Percentage
Ligamentous lesions	13	14
Tendinous lesions	1	0.01
Synovial lesions	12	13
Baker's cyst	11	12
Periarticular soft tissue lesions	7	8
Vascular malformations	6	7
Peri articular cysts	7	8
Joint effusion	34	37
Total	91	100

Ligamentous lesions:

I- Collateral ligaments: 13 patients had collateral ligamentous injury 10 MCL and 3 LCL.

Table (5): Comparison between US & MRI in the detection of the medial collateral ligament injury.

	MCL (MRI)		Total	Test value	p-value
	Negative	Positive			
MCL (US):					
Negative	40 (100.0%)	1 (10%)	41 (82.0%)	43.902	<0.001
Positive	0 (0%)	9 (90%)	9 (18.0%)		(HS)

p-value >0.05: Non significant (NS).

p-value <0.05: Significant (S).

p-value < 0.01: Highly significant (HS).

*: Chi-square test.

Ultrasound detected MCL injury in 9 knee joints while MRI detected it in 10 knee joints both modalities agreed in 9 patients, and ultrasound missed MCL injury in 1 joint detected by MRI (Table 5).

Statistical analysis of these results showed significant agreement (p-value <0.001) and no significant statistical difference between the two modalities in the detection of MCL injury.

Sensitivity=90.0%, Specificity=100%, Positive predictive value=100%, Negative predictive value=97.5%, Accuracy=98.0%.

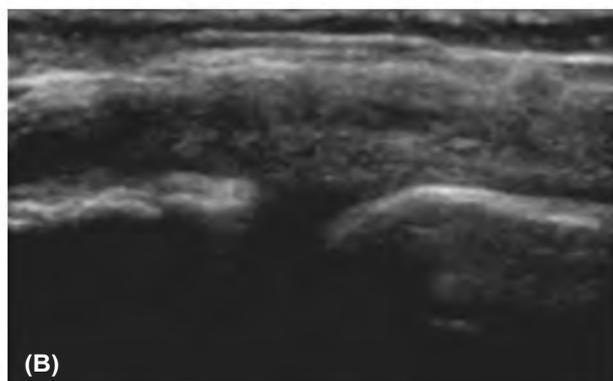


Fig. (1): 41 years old female patient suffered from left knee pain of long time without trauma. (A) MRI was done showed Medial collateral ligament sprain associated with minimal knee joint effusion. (B) US was done over the medial knee region showing thickened medial collateral ligament with heterogeneous hypoechoic texture.

Table (6): Comparison between US & MRI in the detection of the lateral collateral ligament injury.

	LCL (MRI)		Total	Test value	p-value
	Negative	Positive			
<i>LCL (US):</i>					
Negative	47 (100%)	0 (0%)	47 (94.0%)	50.000	<0.001
Positive	0 (0.0%)	3 (100%)	3 (6.0%)		(HS)

p-value >0.05: Non significant (NS).
 p-value <0.05: Significant (S).
 p-value <0.01: Highly significant (HS).
 *: Chi-square test.

Ultrasound detected LCL injury in 3 knee joints and the MRI detected it in 3 knee joints, both modalities agreed in 3 patients (Table 6).

Statistical analysis of these results showed significant agreement (p-value <0.001) and no

significant statistical difference between the two modalities in the detection of LCL injury.

Sensitivity=100%, Specificity=100%, Positive predictive value=100%, Negative predictive value =100%, Accuracy= 100%.

Table (7): Comparison between US & MRI in the detection of the tendinous lesions.

	Tendons (MRI)		Total	Test value	p-value
	Negative	Positive			
<i>Tendons (US):</i>					
Negative	49 (100%)	0 (0%)	49 (98.0%)	50.000	<0.001
Positive	0 (0.0%)	1 (100%)	1 (2.0%)		(HS)

p-value >0.05: Non significant (NS).
 p-value <0.05: Significant (S).
 p-value <0.01: Highly significant (HS).
 *: Chi-square test.

Ultrasound detected tendinous lesions in 1 knee joints and MRI detected it in 1 knee joint (Table 7).

Statistical analysis of these results showed significant agreement (p-value <0.001) and no significant statistical difference between the two modalities in the detection of tendinouse lesions.

Sensitivity=100%, Specificity=100%, Positive predictive value=100%, Negative predictive value =100%, Accuracy=100.0%.

Synovial lesions:

I- Joint effusion:

Sensitivity=100%, Specificity=100%, Positive predictive value=100%, Negative predictive value =100%, Accuracy=100.0%.

II- Synovial thickening:

Sensitivity=100%, Specificity=100%, Positive predictive value=100%, Negative predictive value =100%, Accuracy= 100. 0%.

Peri-articular cystic lesions:

Sensitivity=100%, Specificity=100%, Positive predictive value=100%, Negative predictive value =100%, Accuracy= 100. 0%.

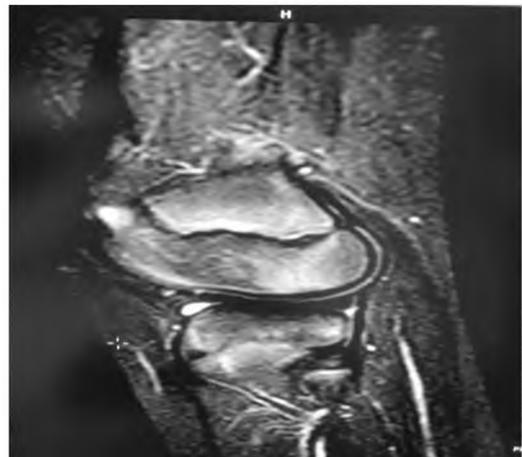
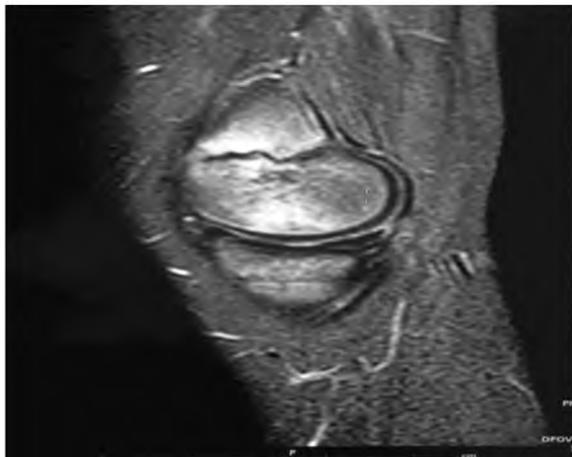
Peri articular soft tissue lesions:

Sensitivity=100%, Specificity=100%, Positive predictive value=100%, Negative predictive value =100%, Accuracy= 100. 0%.



(A)

(B)



(C)

(D)

Fig. (2): 13 years old male patient with left knee pain of 6 months after left knee trauma. (A & B) US was done showed Minimal joint effusion. (C & D) MR was done showed patchy areas of marrow signal alteration seen at posterior aspect of lateral femoral and tibial epiphysis and inferior patellar aspect being low in T1 and high in STIR, denoting marrow contusion and minimal joint effusion.

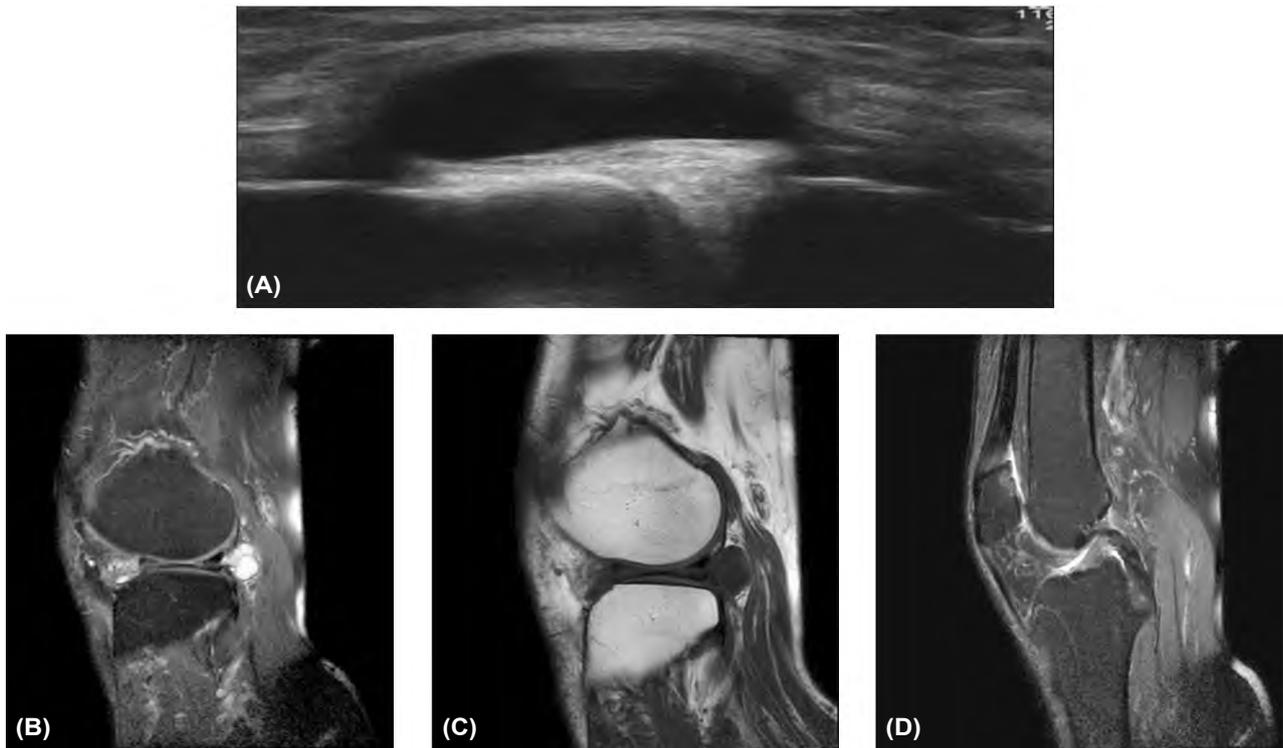


Fig. (3): (A) US was done showing minimal joint effusion, early osteoarthritic changes with mild cartilage thinning and degenerative changes of PHMM and cystic lesion measuring about 17x13 mm related to PHLM, likely meniscal cyst. (B, C & D) MRI was done showed PHMM tear with meniscal cyst, AHMM degeneration, osteoarthritic changes of the joint and Mild joint effusion.

Both MRI and Ultrasound detected and agreed in diagnosis of 46 knee effusion and synovial thickening (Tables 10,11). Both MRI and Ultrasound detected and agreed in diagnosis of 23 joints with different types of cystic lesions and 6 joint with peri-articular soft tissue lesions but the ultrasound missed the detection of two cysts due to increased BMI and large amount of subcutaneous fat in 2 patients despite using superficial and deep probes (Tables 12,13).

Statistical analysis of these results showed significant agreement (p -value <0.001) and no significant statistical difference between the two modalities in the detection of synovial effusion and thickening and also different types of cystic and soft tissue periarticular lesions.

This makes the sensitivity, specificity, positive/negative predictive values and overall accuracy values of US regarding the knee joint effusion, synovial thickening and peri-articular soft tissue lesions all equal 100%.

Regarding peri-articular cystic lesions US showed: Sensitivity=93.3%, specificity= 100%, positive predictive value=100%, negative predictive value=93.7%, accuracy=96.7% and peri-articular vascular malformations.

Sensitivity=100%, Specificity=100%, Positive predictive value=100%, Negative predictive value =100%, Accuracy= 100. 0%.

US and MR examination both agreed in the detection of different 6 vascular malformations (Table 15) this makes their sensitivity, specificity, positive predictive value and negative predictive value and their accuracy 100%.

However US was able to differentiate 4 low flow AVM and 1 high flow AVM using the color Doppler study that MR could not differentiate. While the MR was more beneficial in correct detection of their extension.

Both studied were able to detect 1 soft tissue hemangioma of the vastus intermedius.

Table (8): Comparison between US & MRI in the detection of the joint effusion.

	Effusion (MRI)		Total	Test value	p-value
	Negative	Positive			
<i>Effusion (US):</i>					
Negative	16 (100%)	0 (0%)	16 (32.0%)	50.000	<0.001
Positive	0 (0.0%)	34 (100%)	34 (68.0%)		

p-value >0.05: Non significant (NS).
 p-value <0.05: Significant (S).
 p-value <0.01: Highly significant (HS).
 *: Chi-square test.

Table (9): Comparison between US & MRI in the detection of the synovial thickening.

	Synov. thick (MRI)		Total	Test value	p-value
	Negative	Positive			
<i>Synov thick (US):</i>					
Negative	38 (100%)	0 (0%)	38 (76.0%)	50.000	<0.001
Positive	0 (0.0%)	12 (100%)	12 (24.0%)		

p-value >0.05: Non significant (NS).
 p-value <0.05: Significant (S).
 p-value <0.01: Highly significant (HS).
 *: Chi-square test.

Table (10): The distribution of the synovial thickening.

Synovial thickening	Number of cases
Synovial sarcoma	1 (8.3%)
PVN	1 (8.3%)
Rheumatoid arthritis	4 (33.3%)
Hemophilia	1 (8.3%)
Reactive 'non-specific'	5 (41.7%)

Table (11): Comparison between US & MRI in the detection of the peri-articular cystic lesions.

	Cysts (MRI)		Total	Test value	p-value
	Negative	Negative			
<i>Cysts (MRI):</i>					
Negative	32 (100%)	0 (0%)	32 (64.0%)	50.000	<0.001
Positive	0 (0.0%)	18 (100%)	18 (36.0%)		(HS)

p-value >0.05: Non significant (NS).
 p-value <0.05: Significant (S).
 p-value <0.01: Highly significant (HS).
 *: Chi-square test.

Table (12): The distribution of the peri-articular cystic knee lesions detected.

Cysts	Number of cases
Baker's cyst uncomplicated	9 (50.0%)
Baker's cyst complicated	2 (11.1%)
Ganglion cysts	3 (16.7%)
Cystic hematoma	2 (11.1%)
Meniscal cysts	2 (11.1%)

Table (13): Comparison between US & MRI in the detection of the peri articular soft tissue lesions.

	Muscular (MRI)		Total	Test value	p-value
	Negative	Negative			
<i>Muscular (US):</i>					
Negative	43 (100%)	0 (0%)	43 (86.0%)	50.000	<0.001
Positive	0 (0.0%)	7 (100%)	7 (14.0%)		(HS)

p-value >0.05: Non significant (NS).
 p-value <0.05: Significant (S).
 p-value <0.01: Highly significant (HS).
 *: Chi-square test.

Table (14): The distribution of the periarticular lesions detected.

Muscular and subcutaneous lesions	Number of cases
Hematoma	2 (28.6%)
Intra muscular recurrent rbdomyosarcoma	1 (14.3%)
Sub cutaneous large lipoma	1 (14.3%)
Fibromatosis	2 (28.6%)
Schwannoma	1 (14.3%)

Table (15): Comparison between US & MRI in the detection of the vascular malformations.

	Muscular (MRI)		Total	Test value	p-value
	Negative	Negative			
<i>Muscular (US):</i>					
Negative	44 (100%)	0 (0%)	44 (88.0%)	50.000	<0.001
Positive	0 (0.0%)	6 (100%)	6 (12.0%)		(HS)

p-value >0.05: Non significant (NS).
 p-value <0.05: Significant (S).
 p-value <0.01: Highly significant (HS).
 *: Chi-square test.

Discussion

Ultrasound is an emerging tool in the evaluation of different knee pathologies. US has several advantages over other imaging modalities, which include: Lack of exposure to ionizing radiation, relatively low cost, easy accessibility, high patient acceptability, and utility in depicting soft-tissue inflammation, cartilage changes and bone erosions without the need for contrast material [8,9]. US examination can be correlated to the point of maximal symptoms on physical examination [10,11].

In a recent study by Sekiya et al. [12] they showed 92% sensitivity and 75% specificity for US in detecting lateral collateral ligaments injuries. One study done by Lee et al. [13] showed that the sensitivity of sonography in the detection of MCL injuries was approximately 94%.

These results were concordant with our results regarding the role of US in the diagnosis of collateral ligaments injuries, we concluded that the US is 90% sensitive and 100% specific in the diagnosis of MCL injuries, and 100% sensitive and 100% specific in the diagnosis of LCL injuries. The very few published studies concerned with this type of injury is probably due to its non-surgical nature. We believe that we need more dedicated studies for assessment of US role in the diagnosis of collateral ligaments injuries [13].

D'Agostino et al. [14] studied 600 patients with painful knee OA and found that inflammation evident by synovitis and joint effusion seen by US correlated statistically with advanced radiographic disease. This matched with the results we found that sensitivity, specificity and overall accuracy values of US regarding joint effusion equal 100% [14].

KaoruI and his colleagues in a meta-analysis study done on march 2017 'Fourteen of 601 identified articles were included in the review'. The summary estimates of sensitivity and specificity were 0.91, 0.60 for knee joint, respectively.

Lakkaraju et al. [15], did ultrasound evaluation for two hundred consecutive patients referred with masses and stated that Ultrasound is a useful triage tool for the assessment of masses referred.

Wu et al. [16], studied ultrasound in the diagnosis of the muscular soft tissue sarcomas and showed high concordance between sonographic diagnosis and surgical findings.

This study showed US 100% sensitive, specific and accurate in detection and anatomical evaluation of the peri articular soft tissue lesions in comparison with MRI and not in correlation with the histopathology.

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التصوير بالرنين المغناطيسى والسونار لتقييم الآفات غير العظمية حول المفصالية لمفصل الركبة : دراسة مقارنة

يعد الألم واضطرابات الركبة الأخرى من الشكاوى الشائعة فى الممارسة السريرية.

السونار الموجات فوق الصوتية فى الركبة مناسبة تما ما لتقييم أمراض الركبة، لا سيما فى تقييم إصابات العضلة الرباعية الرؤوس والأوتار الرضفى، وإصابات MCL وLCL، وانصباب المفاصل وتجميع السوائل حول الركبة، وتوجيه التدخلات الجلدية. إن فهم تقنية السونار للتقييم الكامل للركبة والتشريح بالموجات فوق الصوتية ذات الصلة، وظهور السونار للحالات المرضية الشائعة، ومعرفة المزالق المهمة يوفر أداة أخرى لتقييم الحالات المرضية للركبة.

على الرغم من أن الركائز الأساسية لتقييم التصوير للركبة هى الصور الشعاعية والتصوير بالرنين المغناطيسى (MR)، إلا أن التصوير بالموجات فوق الصوتية (السونار) أقل تكلفة من التصوير بالرنين المغناطيسى، ومتاح بسهولة، ودقة قابلة للمقارنة، وتكلفة منخفضة، ودقة مكانية عالية، وتصوير ديناميكى، وتوجيه التدخلات الجلدية، الاتصال المباشر بالمريض، والقدرة على المقارنة مع الركبة المقابلة، وتقييم المرضى الذين يعانون من موانع استخدام التصوير بالرنين المغناطيسى، وربط موقع المريض بالألم بالنتائج الصوتية.

القيد الأساسى للموجات فوق الصوتية للركبة هو أنها تعتمد على المشغل، والخبرة التدريبية المناسبة مطلوبة، وتقييم غير كامل للهياكل العميقة للركبة على وجه الخصوص الأربطة الصليبية، والغضروف المفصلى، وأغلبية الغضروف المفصلى، ولا يزال التصوير بالرنين المغناطيسى التحقيق فى الاختيار.