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Benign Cysts and Cysts-Like Lesions in and Around the Knee: Ultrasound Versus Magnetic Resonance Imaging Assessment with Gold Standard Correlation

Abeer Houssein Ali[1*], Mostafa Thabet Hussein[1], Mohamed Abd El-Radi Abd El-Salam[2], Marina Bahaa Boshra[3], Hamdy M Ibrahim[1]

Departments of [1]Diagnostic Radiology, [2]Orthopeadic Surgery and Traumatology, Faculty of Medicine, Assiut University, [3]Diagnostic Radiology, Health Insurance Hospital, Egyptian Ministry of Health and Population, Assiut, Egypt.

***Corresponding author**: Abeer Houssein Ali, **Mobile:** 01007078382, **E-mail**: abeeryaa@aun.edu.eg **ORCID**: 0000-0003-4207-9311

ABSTRACT

Background: Knee cysts are common clinical findings and MRI is frequently used in their assessment. However, compared to ultrasound (US), MRI is expensive and of limited availability. The objective of the current study is to compare the efficacy of US and MRI in the detection and characterization of benign cysts and cyst-like lesions in and around the knee with a gold standard correlation.

Patients and methods. Patients with benign cysts or cyst-like lesions in or around the knee were included. All patients underwent MRI followed by US of the affected knee. Based on the gold-standard correlation, the diagnostic performances of both imaging modalities in each type of cystic lesion were quantified and compared. Finally, the agreement between each imaging modality and the gold standard and between both modalities was calculated.

Results. The diagnosis of benign knee cystic lesions was confirmed in 96 patients. Baker's cyst was the most frequent followed by meniscal and ganglion cysts. There was a predominance of males, young and middle-aged, and right knee affection. MRI showed insignificantly higher accuracies (100%, 100%, and 99%) than those of US (97%, 95.8%, and 97%) in diagnosing Baker's, meniscal, and ganglion cysts (p>0.05). The agreement between MRI and US was substantial regarding the detection of ganglion cysts (k=0.75), and almost perfect regarding Baker's and meniscal cysts (k=0.96 and 0.90).

Conclusion. US is a time- and cost-effective, easily available, and non-invasive imaging modality with comparable accuracy to MRI in diagnosing benign knee cysts and cyst-like lesions. However, US is of limited performance as regards small parameniscal and intra-articular ganglion cysts.

Keywords: Knee, benign lesion, Cysts, Cyst-like lesion, Baker's cyst, Ultrasound, MRI.

INTRODUCTION

Cysts and cyst-like lesions in and around the knee are common clinical and imaging findings and most are benign [1,2].

A confident diagnosis of benign knee cystic lesions can present an investigational challenge to the radiologist. In most instances; the location, consistency, and pattern of vascularity are the most important factors in determining the etiology and nature of the knee cysts [1,3]. Hence, for optimal patient management with specific therapy and avoidance of unwarranted interventional procedures such as biopsy or arthroscopy, it is of paramount importance for the radiologist to be familiar with the characteristic imaging features, the spectrum of appearances, and potential imaging pitfalls of each knee cystic lesion [1-4].

Because of its excellent tissue contrast and multiplanar capability, MRI has become the modality of choice in the assessment of various knee pathologies including post-traumatic and sports injuries, rheumatological, and oncological imaging [2,5].

Consequently, cystic and cyst-like lesions are frequently encountered during the routine knee MRI assessment. MRI can delineate the location of the lesion and its relation to the surrounding anatomical structures and the typical MRI appearances of knee cysts have been documented in many previous studies [5-7].

However, MRI is of high cost, limited availability, and sometimes can determine the cystic or solid nature and vascular pattern of the lesion only after contrast administration [3,4].

US is the second most frequently used modality in the radiological assessment of clinically suspected musculoskeletal soft tissue lesions with previously documented considerable sensitivity and specificity in the detection of multiple knee cysts [4,8-10].

US is superior to MRI in being widely available, time- and cost-effective with a real-time capability to assess lesion consistency and vascularity without the need for contrast administration[4,10]. Dynamic evaluation and the possible percutaneous US-guided aspiration and therapeutic injection of the depicted cystic lesion are other important advantages of US [4,11,12]. Despite its several advantages, US is operator dependent and requires a long period of training. Furthermore, musculoskeletal US has a number of drawbacks that challenge its wide usage

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including the limited field of view and limited penetration into deeper structures that may diminish its role in the assessment of deep regions and those under the bone, particularly in obese patients [13].

Multiple studies in the literature demonstrated the MRI effectiveness in the diagnosis of various knee cysts and cyst-like lesions [14-16].

Fewer studies have investigated the accuracy of musculoskeletal US in the detection and characterization of knee cysts using MRI as a gold standard [4,10,12,17]. However, most of the aforementioned studies are limited by their retrospective nature and/or the lack of a decisive surgical or histopathological gold standard.

The current study aimed to compare the efficacy of US and MRI in the detection and characterization of benign cysts and cysts-like lesions in and around the knee with gold standard correlation.

PATIENTS AND METHODS

Study design and patients population

All patients of this cross-sectional single-institution study were referred to our Diagnostic Radiology Department from the Orthopedic Outpatient Clinic with internal knee derangement and/or a clinically suspected cystic lesion in or around the knee. Each patient underwent full history taking, clinical examination, and MRI followed by US evaluation of the affected knee. After completion of the MRI, a senior expert musculoskeletal radiologist (M.T.H., 25 years' experience.), reviewed the examination. Each patient with MRI-detected cysts in or around the examined knee was included and all the images and sequences of his/her MRI were stored on the dedicated picture archiving and communication system (PACS). Then, the patient was referred to US of the knee.

The exclusion criteria were previous knee arthroscopy or open surgical intervention, fractures or metallic hardware around the affected knee, claustrophobia or absolute contraindications to MRI (e.g., implanted pacemaker or defibrillator, ferromagnetic aneurysm clips), and bad-quality MRI (e.g., motion artifacts or incomplete protocol). Patients with >3 months interval between imaging and histopathological or surgical evaluation of the lesion or those with histopathologically proven malignant cystic lesions were also excluded from the study.

Patient preparation:

At the time of imaging, the patient was asked to change into a hospital gown and was positioned comfortably to avoid pain, motion artifacts, or muscle compression around the knee.

MRI Protocol:

MRI was conducted using one of two 1.5-Tesla MRI units; Philips Achieva (Philips Medical Systems, Best, The Netherlands) in 42 patients and Siemens Sempra (Siemens Healthcare, Erlangen, Germany) in 54 patients. The patient was placed supine, feet first with the examined limb in a neutral position and the knee within a dedicated knee coil. The scanning range was adjusted to cover from the tibial tuberosity up to the upper patellar border, from the lateral to medial femoral condyles, and from the patella to the line of the popliteal artery in the axial, oblique sagittal and coronal planes, respectively. Multiple 2D-TSE sequences with and without fat-saturation were acquired. The protocol was completed within 12-18 minutes (**Table 1**).

Table 1: Sequences, planes, and parameters of the MRI protocol.

	Sequences and planes						
Parameters	**Sagittal T_1 TSE**	**Sagittal T_2 TSE**	**Sagittal STIR**	**Sagittal FS-PDWI**	**Coronal STIR**	**Coronal FS PDWI**	**Axial T_2 TSE**
Repetition-time (ms)	400-512	5180-5269	4000-5163	2620-3000	4000-5163	2620-3000	5180-5269
Echo-time (ms)	13-25	100-112	40-50	30-36	40-50	30-36	100-112
Matrix (pixels)	288 x 288	204 x147	156 x136	252 x 160	156 x136	252 x 160	204 x 147
Field of view	16	16	16	16	17	17	16
Slice-thickness (mm)	3-4	3-4	3-4	3-4	3-4	3-4	3-4
Acquisition time (min: sec)	1:50-3:40	1:40-3:18	2:00-3:13	1:42-2:00	2:00-3:13	1:42-2:00	1:40-3:18

Protocol of US examination:

US evaluation was performed on the same day of MRI in an US-room adjacent to the MRI unit. The US examiner was blinded to the MRI findings and had an access only to the patient's history and clinical findings. Using the general musculoskeletal parameters of the same high-resolution US machine (Philips-Affiniti-50G, Philips-medical systems, Nederland), all patients were examined by the same senior radiologist (A.H.A., 15 years' experience in the musculoskeletal US). The linear transducer frequency was adjusted from 12-5 MHz and a comprehensive knee US assessment was performed in a methodic and standardized manner using the grayscale. All knee compartments were evaluated in a protocol similar to that described by Alves et al. [18].

For anterior evaluation, the patient was positioned supine with the knee slightly flexed and a rolled towel or a small pillow was placed at the popliteal fossa to support this position. Then, the hip was externally rotated for assessment of the medial knee. After which, the hip was internally rotated to assess the lateral knee compartment. If this position was uncomfortable or painful to the patient, he/she could lie on his or her contralateral side. Lastly, the patient was placed prone with the knee extended to assess the posterior compartment. Care was taken to prevent any angulation during US evaluation to avoid subsequent anisotropy. Anisotropy within the medial head of gastrocnemius or the semimembranosus tendons can be misdiagnosed as a small Baker's cyst. Anisotropy within the semimembranosus tendon can also be mistaken for a para-meniscal cyst [18].

Any detected cystic lesion was scanned in a multi-planar manner and underwent dynamic US evaluation to assess its relations to the adjacent structures. Then, Color Doppler interrogation was applied to check for the presence, extent, and configuration of any vascularity at the periphery, internal septa, or solid component of the lesion. Multiple images and videos were obtained for each lesion (regarding its maximum dimensions, relations to the surrounding anatomical structures, vascularity, and any associated knee pathology) and were stored separately on the US device's DICOM viewer.

Image assessment

Later, a single fellowship radiologist (M.B.B.) collected the MRI and US examinations of all patients. After hiding patients' data, two musculoskeletal radiologists (A.H.A. and H.M.I., 15 and 10 years of experience, respectively) randomly and independently assessed the examinations in four separate sessions in such a way that the two radiologists evaluated each examination. The two radiologists had access only to the patient history and clinical findings. Additionally, each radiologist was blinded to the criteria of the lesion in the other modality and to the impression of the other reporter on the same examination. The images of each modality were assessed for the presence and location of any cystic lesion as well as its relation to the surrounding knee structures.

The lesion MRI signal was assessed in all sequences and was reported as hypointense, hyperintense, or isointense relative to the adjacent muscles. Similarly, the US echogenicity was defined as anechoic, hypoechoic, hyperechoic, or isoechoic. The internal texture was classified as homogeneous or heterogeneous while the composition was characterized as purely cystic or mixed. Any septations, calcifications, or loss bodies inside the cyst were also reported. The presence of infection or hemorrhage was suspected by the change of the cyst signal intensity or echogenicity. Indistinct borders and diffuse extension of the cyst were also considered clues of its rupture. Then, the lesion was classified as avascular or vascular. Lastly, an impression was given to each examination by each radiologist, and the maximum width, length, and depth of the lesion were measured with a calculation of the size. In case of initial discrepancy between the two radiologists, another opinion was obtained from a third senior radiologist (M.T.H.) or an orthopedic surgeon (M.A.A.) who blindly reassessed the disputed examination, and a final consensus was obtained for each modality.

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Gold standard correlation:

Some of the detected cystic lesions underwent arthroscopic or open surgical excision that was performed by a single expert orthopedic surgeon (M.A.A.) and was followed by histopathological examination. Other lesions underwent US-guided fine-needle aspiration cytology (FNAC) or diagnostic and therapeutic angiography in case of suspected vascular nature of the lesion.

Ethical consideration:

This study had approval from Assiut University, Egypt, Faculty of Medicine Research Ethics Committee (IRB No: 17100745). All patients who participated in this study signed informed written consent for participation and publication of the data contained in this research. The included procedures were performed in full accordance with the code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis

Data were verified, coded by the researchers, and analyzed using IBM-SPSS 24.0 (IBM-SPSS Inc., Chicago, IL, USA). Descriptive statistics (means, standard deviations (SD), ranges, and percentages) were calculated. The Chi-square test was used to compare the difference in the distribution of frequencies among different groups. ROC curve was depicted to investigate the diagnostic performance of US and MRI, analyzed as the area under the curve (AUC), standard error (SE), and 95% CI. Validity statistics (sensitivity, specificity, positive and negative predictive value "PPV & NPV") were calculated. The exact McNemar test with binomial distribution was used to compare the diagnostic performances of the two imaging tests. The agreement between imaging modalities, each modality, and the available gold standard regarding the diagnosis of each lesion was calculated using kappa (k) coefficients. P-value ≤ 0.05 was considered significant.

RESULTS

According to the inclusion and exclusion criteria previously listed in the methodology section, 96 patients (37.06 ± 14.5years) were included during the current study time course. The majority of patients were males, more than one-half were presented with right knee affection, and no bilateral involvement was observed. The posterior knee compartment was the most frequently affected. The majority of included cystic lesions were incidentally discovered during the clinical or MRI assessment with no symptoms. Pain was the most frequently encountered complaint in symptomatic cases **(Table 2).**

Table 2: Demographic characteristics of the study population

Variable	Category	N = 96
Age in years	Mean ± SD	37.06 ± 14.5
	Median (Range)	36 (13-73)
Sex	Male	69 (72%)
	Female	27 (28%)
Affected knee	Right	50 (52%)
	Left	46 (48%)
Affected compartment	Posterior	68 (70.8%)
	Lateral	14 (14.5%)
	Anterior	6 (6.2%)
	Medial	4 (4.2%)
	Posterior-medial	2 (2.1%)
	Posterior-lateral	2 (2.1%)
Clinical presentation	**Asymptomatic cyst**	54 (56.2%)
	-Discovered during clinical evaluation	36 (37.5%)
	-Detected during MRI assessment	18 (18.75%)
	Symptomatic swelling	42 (43.8%)
	-Non-Painful	10 (10.4%)
	-Painful	32 (33.3%)
	Posterior Pain	12 (12.4%)
	Lateral Pain	14 (14.6%)
	Medial Pain	4 (4.2%)
	Anterior Pain	2 (2.1%)

Based on the gold standard correlation, sixty Baker's cysts were included (treated by arthroscopic drainage and ligation of the cyst neck in 58 limbs, and by open surgery in 2 cysts complicated by synovial osteochondomatosis). Arthroscopy confirmed the diagnosis of 20 meniscal (16 parameniscal and 4 meniscal) cysts **(Figure 1)**. The diagnosis of ganglion cyst was proven in eight knees and it was extra-articular in three (evidenced by US-guided FNAC) **(Figure 2)** and intra-articular in five (confirmed by arthroscopy in four and by open surgical excision and histopathology in one with an intraosseous component **(Figure 3)**. Two cases of bursitis were also comprised (one was prepatellar ascertained by its anatomical location and US-guided FNAC and the other was chronic calcified iliotibial bursitis confirmed by open surgery done for an associated iliotibial tract syndrome). Moreover, two aneurysmal bone cysts were included and both underwent open surgical excision followed by histopathology in order to confirm the benign nature of the excised cyst. The frequencies and percentages of the included benign cystic lesions based on their gold standard diagnosis are shown in **Table 3**.

Table 3: The detailed gold standard findings of the included cystic lesions.

Type of cyst	Category	Frequency (percentage)	The used gold standard
Baker's cyst (n=60, 62.5%)	Simple	54 (56.3%)	Arthroscopy + drainage and neck ligation
	Complicated by: ✓ Synovial osteochondromatosis	2 (2.1%)	Open surgical drainage + synovial debridement + neck ligation
	✓ Hemorrhage	2 (2.1%)	FNAC followed by arthroscopic drainage and neck ligation
	✓ Infection	1 (1%)	
	✓ Rupture	1 (1%)	
Meniscal cyst (n=20, 21%)	Intra-meniscal	4 (4.2%)	Arthroscopy
	Para-meniscal	16 (16.7%)	
Ganglion cyst (n=8, 8.3%)	Extra-articular	3 (3.1%)	FNAC
	Intra-articular	5 (5.2%)	Arthroscopy (four) open surgery (one) + histopathology
Bursitis (n=2, 2.1%)	Prepatellar bursitis	1 (1%)	FNAC
	Chronic calcified iliotibial bursitis	1 (1%)	Open surgery
Miscellaneous cysts and cysts-like lesions (n=6, 6.25%)	Aneurysmal Bone Cyst	2 (2.1%)	Open surgery
	Hemangioma	2 (2.1%)	ngiography
	Popliteal artery pseudo aneurysm	1 (1%)	Angiography
	Hematoma	1 (1%)	FNAC

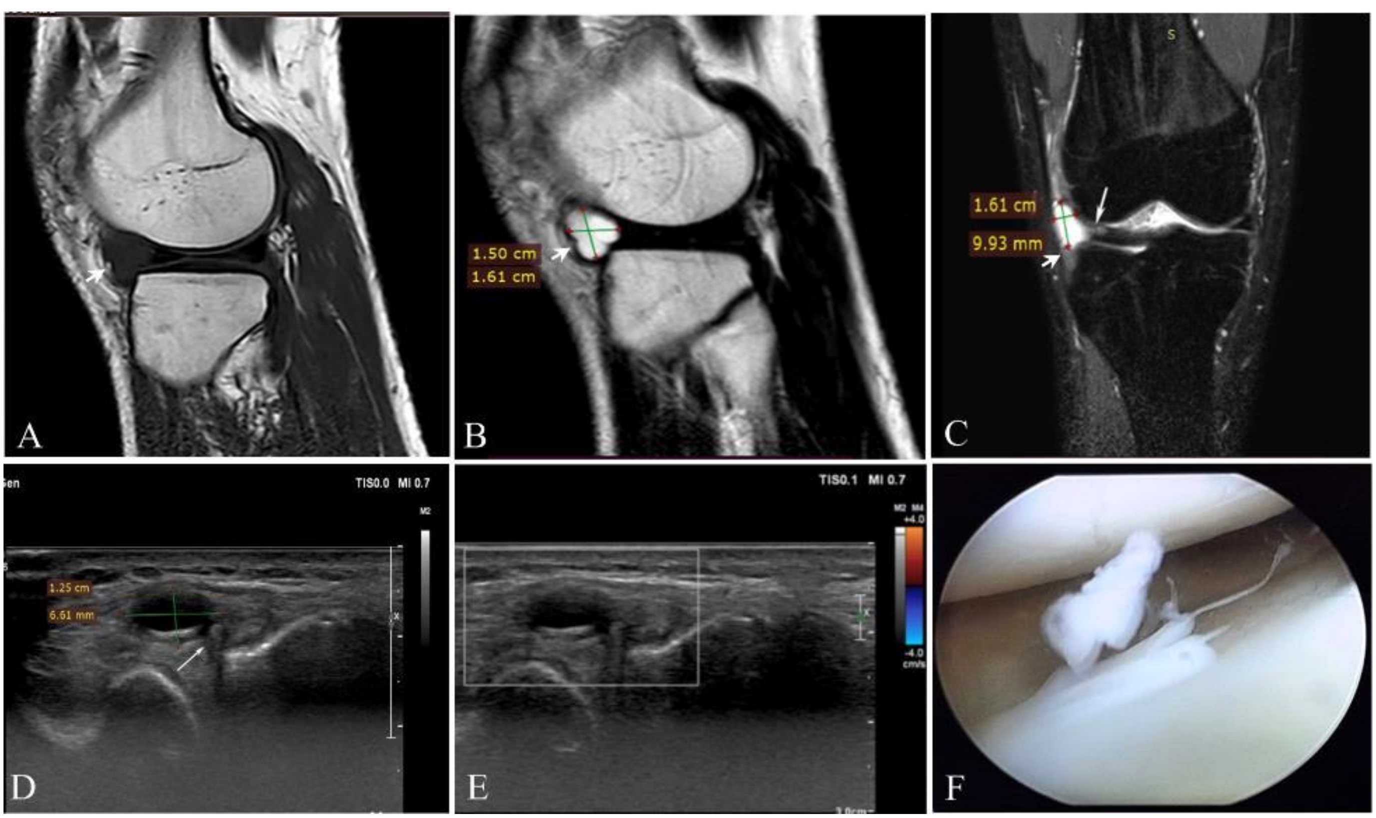

Figure 1: A 21 years male patient presented with posttraumatic right lateral knee pain. A-C: Sagittal oblique T_1W & T_2W and coronal oblique SPAIR showing a well-defined fluid signal cystic lesion **(**1.5 x 1 x 1.6 cm) abutting the lateral meniscus anterior horn **(Short arrows in A-C)** and connected to a horizontal hyperintense meniscal cleft **(Long arrow in C). D&E:** Corresponding longitudinal gray-scale and color Doppler US views of the same knee showing a thin-walled anechoic cyst (0.7 x 0.6 x 1.3 cm) connected to a fluid-filled tear traversing the lateral meniscus anterior horn **(Arrow in D)** and shows no color flow inside **(E)**. **H:** An arthroscopic image confirming the US and MRI diagnosis of AHLM tear with parameniscal cyst.

As matched with the arthroscopic and open surgical diagnosis of Baker's cysts, US has missed the detection of two small cysts with a sensitivity, specificity, and accuracy of 96.7%, 100%, and 97%, respectively. Whereas, all statistical parameters of MRI were 100%, but with no statistically significant difference between the diagnostic performance of the two imaging modalities (p>0.16).

Hemorrhage was observed within two of the included Baker's cysts, while one was complicated by rupture and another one by infection as confirmed by culture performed after US-guided FNAC of the cyst. Two of the arthroscopically proven parameniscal cysts were not observed during US examination. Moreover, US incorrectly diagnosed an arthroscopically confirmed large multiloculated hemorrhagic parameniscal cyst as an intra-articular ganglion cyst with a sensitivity, specificity, PPV, NPV, and accuracy of 85%,100, 100%, 95%, and 95.8%, respectively while those of MRI were all 100% (p=0.083) **(Figure. 1)**.

With exception of one case of infrapatellar ganglion that was impressed by MRI as an encysted effusion; all ganglion cysts were correctly diagnosed by MRI with a sensitivity, specificity, and accuracy of 87.5%, 100%, and 98.96%, versus 75%, 98.9%, and 97% for the US which could not detect the presence of two small intra-articular ganglion cysts (p=0.56). Otherwise, all of the remaining cystic lesions were correctly detected and diagnosed by MRI and US **(Figure 2 and 3, and Table 4).**

Table 4: Diagnostic performance of US and MRI versus gold standard diagnosis of various cystic lesions:

Parameter	US vs. Gold Standard Diagnosis					MRI vs. Gold Standard Diagnosis					*p*- value*
	Sensitivity %	Specificity %	PPV %	NPV %	Accuracy %	Sensitivity %	Specificity %	PPV %	NPV %	Accuracy %	
Baker's cyst	96.7	100	100	96.2	97	100	100	100	100	100	0.16
Meniscal (intra and para-meniscal) cyst	85	100	100	95	95.8	100	100	100	100	100	0.083
Ganglion cyst	75	98.9	85.7	97.8	97	87.5	100	100	98.9	99	0.56
Bursitis	100	100	100	100	100	100	100	100	100	100	**
Aneurysmal Bone cyst	100	100	100	100	100	100	100	100	100	100	**
Haemangioma	100	100	100	100	100	100	100	100	100	100	**
Popliteal artery pseudo-aneurysm	100	100	100	100	100	100	100	100	100	100	**
Haematoma	100	100	100	100	100	100	100	100	100	100	**

* McNemar test p-value for comparison between the diagnostic performances of MRI and US.
** McNemar test could not be performed because there were no discordances.

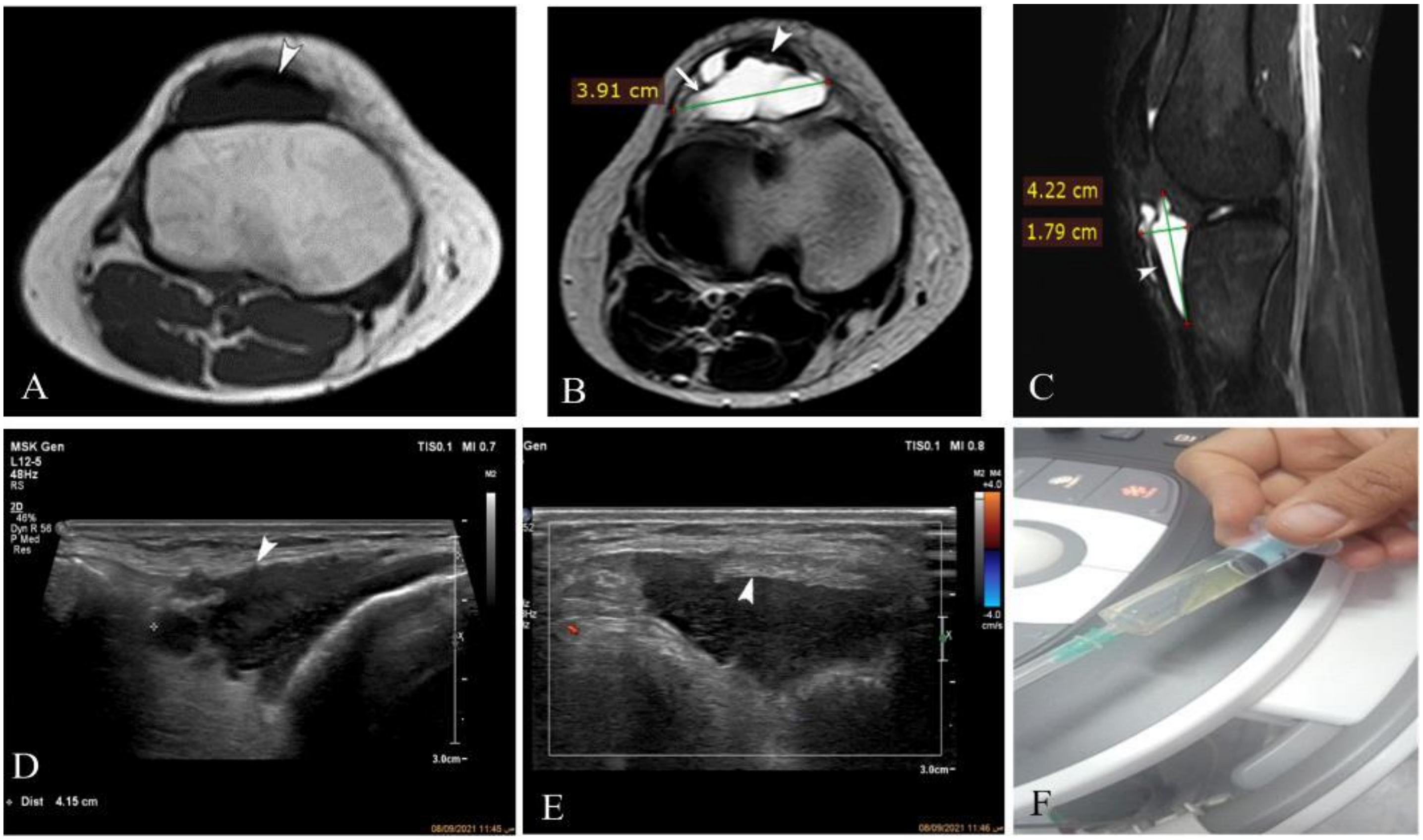

Figure 2: A 31 years female with painless right anterior knee swelling. A-C: Axial T_1, T_2W, and Sagittal oblique STIR showing a well-defined lobulated fluid-signal extra-articular lesion (1.8 x 3.9 x 4.2 cm) surrounding the proximal patellar tendon **(Arrowheads in A-C)** and extending between the tendon and Hoffa's fat pad and is homogenously hypointense in T_1WI and hyperintense with very thin hypointense internal septations in T_2WI **(Arrow in B). D&E:** Corresponding longitudinal gray-scale and transverse Color Doppler US images demonstrating a well-defined infrapatellar lobulated-branched hypoechoic lesion (3.9 x 1.2 x 4.2 cm) extending superficial and deep to the patellar tendon **(Arrowheads in D and E)** with turbid fluid content and internal echoes but no vascularity inside **(E). F:** US-guided fine-needle aspiration showing the thick viscid oily texture of the aspirate (cytology confirmed the MRI and US diagnosis of an infrapatellar (Hoffa's fat pad) ganglion cyst).

The degree of agreement between MRI and US and between each of them and the gold standard diagnosis varied according to the type of cystic lesion. **(Table 5).** Baker's cyst showed a significantly higher mean age compared to the meniscal and ganglion cysts (p=0.008). Joint effusion was detected in 81.6% of knees with Baker's cysts besides 70% of them showed concomitant PHMM tears. On the other hand, 90% of the included meniscal cysts were connected to underlying meniscal tears. In contrast, only 25% of ganglion cysts were associated with non-connecting meniscal tears and one-half of the ganglions were in osteoarthritic knees **(Table 6).** Eight lesions (8.3%) were observed to be calcified in US versus four lesions (4.2%) in MRI (p=0.23). The mean size of the included cystic lesions calculated from MRI measurements was significantly higher than those calculated from US measurements (34.36±38.1 versus 21.21±25.2, respectively) (p<0.001).

Table 5: Agreement between gold standard, US, and MRI diagnosis of cystic lesions.

Parameter	MRI vs. Gold Standard	US vs. Gold Standard	MRI Vs. US
Baker's cyst	1	0.96	0.96
Meniscal (intra- and para-meniscal) cyst	1	0.90	0.90
Ganglion Cyst	0.93	0.78	0.75
Bursitis	1	1	1
Aneurysmal Bone Cyst	1	1	1
Haemangioma	1	1	1
Popliteal artery pseudoaneurysm	1	1	1
Haematoma	1	1	1

Degree of agreement calculated by kappa coefficient (k); ($k \leq 0.00$=no agreement, 0.01–0.20= poor agreement, 0.21–0.40=fair agreement, 0.41–0.60=moderate agreement, 0.61–0.80=substantial agreement, 0.81– <1= almost perfect agreement, and 1=perfect agreement).

Table 6: Distribution of Baker's, meniscal, and ganglion cysts according to age, sex, affected side, and associated knee pathologies

Cyst / Parameter	Baker's cyst	Meniscal (intra- and paramenical) cyst	Ganglion cyst	*P*- value
Frequency	60	20	8	<0.001
Age "Range (mean+/-SD)" (years)	17-73 (40.4±14.8)	19-47 (29.2±8.7)	21-48 (32.63±9.7)	0.008
Sex (Males/Females)	50/10	16/4	6/2	0.92
Affected side (RT/LT)	45/15	14/6	5/3	0.83
Associated knee pathologies:				
-Joint effusion	49/60 (81.6%)	14/20 (70%)	2/8 (25%)	
-ACL tear	35/60 (58.3%)	4/20 (20%)	2/8 (25%)	
-PCL tear	5/60 (8.3%)	0/20 (0%)	0/8 (0%)	
-AHMM tear	4/60 (6.6%)	0/20 (0%)	0/8 (0%)	
-PHMM tear	42/60 (70%)	8/20 (40%)	2/8 (25%)	
-AHLM tear	4/60 (6.6%)	8/20 (40%)	0/8 (0%)	
-PHLM tear	8/60 (13.3%)	2/20 (10%)	0/8 (0%)	
-Osteoarthritis	18/60 (30%)	0/20 (0%)	4/8 (50%)	

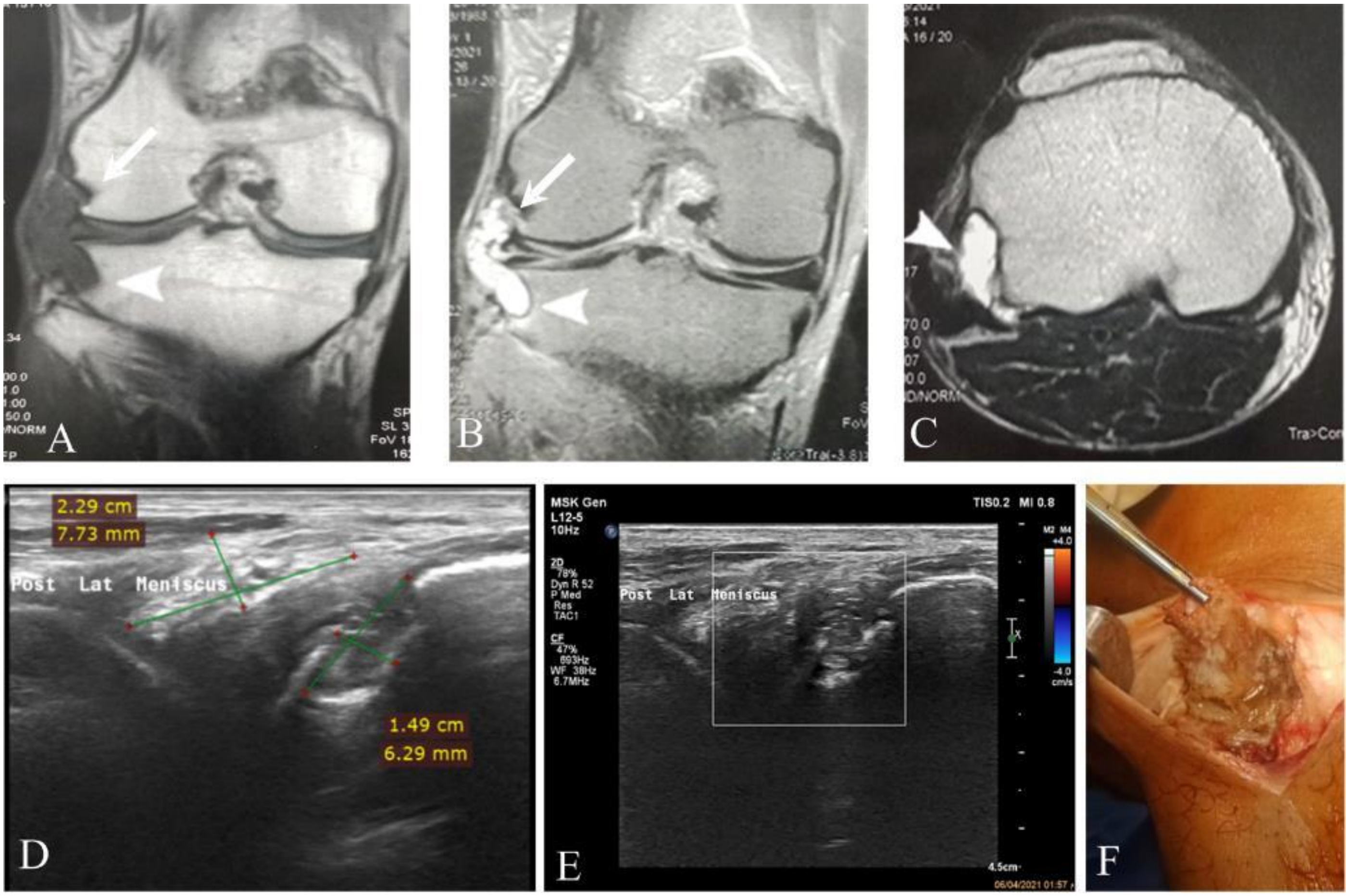

Figure 3: A 38 years male presented with right lateral painless knee swelling.
A-E: Coronal oblique T_1W & SPAIR, and axial T_2W demonstrating a well-defined lobulated multilocular cystic lesion abuts the lateral meniscus posterior horn with no definite connection to the adjacent meniscal degenerative tear **(Arrows in A & B)**. The cyst extends antero-inferiorly scalloping and eroding the posterolateral cortex of the tibial epimetaphysis with an intraosseous component **(Arrowheads in A-C).** Both components of the cyst are hypointense on T_1W and hyperintense on T_2W and SPAIR with multiple hypointense thin septations inside (characteristic "bunch of grapes" appearance). **D&E:** Longitudinal gray-scale and color Doppler US images of the same knee showing a large multiloculated cystic lesion with an extraosseous component adjacent to the PHLM (7.7 mm x 2.3 cm) and an intraosseous component eroding into the posterolateral aspect of the upper tibia (6.3 mm x 1.5 cm). Both components show heterogeneous echogenicity, multiple septations, and no color flow inside **(E).** Both MRI and US concluded an intra-articular ganglion cyst with an intraosseous component. **F:** The open surgical excision of the lesion that has been sent for histopathology, confirmed the diagnosis of ganglion cysts in both components.

DISCUSSION

A variety of benign knee cysts or cyst-like lesions can be encountered in daily clinical practice or during routine imaging of internal knee derangement [(3)]. MRI and US are the most frequently utilized imaging tests in case of suspected knee pathology, particularly cystic lesions [(11,19)]. The majority of benign knee cysts have characteristic US and MRI appearances that may help to reach a correct diagnosis, hence alleviating the need for any additional interventional procedures [(2-4)].

The present study was performed to compare the efficacy of US and MRI in the detection and characterization of benign cysts and cyst-like lesions in and around the knee with a gold standard correlation. In accordance with prior studies [(19,20)], the current results stated a higher prevalence of internal knee derangement in young and middle-aged males with more frequent right knee involvement. This could be attributed to the higher activity of the young and middle-aged males and to right limb overuse, particularly among the athletic and hard workers of our community with a higher risk of sports and occupational injuries. Knee cysts may present with pain, a palpable swelling, or disability, or may incidentally be detected during the clinical or MRI examination [(1)]. In view of that, the majority of cystic lesions in the current work were asymptomatic and pain was the most frequent complaint in symptomatic cases.

Baker's cyst was the most frequently detected cystic lesion in the present study, and in consistency with multiple previous reports, it was more common in old-aged males [(8,21,22)]. The progressive degenerative thinning out or opening of the joint capsule with aging could explain our results [(23)]. The capsular opening is aggravated under the effect of the increased intra-articular pressure caused by joint effusion [(21–23)]. By detecting joint effusion in association with the majority of Baker's cysts; the present study is in agreement with the study of Liao et al.[(23)], in stating a close relationship between Baker's cyst formation and the presence of knee effusion. Moreover, approximately two-thirds of the current study Baker's cysts were associated with PHMM tear. In a relatively similar result, Sansone and De Ponti [(24)] observed the presence of PHMM tear in 84–90% of cases with Baker's cyst and they thought that the meniscal tear might act as a one-direction valve-like mechanism between the knee joint cavity and the extra-articular bursal fluid collection. Approximately one-third of the current study Baker's cysts were in osteoarthritic knees. Jiang and Ni concluded that the correction of the unidirectional valvular mechanism would prevent Baker's cyst recurrence in the osteoarthritic knee [(25)]. In concurrence with previous studies [(4,21)], US examination of our study was as accurate as MRI in the detection of Baker's cysts with an almost perfect agreement with the arthroscopic and open surgical diagnosis and no significant difference between the diagnostic performances of both modalities. The two Baker's cysts that had been missed by US could be explained by their small size, patients' obesity, together with the limited penetration of musculoskeletal US [(13)].

It was previously reported that meniscal and ganglion cysts can present as palpable knee swelling [(26)]. In the present study, the meniscal cyst was the second most frequently encountered cystic lesion followed by ganglion cyst and in concordance, with former studies [(1,4,27-29)] both were more prevalent in young males with a male: female ratio of 4:1 and 3:1, respectively and slight predominance of right knee involvement. Ganglion cyst is usually identified as an intra-articular or extra-articular multiloculated cystic lesion [(2,14,16,27,29)]. It is of vital importance for preoperative imaging to exclude the presence of any intra-capsular or intraosseous extension of the ganglion cyst in order to reduce the possibility of recurrence [(2)]. Moreover, an intra-articular ganglion cyst should be differentiated from an intra-articularly dissecting parameniscal cyst because both entities require quite different treatment approaches [(1,2,14,29)]. In their study, De Smet et al. [(28)] supported the diagnosis of parameniscal cyst rather than ganglion cyst for any cyst adjacent to the meniscus regardless of the presence or absence of a connecting meniscal tear and they advocated their opinion by the fact that parameniscal indicates the cyst location, not its cause. In contrast, Saddik et al. [(30)] recommended that the cyst should be considered parameniscal if there is an underlying meniscal tear and that the diagnosis of a ganglion cyst can be suspected only if no meniscal tear is identified. In agreement with many previous studies [(1,26,28,31)], the majority of parameniscal cysts and all meniscal cysts of the current work were associated with underlying meniscal tears extending into the cyst. While only two of the detected intra-articular ganglion cysts were associated with meniscal tears nevertheless with no definite connection to the cyst. It was formerly suggested that meniscal cysts were formed as a result of synovial fluid extrusion through the meniscal tear and that the presence of chronic knee effusion increases the probability of their development [(1)]. In contrast, the pathogenesis of ganglion cysts is still a matter of debate whether they are degenerative or post-traumatic cysts [(2)]. In the present work, joint effusion was present in 75% of knees with parameniscal cysts and in only 25% of those with ganglion cysts and paucity of joint fluid was one of the findings that favor the diagnosis of the ganglion cyst. In the same regard, one-half of the included ganglion cysts were in osteoarthritic knees.

In the current work, MRI correctly accomplished the diagnosis of all meniscal cysts with a perfect agreement with arthroscopy. However, US could not detect three parameniscal cysts and incorrectly concluded an impression of PCL ganglion cyst in an arthroscopically proven large multilocular complicated PHMM parameniscal cyst. The diagnostic confusion of US in the above-mentioned parameniscal cyst could be attributed to the large size and central intra-articular extension of the cyst posterior to the PCL with a particular location simulating a PCL ganglion cyst. The inability to detect the underlying meniscal tear might add to this confusion. Moreover, US of the present work has missed two small intra-articular ganglion cysts. Thus, in agreement with a recent study [(4),] the current data revealed that compared to MRI, US is less sensitive and of reduced specificity in the detection and characterization of small parameniscal cysts and intra-articular ganglion cysts. However, in contrast to the aforementioned study [(4)] and in agreement with the case report of Choi et al. [(32)], MRI and US of the current study equally identified the surgically-proven intraosseous component of an intra-articular ganglion cyst.

Due to its high ability to detect even minimal bursal fluid, MRI is the first modality usually suited for the evaluation of knee bursae [(1,2,6)]. Nevertheless, by correctly diagnosing the two enrolled cases of bursitis with equal accuracy to that of MRI, US examination of the current study confirmed the previously documented data on the valuable role of musculoskeletal US in the assessment of knee bursae [(4,9,17)]. Based on the current and former results, US can be used as an alternative accurate tool in patients with bursitis who cannot undergo MRI.

Our data are concordant with a series of previous studies [(3,4,18,33)] in reporting the validity of MRI and US in characterizing aneurysmal bone cysts, miscellaneous knee cysts, and cyst-mimics such as hemangioma, pseudoaneurysm, and hematoma using the diagnostic hallmarks of each lesion. The pattern of vascularity and calcifications are essential imaging findings during the assessment of musculoskeletal soft tissue lesions because both can differentiate benign from malignant lesions or suggest a certain diagnosis [(34)]. In our study, both MRI and US correctly established the pattern of vascularity in four of the included vascular lesions. It has been reported that it may be difficult to distinguish between calcifications and ossification by US, especially in the presence of posterior acoustic shadowing, and that small calcification may be missed on MRI, particularly when surrounded by low signal structures as ligaments or tendons [(35)]. In the current work, US was superior to MRI in the detection of calcification within cystic lesions.

The mean size of cystic lesions derived from US measurements was significantly lower than that calculated from MRI measurements and this might be caused by the limited field of view with the inability to depict the lesion in a single image, which is an inherent disadvantage in musculoskeletal US [(13)].

There were a number of potential limitations that might be inherent to the materials and methods of the current study. First, the disparity of the used gold standard might have influenced the patients' care and hence the study results. Second, the present work was conducted as a single-institution study on a relatively small sample size so the numbers of some lesions were small to allow further statistical analysis. Third, only patients who met the inclusion criteria and accepted participation in the study were included and this might have led to a selection bias. Fourth, because the two radiologists analyzed all MRI and US images in consensus, the intra-observer and inter-observer variabilities were not assessed. Fifth, the inclusion of patients with MRI-detected cystic lesions might have led to verification bias. Likewise, because the decision to perform arthroscopy or open surgical excision of the lesion was based not only on the clinical findings but also on the preoperative imaging findings, a verification bias might also have been introduced by the availability of the imaging findings to the orthopedic surgeon.

In conclusion, US is a time- and cost-effective, easily available, and non-invasive imaging modality with comparable accuracy to MRI in diagnosing benign knee cysts and cyst-like lesions. However, US is of limited performance as regards small parameniscal and intra-articular ganglion cysts.

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