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MUSCULOSKELETAL DISORDERS OF THE LOWER LIMB-ULTRASOUND AND MAGNETIC RESONANCE IMAGING CORRELATION

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ABSTRACT

Background: There have been a number of significant advances in musculoskeletal ultrasound. US can now be considered an important diagnostic tool alongside MRI in imaging of the musculoskeletal system. **Aim of the work:** correlation between high resolution ultrasound and MRI for diagnostic accuracy in evaluation of musculoskeletal disorders of lower extremities. **Patient and Methods:** this was done in Dr.Nour Mohamed Khan Hospital as a prospective study in the period from May 2017 to June 2019 The study included 298 patients classified as intra , peri and extra articular and soft tissue Leasions considering inclusion and exclusion criteria with a through clinical evaluation , high- resolution ultrasound and MRI with different modes of imaging. **Results:** High resolution US was in good agreement with MRI for intra-articular, periarticular and soft tissue masses apart from bony and deep intra-articular structures, eg, bone marrow adema and bony lesions for which MRI is the imaging modality of choice. **Conclusion:** this work has high light ended the role of high resolution US as an easy, cheap tool of diagnosis for lower extremity musculoskeletal disorders as well as a complementary roles with MRI, the gold standard method for evaluation of MSK disorders.

KEYWORDS: MSK ultrasound, MRI, Intra, extra-articular, Soft- tissue, correlation.

INTRODUCTION

Within the past decade, musculoskeletal ultrasound (US) has become an established imaging technique for the diagnosis and follow up of patients with joint diseases. This has been made possible through technological improvements, resulting in faster computers and higher frequency transducers **(Gibbon & Wakefield, 1999)**.

US is most commonly used in the assessment of soft tissue disease or detection of fluid collection and can be used to visualize other structures, such as cartilage and bone surfaces. Owing to the better axial and lateral resolution of US, even minute bone surface abnormalities may be depicted. **(Grassi & Cervini, 1998).** Ultrasound and MRI technologies have added greatly to an understanding of joint disease pathophysiology i.e. rheumatoid arthritis and crystal deposition disorders **(Wakefield and Gibbon, et al., 1999).**

These not only have added to our basic understanding of the earliest lesions of these disorders and how they evolve with time and in the setting of treatment but also have been helpful in diagnosing disease and guiding treatment **(Manger and Kalden, 1995).** Most musculoskeletal work is performed using “grey scale”, which means images are produced in a black and white format; each white dot in the image represents a reflected sound wave. Sound waves travel in a similar way to light waves and therefore the denser a material is for example, bone cortex, the more reflective it is and the whiter it appears on the screen. Water is the least reflective body material and therefore appears as black as the sound waves travel straight through it **(Manger and Backhaus, 1997).**

The aim of our study is to know the sonographic and corresponding magnetic resonance imaging (MRI) appearance of various musculoskeletal disorders of the lower limb. The role of high-resolution ultrasound (US) is highlighted, as well as the complementary relation between both imaging modalities. We also discuss the advantages of US over MRI in the investigation of musculoskeletal disorders of the lower limb. The MRI and US appearances of various articular, periarticular, and soft tissue pathologies of the lower limb are compared and reviewed, and where possible, the advantages of each modality are identified.

MATERIALS AND METHODS

This study was carried out on 298 patients. The period of this study covered two year from March 2017 to June 2019 The work was carried out at the radiology department. The cases were referred from orthopedic surgery and physical medicine outpatient clinics at Dr. Nour Mohamed Khan Hospital, 298 patients with age range from 19 to 65 years were included.

Inclusion Criteria
All patients with any musculoskeletal lower extremity disorders (based on clinical and radiographic findings) and those patients were suffering from symptoms such as pain, limping or lower limb swellings or masses.

Exclusion criteria
- Contraindications to perform magnetic resonance imaging (e.g. cardiac pacemakers, metallic foreign body, metallic aneurysm clips and other metallic implantations).
- Contraindications to intravenous contrast e.g., patients with renal impairment, allergic patients or those known to have a history of anaphylactic shock from contrast media.

Methods: All patients were subjected to the following: 1-Demographic and clinical data collection.

2-Imaging procedures
All patients were subjected to superficial high resolution ultrasound and MRI Exam.

All patient were classified into three main groups;
- Group I: Articular disease: Including (hip, knee, ankle and foot).
- Group II: Periarticular disease: (tendons, ligaments and bursae).
- Group III: Soft tissue disorders (muscles, nerves and subcutaneous swelling as well as vascular tumors).

[A] Magnetic Resonance Imaging: (MRI)
MRI was done and tailored according to the region of interest using most of the following series implement MRI protocols for lower extremities:
Musculoskeletal Ultrasound protocols For lower extremities

Technique for high-resolution ultrasound:
- High frequency (7.5- 20 MHz), transducers are generally best for demonstrating superficial structures such as tendons, ligaments and small joints.
- Low frequency transducers (3.5- 5 MHz) are sometimes more suited for larger or deeper sited joints such as hip scanning.

Diagnostic ultrasound of the hip
Examination of the hip is dependent upon the specific structure and pathology suspected from a thorough clinical examination. In addition to static scanning, dynamic scanning should be included particularly when imaging tendons and ligaments to fully assess the patency of these structures.

The knee US scanning protocol incudes: Exploration the quadrants of the knee, anterior, medial, lateral and posterior. US would normally be focused on only one or two of these quadrants depending upon the clinical diagnosis.
Ankle and foot US scanning protocol: The ankle may be considered as consisting of four quadrants; anterior, medial, lateral and posterior with the foot being considered separately. Ultrasound would normally be focused only one or two of these quadrants or the foot depending upon the clinical diagnosis.

The groin is examined mainly to search for pathologies of the grades muscle, long and short adductor (common insertion) as well as the pectineus muscle.

Peripheral nerve protocol: Nerves have a fascicular pattern with hypoechoic longitudinal neuronal fascicles interspersed with hyperechoic interfasicular, connective tissue and epineurium, best appreciated when imaged in the short axis. Nerves course adjacent to vessels and are readily distinguished from the surrounding tendons with a dynamic examination, during which the nerve demonstrates relatively little movement compared with the adjacent tendons.
Soft Tissue mass US protocol: The mass should be scanned in both long and short – axis planes.

Ethical committee approval
The aim and nature of the study were explained for each patient before inclusion. An informed consent was obtained Then examinations were performed.

Statistical analysis
Data collected throughout history, basic clinical examination, imaging investigations and outcome measures coded, entered and analyzed using Microsoft Excel software. Data were then imported into Statistical Package for the Social Sciences (SPSS version 20.0)

RESULTS
Table 1: Showed that ultrasound was able to diagnose 80% of cases with hip joint effusion diagnosed by MRI with a statistically significant positive correlation; sensitivity 100% , specificity 88.2%, PPV 80% , NPV 100% and kappa value 0.62; P. value (<0.001). **Table 2:**With a p.value (< 0.001) , there was a moderately positive correlation between US and MRI as regards the hip joint with a sensitivity 77.8% , specificity 90.2%, PPV 63.6% , NPV 94.9% and kappa value 0.62. **Table 3:** Diagnosis of intra- articular cartilagenous, Labral hip disorders has shown positive results in 11 cases diagnosed by MRI and in 6 patients diagnosed by US with a moderately positive correlation (P. value < 0.001), sensitivity 54.4%, specificity 100%, PPV 100% , NPV 88.6% and kappa value 65%. **Table 4:**Ultrasound has shown a strong positive correlation with MRI as regards evaluation of hip cartilagenous free intra – articular bodies (P. value < 0.001), with a sensitivity 71.4 %, specificity 100% , PPV 100% , NPV 95.6% and kappa value 0.65.**Table 5:**As regards peri-articular hip enthesopathy, ultrasound has shown a strong positive correlation with MRI (P.value<0.001) with sensitivity

100%, specificity 95.3%, PPV 77.8%, NPV 100% and kappa value 0.85. **Table 6:**As regards knee joint effusion, there was a strong positive carnation between ultrasound and MRI (P.value <0.001) with a sensitivity 100% specificity 83%, PPV 80%, NPV 100% and a kappa value 0.8.**Table 7:**There was a strong positive correlation between US and MRI (P. value <0.001) as regards synovial pathologies at the knee with a sensitivity 91.7%, specificity 97.4%, PPV 91.7%, NPV 97.4% and a kappa value 0.89. **Table 8:**With high accuracy,ultrasound has shown a strong positive correlation with MRI for diagnosis of knee peri-articular bursitis (p.value<0.001) with a sensitivity 100%, specificity 97.8%, PPV 83.3%, NPV 100% and kappa value 0.9.**Table 9:**There was a strong position correlation between US and MRI (P. value < 0.001) for diagnosis of knee peri- articular tendon tears, with a sensitivity 100%, specificity 95.2% PPV, 80%, NPV 100% and kappa value 0.87.**Table 10:**Ultrasound correlated with MRI for diagnosis of Matron's neuroma has shown strong positive correlation (P. value=<0.001), with a sensitivity 100%, specificity 99%, PPV 87.5%, NPV 100% and kappa value 0.93.**Table 11:**There is a strong correlation between MRI and US as regards evaluation of ganglion cysts (P.value =<0.001) with a sensitivity 100%, specificity 97.7%, PPV 83.3% NPV 100% and kappa value 0.9. **Table 12:**For diagnosis of tissue metastasis, Us was not as accurate as MRI with a moderate positive correlation (P.value=<0.001) with a sensitivity 50%, specificity 100%, PPV 100%, NPV 99% and kappa value 0.67. **Table 13 :**For diagnosis of osteomyelitis with artificial prosthesis Us has shown a maderate positive correlation (P.value=<0.001) with a sensitivity 100%, specificity 97.9%, PPV 66.7%, NPV 100% and kappa value 0.79. **Table 14:**Ultrasound is a good tool for diagnosis of lower limb haematomas showing a strong positive correlation with MRI (P.value=<0.001) with a sensitivity 100%, specificity 100%, PPV 100%, NPV 100% and kappa value 1.0. **Table 15:**Ultrasound has shown a positive correlation with MRI as regard lower extremity intra- articular synovial disorders (P. value =< 0.001) with a sensitivity 92.5%, specificity 94.4%, PPV 80.4% , NPV 89.1% and kappa value 0.82.

Table 1.

			MRI		Total
			Negative	Positive	
US	Negative	Count	30	0	30
		% within US	100.0%	0.0%	100.0%
		% within MRI	88.2%	0.0%	60.0%
	Positive	Count	4	16	20
		% within US	20.0%	80.0%	100.0%
		% within MRI	11.8%	100.0%	40.0%
Total		Count	34	16	50
		% within US	68.0%	32.0%	100.0%
		% within MRI	100.0%	100.0%	100.0%

Table 2.

			MRI		Total
			Negative	Positive	
		Count	37	2	39
		% within US	94.9%	5.1%	100.0%
	Negative	% within MRI	90.2%	22.2%	78.0%
US		Count	4	7	11
		% within US	36.4%	63.6%	100.0%
		% within MRI	9.8%	77.8%	22.0%
	Positive	Count	41	9	50
Total		% within US	82.0%	18.0%	100.0%
		% within MRI	100.0%	100.0%	100.0%

Table 3.

			MRI		Total
			Negative	Positive	
		Count	39	5	44
		% within US	88.6%	11.4%	100.0%
	Negative	% within MRI	100.0%	45.5%	88.0%
US		Count	0	6	6
		% within US	0.0%	100.0%	100.0%
	Positive	% within MRI	0.0%	54.5%	12.0%
		Count	39	11	50
Total		% within US	78.0%	22.0%	100.0%
		% within MRI	100.0%	100.0%	100.0%

Table 4.

			MRI		Total
			Negative	**Positive**	
		Count	43	2	45
		% within US	95.6%	4.4%	100.0%
	Negative	% within MRI	100.0%	28.6%	90.0%
US		Count	0	5	5
		% within US	0.0%	100.0%	100.0%
	Positive	% within MRI	0.0%	71.4%	10.0%
		Count	43	7	50
Total		% within US	86.0%	14.0%	100.0%
		% within MRI	100.0%	100.0%	100.0%

Table 5.

			MRI		Total
			Negative	**Positive**	
		Count	41	0	41
		% within US	100.0%	0.0%	100.0%
	Negative	% within MRI	95.3%	0.0%	82.0%
US		Count	2	7	9
		% within US	22.2%	77.8%	100.0%
	Positive	% within MRI	4.7%	100.0%	18.0%
		Count	43	7	50
Total		% within US	86.0%	14.0%	100.0%
		% within MRI	100.0%	100.0%	100.0%

Table 6.

			MRI		Total
			Negative	**Positive**	
		Count	25	0	25
		% within US	100.0%	0.0%	100.0%
	Negative	% within MRI	83.3%	0.0%	50.0%
US		Count	5	20	25
		% within US	20.0%	80.0%	100.0%
	Positive	% within MRI	16.7%	100.0%	50.0%
		Count	30	20	50
Total		% within US	60.0%	40.0%	100.0%
		% within MRI	100.0%	100.0%	100.0%

Table 7.

			MRI		Total
			Negative	**Positive**	
		Count	37	1	38
		% within US	97.4%	2.6%	100.0%
	Negative	% within MRI	97.4%	8.3%	76.0%
US		Count	1	11	12
		% within US	8.3%	91.7%	100.0%
	Positive	% within MRI	2.6%	91.7%	24.0%
		Count	38	12	50
Total		% within US	76.0%	24.0%	100.0%
		% within MRI	100.0%	100.0%	100.0%

Table 8.

			MRI		Total
			Negative	**Positive**	
		Count	44	0	44
		% within US	100.0%	0.0%	100.0%
	Negative	% within MRI	97.8%	0.0%	88.0%
US		Count	1	5	6
		% within US	16.7%	83.3%	100.0%
	Positive	% within MRI	2.2%	100.0%	12.0%
		Count	45	5	50
Total		% within US	90.0%	10.0%	100.0%
		% within MRI	100.0%	100.0%	100.0%

Table 9.

			MRI		Total
			Negative	**Positive**	
		Count	40	0	40
		% within US	100.0%	0.0%	100.0%
	Negative	% within MRI	95.2%	0.0%	80.0%
US		Count	2	8	10
		% within US	20.0%	80.0%	100.0%
	Positive	% within MRI	4.8%	100.0%	20.0%
		Count	42	8	50
Total		% within US	84.0%	16.0%	100.0%
		% within MRI	100.0%	100.0%	100.0%

Table 10.

			MRI		Total
			Negative	**Positive**	
		Count	104	0	104
		% within US	100.0%	0.0%	100.0%
	Negative	% within MRI	99.0%	0.0%	92.9%
US		Count	1	7	8
	Positive	% within US	12.5%	87.5%	100.0%
		% within MRI	1.0%	100.0%	7.1%
		Count	105	7	112
Total		% within US	93.8%	6.3%	100.0%
		% within MRI	100.0%	100.0%	100.0%

Table 11.

			MRI		
			Positive	**Negative**	**Total**
		Count	86	0	86
		% within US	100.0%	0.0%	100.0%
	Negative	% within MRI	97.7%	0.0%	87.8%
US		Count	2	10	12
		% within US	16.7%	83.3%	100.0%
	Positive	% within MRI	2.3%	100.0%	12.2%
		Count	88	10	98
Total		% within US	89.8%	10.2%	100.0%
		% within MRI	100.0%	100.0%	100.0%

Table 12.

	MRI	**Total**			
	Negative	Positive			
		Count	96	1	97
		% within US	99.0%	1.0%	100.0%
	Negative	% within MRI	100.0%	50.0%	99.0%
US		Count	0	1	1
		% within US	0.0%	100.0%	100.0%
	Positive	% within MRI	0.0%	50.0%	1.0%
		Count	96	2	98
Total		% within US	98.0%	2.0%	100.0%
		% within MRI	100.0%	100.0%	100.0%

Table 13.

			MRI		**Total**
			Negative	**Positive**	
		Count	92	0	92
		% within US	100.0%	0.0%	100.0%
	Negative	% within MRI	97.9%	0.0%	93.9%
US		Count	2	4	6
		% within US	33.3%	66.7%	100.0%
	Positive	% within MRI	2.1%	100.0%	6.1%
		Count	94	4	98
Total		% within US	95.9%	4.1%	100.0%
		% within MRI	100.0%	100.0%	100.0%

Table 14.

			MRI		**Total**
			Negative	**Positive**	
		Count	88	0	88
		% within US	100.0%	0.0%	100.0%
	Negative	% within MRI	100.0%	0.0%	89.8%
US		Count	0	10	10
		% within US	0.0%	100.0%	100.0%
	Positive	% within MRI	0.0%	100.0%	10.2%
		Count	88	10	98
Total		% within US	89.8%	10.2%	100.0%
		% within MRI	100.0%	100.0%	100.0%

Table 15.

			MRI		**Total**
			Negative	**Positive**	
		Count	151	3	154
		% within US	98.1%	1.9%	100.0%
	Negative	% within MRI	94.4%	7.5%	77.0%
US		Count	9	37	46
		% within US	19.6%	80.4%	100.0%
	Positive	% within MRI	5.6%	92.5%	23.0%
		Count	160	40	200
Total		% within US	80.0%	20.0%	100.0%
		% within MRI	100.0%	100.0%	100.0%

DISCUSSION

Our results regarding joint effusion has shown a strong +ve correlation between ultrasound and MRI. (P. value<0.8).These results were in agreement wall the results postulated by **Iwona et al. 2017**, with good correlation between US and MRI in the evaluation of synovial disorders and joint effusion in patients suffering from rheumatoid arthritis. Out of the fifty patents with hip pathology 13 were diagnosed to have synovial disorders. Ultrasound has shown a moderately position correlation with MRI, (P. value < 0.001). **In 2013. Joseph et al,** described a good correlation between US and MRI in the assessment of hip intra-articular loose bodies with a sensitivity 33% specificity 100%, PPV 100% and NPV 88%.These findings were in agreement with results of the present study which has shown a good positive correlation between US and MRI with sensitivity 71.4%, specificity 100% PPV 100% and NPV 95.6%. There was a good positive correlation between ultrasound and MRI in evaluation of hip peri-articular bursitis (p. value< 0.001) sensitivity, specificity, PPV, and NPV; 69.2%, 100%, 100%, and 90.2% respectively. **Talia Friedman et al., 2012** postulated that there was a good positive correlation between US and MRI in the evaluation of peri- articular hip bursitis (P. value <0.001) and that US and MRI were equally capable of depicting ilio-psoas bursitis, with the MRI having the slight advantage that the communication of the bursitis with the hip can be demonstrated. With its large field of view MRI can encompass a large bursa better than US and demonstrate its relationship to the joint **(wanderbaldinger et al., 2002).** increasing over the last decade (**Abrahwan et al., 2011).**The present study has shown a strong positive correlation with MRI as regards the diagnosis of knee synovial disorders (P- value< 0.001).These results were in agreement with that reported by **Maged et al. (2012),** aiming at evaluation of the role of ultrasonography in the assessment of synovial lesions of the knee joint in correlation with MRI. 39 cases: 25 females and 15 males with 69 symptomatic knee joints were included in this study with an age range from 22 to 62 years. All patients were subjected to evaluation of knee joint evaluation using US and MRI. Results have shown high correlation between US and MRI as regards synovial disorders of the knee joint. The results were concordant with a strongly positive agreement (p. value =<0.001) with sensitivity, specificity, PPV and NPV kike our present study. Ultrasound showed a weak correlation with MRI as regards diagnosis of cruciate ligament lesions (P. value=<0.01) with a 25% sensitivity and 100% sensitivity.In a study postulated by **Ghosh et al., 2017**, showed ultrasound has 67% sensitivity and 83% with PPV of 67% and NPV of 83% for combined medial meniscus and medial cruciate ligament (MCL) tears.**Abdel Monem and Enaba, 2012** reported that correlation between ultrasound and MRI as regards anterior cruciate ligament lesions in 30 patients, there was a good correlation with an accuracy 83.3% sensitivity 81.8% and a specificity 84.2%. In the present study, there was a strong correlation between ultrasound and MRI as regards evaluation bursae in the knee (p. value=<0.001) with a sensitivity and specificity 100% and 97.8% respectively **Draghi et al, 2015**, correlated ultrasound and MRI for the study of knee bursitis they've reported a strong correlation between ultrasound and MRI with sensitivity and specificity; 86.67% and 100% respectively. **Steinbach and Stevens, 2013**. Reported that ultrasound has the same sensitivity as MRI. However US has low sensitivity with respect to MRI in the evaluation of only suprapatellar bursa. Results of the present study has shown a strong positive correlation between ultrasound and MRI in the evaluation of the popliteal (Baker's) cyst (P- value=<0.001), with a sensitivity 100% and specificity 100% In a retrospective study published by **Word et al., 2001**, 36 patient were studied, they found a strong positive correlation between ultrasound and MRI as regards evaluation of popliteal (Baker's) cyst. The sonography reports revealed that 21 Baker's cysts were correctly diagnosed, wherease the meniscal cyst and myxoid liposorcoma were misdiagnosed as Baker's cyst. They concluded that identification of fluid between semimembranosus and medial gastrocnemius tendons in communication with a posterior knee cyst indicates Baker's cyst with 100% accuracy. The present study has shown a strong correlation between US and MRI as regards ankle impingement syndromes with a sensitivity 100% and specificity 100%, PPV 100% and NPV 100%.

Berman et al., 2017. Reported results in agreement with our result as regards anterolateral impingement, anterior impingement, anteromedial impingement, posteromedial impingement.It is important for the clinicians to differentiate between effusion – the excess fluid in joints- and physiologic fluid accumulation, as the latter does not need clinical intervention. When compared with MRI, ultrasound has the disadvantage of small field of view, poor image presentation and difficulty in demonstrating, contrast enhanced magnetic resonance provides a better measure of capillary permeability and extracellular fluid than does ultrasound. The ability to image simultaneously multiple small joints in the hands and feet and their enhancement characteristics cannot be matched ultrasound **(Mcnally, 2008).**In the present study, US has shown a moderate agreement with MRI as regards the diagnosis of cartilaginous lesions of the foot (P- value =<0.001), with a sensitivity 87.5%, Specificity 88.1%, PPV 58.3% and NPV 97.4%.**Boutry et al.,** 2007 reported that US is still less sensitive and accurate like MRI for evaluation of cartilage lesions of the foot. These result were in agreement with that published by **Conaghan et al. (2003)** who studied the relationship between synovitis and bone damage in a randomized magnetic resonance imaging study of small joints in patients with early rheumatoid arthritis. **Horikoshi et al., 2010,** has shown a good correlation between US and MRI as regards different joint pathologies in patients with RA.

CONCLUSION AND RECOMMENDATIONS

A number of factors affect utilization of musculoskeletal ultrasound, which indirectly affects MRI utilization. The proliferation of less expensive compact ultrasound units has opened, the musculoskeletal ultrasound beyond radiologists, potentially reducing the number of ultrasound and MRI studies interpreted by radiologists. The use of ultrasound in place of MRI for specific examinations can result in significant cost saving in the health care system but can reduce MRI use. Training on MSKUS is recommended, further progress is required to integrate MSKUS into radiology residency programs similar to musculoskeletal fellowship programs when compared with MRI, ultrasound has similar accuracies for many applications with proper training and adequate experience. US can complement MRI in the evaluation of peripheral nerves, foreign bodies, abnormalities adjacent to hardware and conditions that require dynamic tests or special positioning for diagnosis.

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