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Comparative Study Between Ultrasound and Magnetic Resonance Imaging for Inflammatory Peripheral Joints Pathology

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Abstract

Background: Musculoskeletal ultrasound (US) and magnetic resonance imaging (MRI) are two new imaging methods that play a significant role in the diagnosis, therapy selection, and disease monitoring of inflammatory disorders of the joints. **Aim:** To compare the ultrasound & MRI findings in inflammatory pathology of peripheral joints. **Methods:** The study included patients who were referred with clinically suspected peripheral joints inflammatory pathology for MRI evaluation. All the patients had been subjected to MRI followed by Ultrasound assessment and the results had been compared. **Results:** This research was conducted on 22 cases with clinically suspected peripheral joints pathology. There was a significant excellent agreement among US & MRI in detection of hands & feet muscles tenosynovitis, marginal osteophytes, bony calcaneal spur, planter fasciitis (kappa =1.00, p<0.001). There was a significant good agreement among US & MRI in detection of joint effusion (kappa =0.792, p<0.001). There were two cases that positive for talar head marrow contusion in MRI who cannot be detected by US with no agreement between US & MRI in detection of talar head marrow contusion. **Conclusion:** Both ultrasound & MRI findings showed an excellent agreement and high accuracy in detection of non-traumatic pathology of peripheral joints.

Key words: Inflammatory peripheral joints, Magnetic resonance imaging, Musculoskeletal ultrasound

Introduction

Diagnostic ultrasonography for musculoskeletal conditions (MSK-DUSI) has been expanding outside the realm of radiology. A number of healthcare settings have reported increased use of this technology [1].

Bone degradation, synovial hyperplasia, synovial vascularization, and synovial fluid are some ultrasound findings associated with inflammatory joints. Under normal circumstances, synovial fluid is also present in some joints and may be seen by sonography [2].

Rapid advances in technology have made US widely accepted by patients, making it what one might call the "extended diagnostic finger" of the practicing rheumatologist. Therefore,

standardization is required for proper assessment of joint inflammation including synovitis and bone processes [3].

When compared to other imaging methods, MR delivers the most information on the wrist's bones and soft tissues. Compared to CT and ultrasound, MRI has inferior spatial resolution and is more expensive, slower, and less convenient to use. Patients may experience discomfort or claustrophobia in the imaging posture, or they may not be candidates for MRI due to pacemakers or incompatible vascular implants [4].

MRI is increasingly employed in the evaluation of early rheumatoid arthritis due to its superior morphologic characterisation compared to US. MRI is also widely accepted as the noninvasive imaging modality of choice for visualization of the inflamed synovium in established RA. Although MRI has several advantages over US, it comes with a number of drawbacks as well. There may be a significant role for comparative evaluation of the diagnostic performance and identification of the added value of each approach in patient care [5].

Our primary objective for doing this study was to compare the ultrasound & MRI findings in inflammatory pathology of peripheral joints.

Materials and Methods

Patients

In the Radiodiagnosis Department of Ain Shams University Hospitals, 22 patients participated in prospective research during the period from January 2022 to May 2023. The study was submitted for approval by Ethical and Scientific Research Committees at the Faculty of Medicine, Ain Shams University. The participants all provided written informed permission.

Inclusion Criteria:

The research included patients who were referred with clinically suspected peripheral joints inflammatory pathology for MRI evaluation. All the patients had been subjected to MRI followed by Ultrasound assessment and the results had been compared.

Exclusion Criteria:

We excluded patients with history of trauma, severe allergies to contrast material or severe kidney disease, contraindications to MRI i.e., metallic plates and screws of internal fixations and the metallic prosthesis of total joints replacement, pregnancy and lactating female.

Patient preparation:

Detailed explanation of imaging procedures, duration, and complications. Insertion of a wide pore (18-20 g) IV cannula was done in case of contrast material injection.

Study tools:

The referral physician conducted a thorough history and physical examination. Complete kidney function tests were estimated. All patients had been undergone MRI using dedicated peripheral extremity coil & then ultrasound examination using superficial linear probe.

Study procedures:

Methods of MRI examination:

The examination was performed with Achiva Philips 1.5 tesla MR system using dedicated peripheral extremity coil. cases were placed in the supine or setting position.

MRI Protocol:

- • Images in the axial, coronal, and sagittal planes of the T1 weighting scale.
- • Images in the axial, coronal, and sagittal planes with a T2 weighting.
- Axial, coronal & sagittal STIR images.
- +/- T1 post contrast images.

Methods of ultrasound examination:

The examination was performed with Philips machine linear superficial probe. The patient were in a sitting position in front of the examiner during the wrist joint examination and in supine, sitting or prone position during the ankle joint examination.

Image analysis and interpretation:

Interpretation of the MRI result will be done by a radiologist with at least five year experience in musculoskeletal MRI. Ultrasound examination had been done by a radiologist with at least five year experience in musculoskeletal US being blinded to the MRI result. Then data had been correlated.

Risk and complications of MRI contrast media (Gadolinium):

Adverse reactions are commonly minimal: headache, nausea, dizziness and itchy skin rash. Rarely : Severe anaphylactic reactions , Nephrogenic systemic fibrosis (NSF) , and Gadolinium retention in bones .

Statistical analysis:

SPSS (Statistical Package for the Social Sciences) version 26.0, Microsoft Excel 2016, and MedCalC (Medical Calculation Calculator) version 19.1 will be used to tabulate and statistically analyze the acquired data. For numerical parametric data, descriptive statistics were calculated as mean ± SD (standard deviation), minimum, and maximum values; for categorical data, descriptive statistics were calculated as number and percentage. The Chi-square test for separate groups was used for inferential analysis of qualitative data. A P-value of less than 0.05 was considered significant.

Results and Discussion

This research was conducted on 22 cases with clinically suspected peripheral joints pathology. The age of studied cases varied from 30 years & 56 years with mean age was 47.55± 7.60 years. The age group between 50-60 years was the most frequent (63.6%). Regarding gender, the male to female ratio was 0.83:1, with 10 men (45.5% of the total) and 12 women (54.5%). Twelve individuals had problems with their ankle joints representing (54.5%) of all tendons injuries followed by wrist joint in 36.4% cases, then wrist & hand small joints in 9.1% patients.

There was a high degree of concordance between US and MRI in detection of joint effusion (kappa =0.792, p<0.001). The comparative study between MRI & US regarding detection of joint effusion showed 100 % specificity, 100 % PPV, 87.5 % sensitivity, 75 % NPV & 90.91% overall accuracy as shown in table (1).

In addition, US and MRI were in strikingly close agreement in detection of hands & feet muscles tenosynovitis (kappa =1.00, p<0.001)**. For example,** the research contrasting US and MRI regarding detection of Peroneal tendons tenosynovitis demonstrated one hundred percent sensitivity, one hundred percent specificity, one hundred percent PPV, one hundred percent NPV & one hundred percent overall accuracy as shown in table (2).

There were two cases that positive for talar head marrow contusion in MRI who cannot be detected by US with no agreement between US & MRI in detection of talar head marrow contusion. The comparative study between MRI and US regarding detection of Talar head subchondritis showed 0 % sensitivity, 100 % specificity, 90.9 % NPV, and 90.9% overall accuracy (Table 3)**.**

We found that the results of US and MRI agreed with one another quite well. in detection of bony calcaneal spur (kappa =1.00, p<0.001)**.** The research that compared MRI and US regarding detection of bony calcaneal spur indicated 100 % PPV, 100 % NPV, 100 % sensitivity, 100 % specificity & 100% overall accuracy (Table 4).

Also, The results of US and MRI agreed with one another quite well in detection of planter fasciitis (kappa =1.00, p<0.001)**.** The research that compared MRI and US regarding detection of planter fasciitis showed one hundred percent sensitivity, one hundred percent specificity, one hundred percent PPV, one hundred percent NPV & one hundred percent overall accuracy (Table 5).

The US has a significant excellent agreement with MRI in detection of Tenosynovitis of hands and feet muscles tendons, For example, 4th extensor compartment tendons (EDL & EIP tendons) (kappa =1.00, p<0.001). The research that compared MRI and US regarding detection of Tenosynovitis of 4th extensor compartment tendons (EDL & EIP tendons) indicated 100 % PPV, 100 % sensitivity, 100 % specificity, 100 % NPV & 100% overall accuracy (Table 6).

Table (1): Accuracy measures of US regarding detection of joint effusion in relation to MRI:

Joint effusion		MRI						Total	Sensitivity	Specificity	PPV	NPV	Accuracy	p-value
		Negative			Positive									
US	Negative	6	27.3%	(TN)	2	9.1%	(FN)	8 (36.4%)	87.5%	100%	100%	75%	90.91%	<0.001
	Positive	0	0.0%	(FP)	14	63.6%	(TP)	14 (63.6%)						
	Total	6	27.3%		16	72.7%		22 (100%)						

Table (2): Accuracy measures of US regarding detection of Peroneal tendons tenosynovitis in relation to MRI:

Peroneal tendons tenosynovitis		MRI						Total	Sensitivity	Specificity	PPV	NPV	Accuracy	p-value
		Negative			Positive									
US	Negative	16	72.7%	(TN)	0	0.0%	(FN)	16 (72.7%)	100%	100%	100%	100%	100%	<0.001
	Positive	0	0.0%	(FP)	6	27.3%	(TP)	6 (27.3%)						
	Total	16	72.7%		6	27.3%		22 (100%)						

Table (3): Accuracy measures of US regarding detection of Talar head marrow contusion in relation to MRI:

Talar head marrow contusion		MRI						Total	Sensitivity	Specificity	PPV	NPV	Accuracy	p-value
		Negative			Positive									
US	Negative	20	90.9%	(TN)	2	9.1%	(FN)	22 (100%)	0%	100%	NA	90.9%	90.9%	NA
	Positive	0	0.0%	(FP)	0	0.0%	(TP)	0 (0.0%)						
	Total	20	90.9%		2	9.1%		22 (100%)						

Table (4): Accuracy measures of US regarding detection of Bony calcaneal spur in relation to MRI:

Bony calcaneal spur		MRI						Total	Sensitivity	Specificity	PPV	NPV	Accuracy	p-value
		Negative			Positive									
US	Negative	20	90.9%	(TN)	0	0.0%	(FN)	20 (90.9%)	100%	100%	100%	100%	100%	<0.001
	Positive	0	0.0%	(FP)	2	9.1%	(TP)	2 (9.1%)						
	Total	20	90.9%		2	9.1%		22 (100%)						

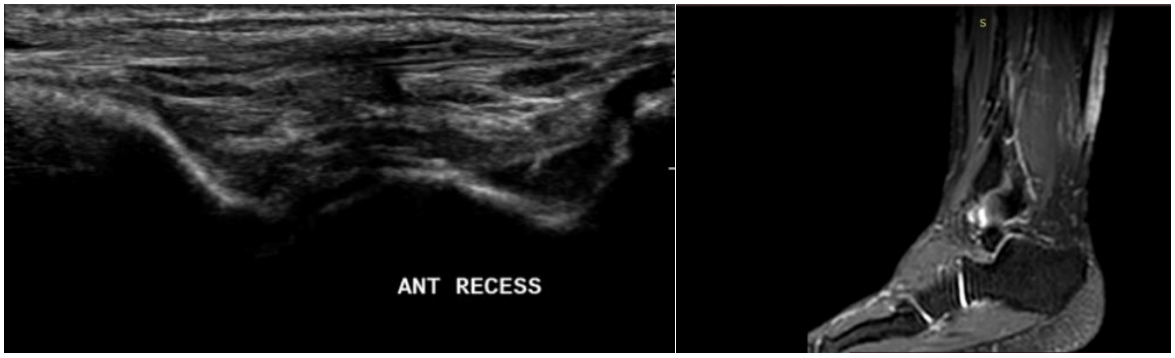
TP: True positive, **TN**: True negative, **FP**: False positive, **FN**: False negative

Table (5): Accuracy measures of US regarding detection of Planter fasciitis in relation to MRI:

Planter fasciitis		MRI						Total	Sensitivity	Specificity	PPV	NPV	Accuracy	p-value
		Negative			Positive									
US	Negative	20	90.9%	(TN)	0	0.0%	(FN)	20 (90.9%)	100%	100%	100%	100%	100%	<0.001
	Positive	0	0.0%	(FP)	2	9.1%	(TP)	2 (9.1%)						
	Total	20	90.9%		2	9.1%		22 (100%)						

Table (6): Accuracy measures of US regarding detection of Tenosynovitis of 4th extensor compartment tendons (EDL & EIP tendons) in relation to MRI:

Tenosynovitis of 4th extensor compartment tendons (EDL & EIP tendons)		MRI						Total	Sensitivity	Specificity	PPV	NPV	Accuracy	p-value
		Negative			Positive									
US	Negative	18	81.8%	(TN)	0	0.0%	(FN)	18 (81.8%)	100%	100%	100%	100%	100%	<0.001
	Positive	0	0.0%	(FP)	4	18.2%	(TP)	4 (18.2%)						
	Total	18	81.8%		4	18.2%		22 (100%)						



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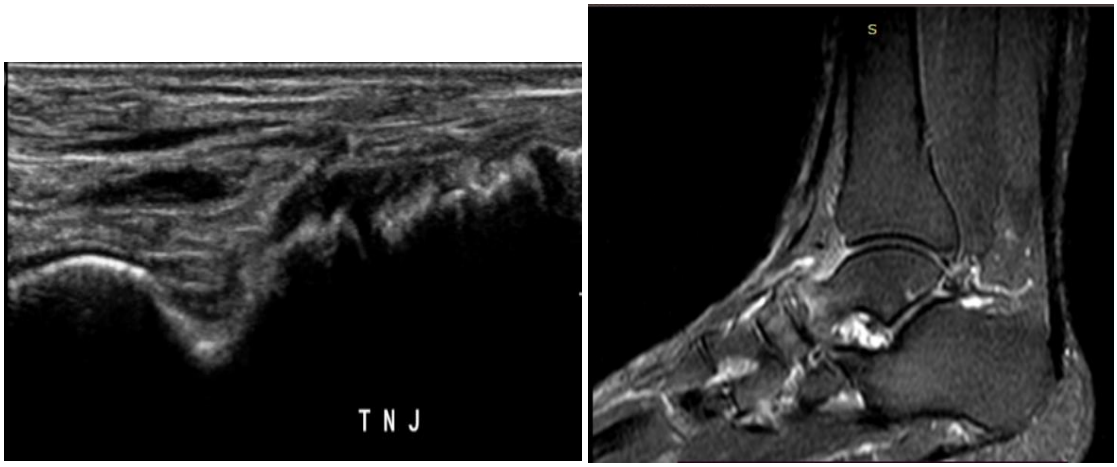

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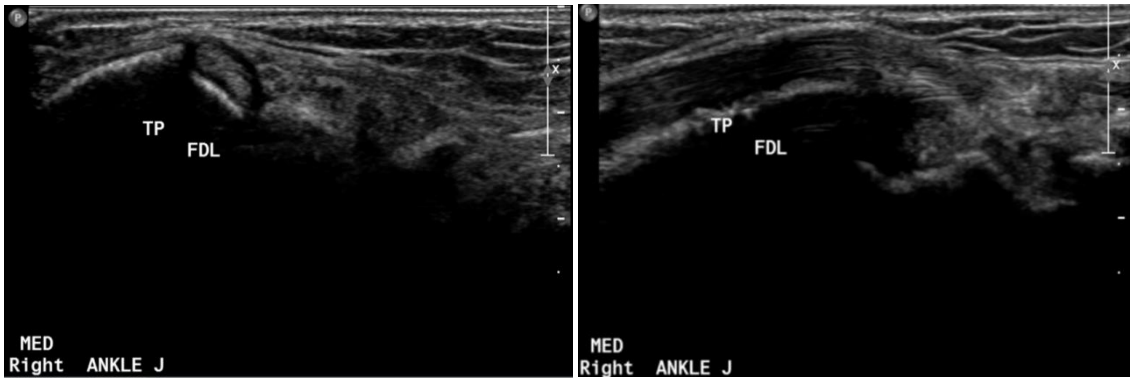

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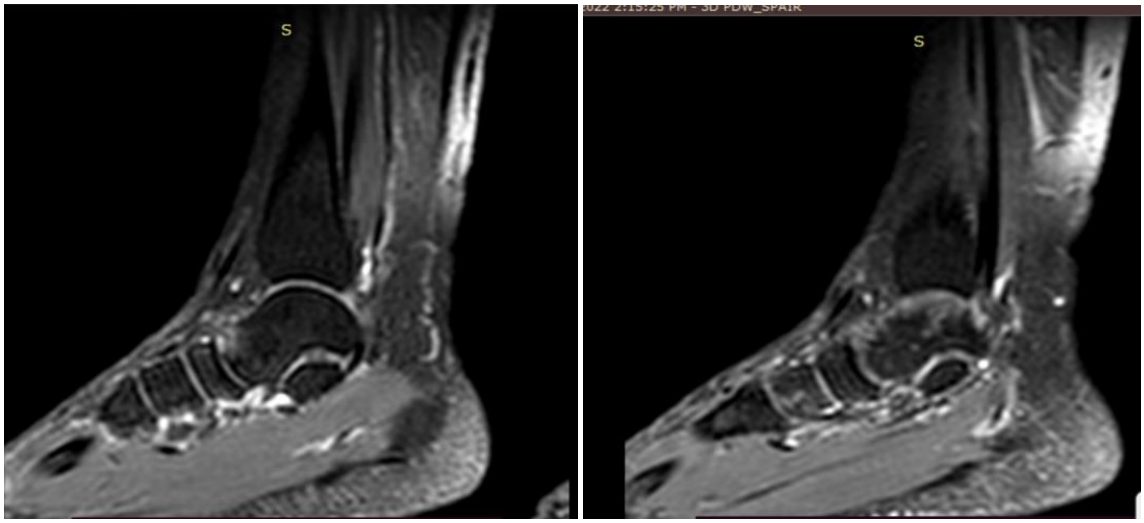
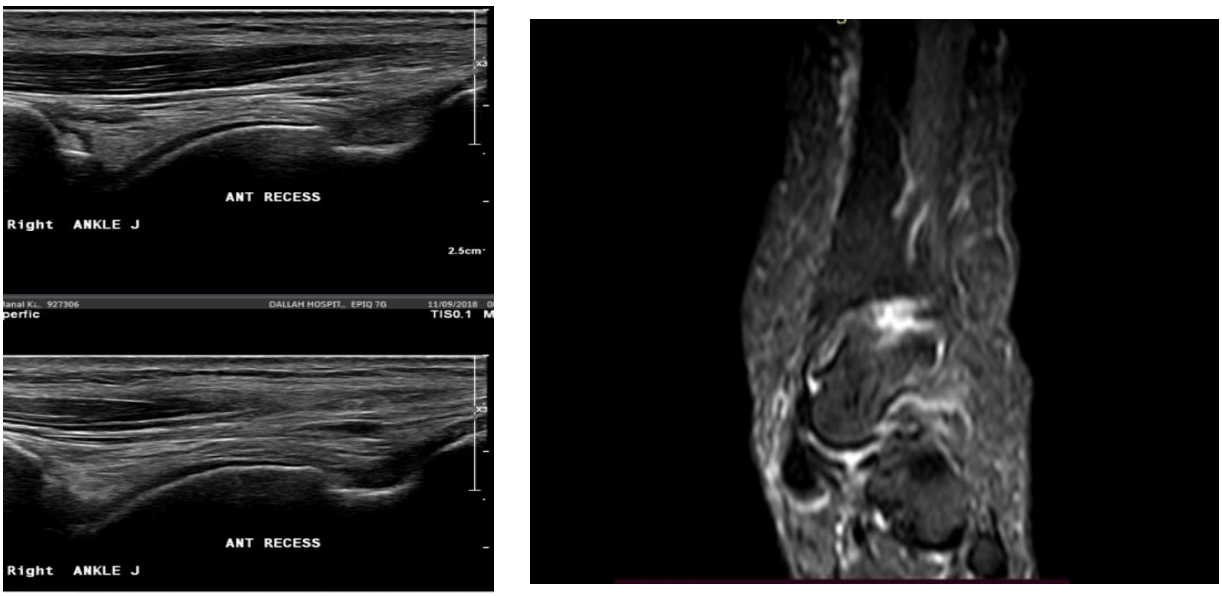


G **H**

Figure (1): Male patient, 44 yrs old complaining of morning stiffness & limitation of movemnets in his ankle joint. 1-A. Ultrasound image (transverse view) showing mild anterior recess joint effusion. B. STIR Magnetic resonance image (sagittal view) of the foot showing mild joint effusion. C. Ultrasound images (saggital view) showing mild talonavicular synovitis & marginal osteophytes. D. T2- WI MRI image showing mild OA changes of TN joint. E&F. Ultrasound image s(transverse & sagittal views) showing mild tibialis posterior tenosynovitis. G. PD MRI image (sagittal views) showing mild tibialis posterior tenosynovitis. H. PD MRI (sagittal view) showing talar head subarticular chondritis.



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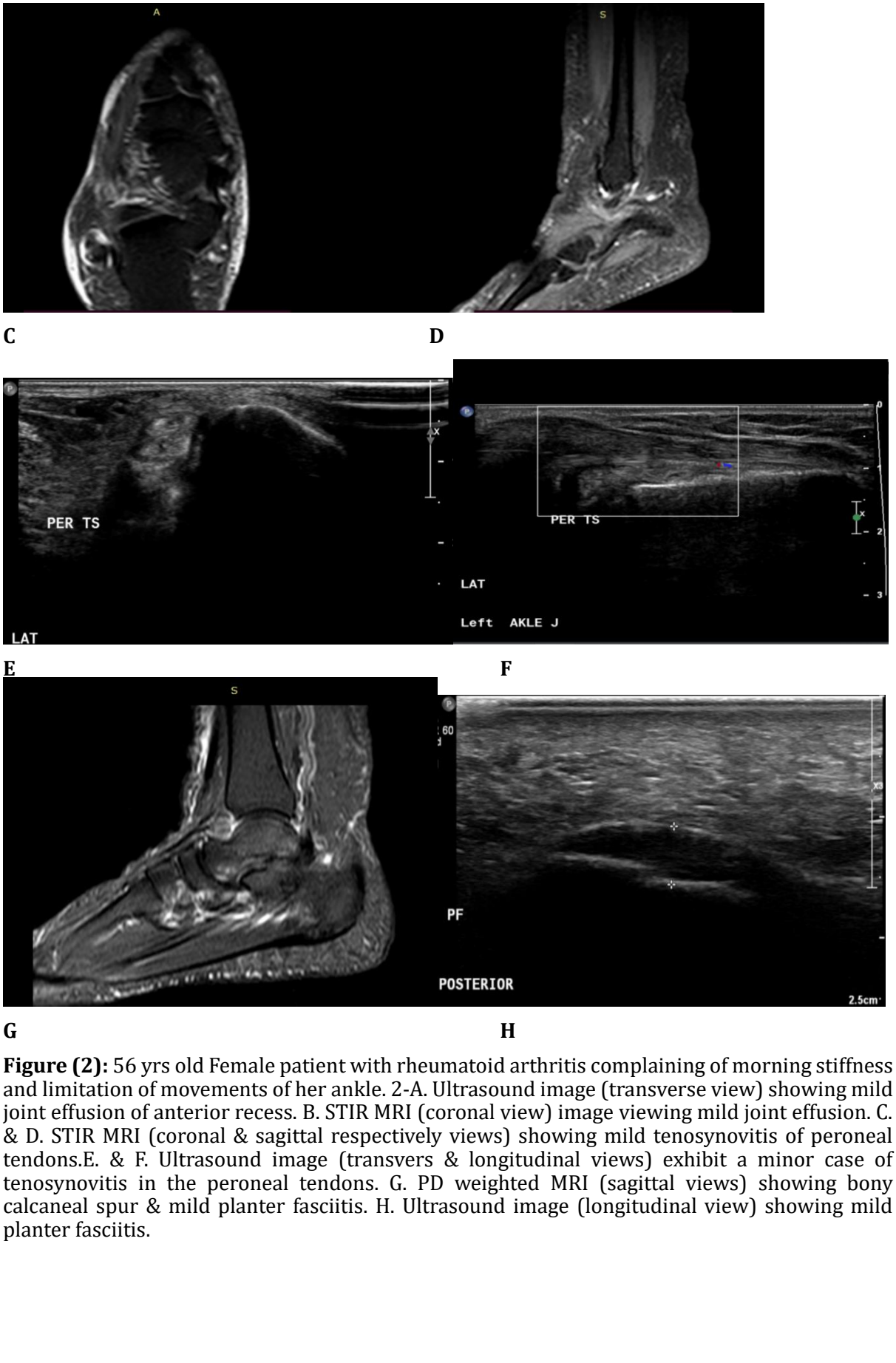

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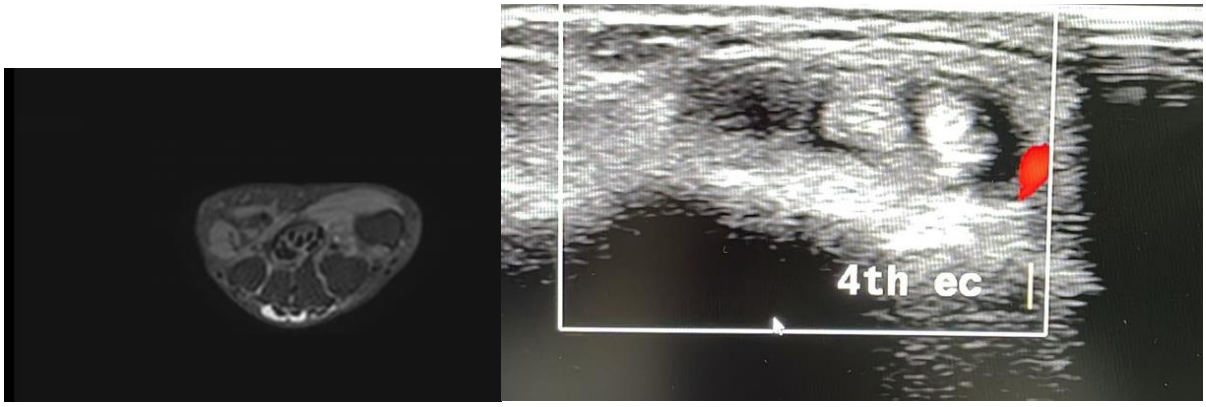
Figure (2): 56 yrs old Female patient with rheumatoid arthritis complaining of morning stiffness and limitation of movements of her ankle. 2-A. Ultrasound image (transverse view) showing mild joint effusion of anterior recess. B. STIR MRI (coronal view) image viewing mild joint effusion. C. & D. STIR MRI (coronal & sagittal respectively views) showing mild tenosynovitis of peroneal tendons.E. & F. Ultrasound image (transvers & longitudinal views) exhibit a minor case of tenosynovitis in the peroneal tendons. G. PD weighted MRI (sagittal views) showing bony calcaneal spur & mild planter fasciitis. H. Ultrasound image (longitudinal view) showing mild planter fasciitis.



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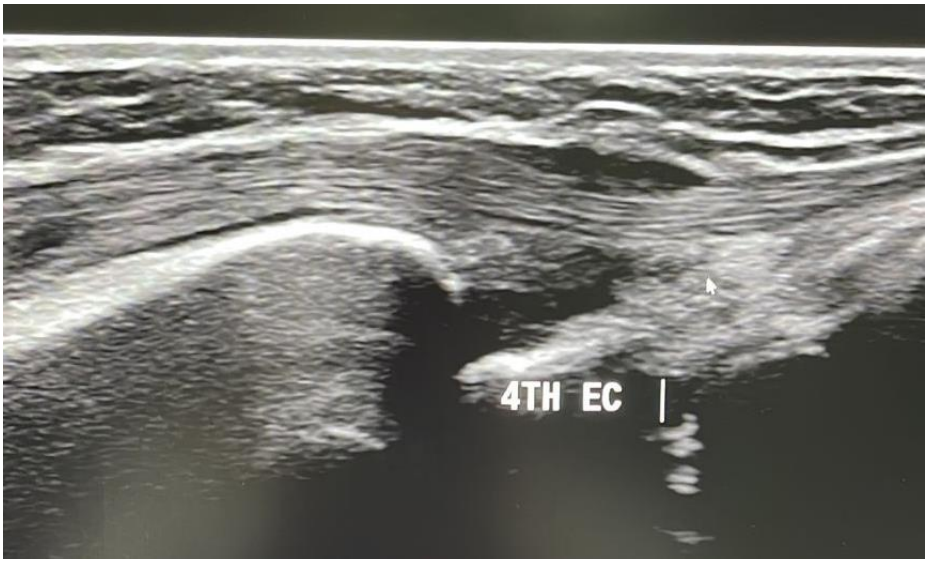
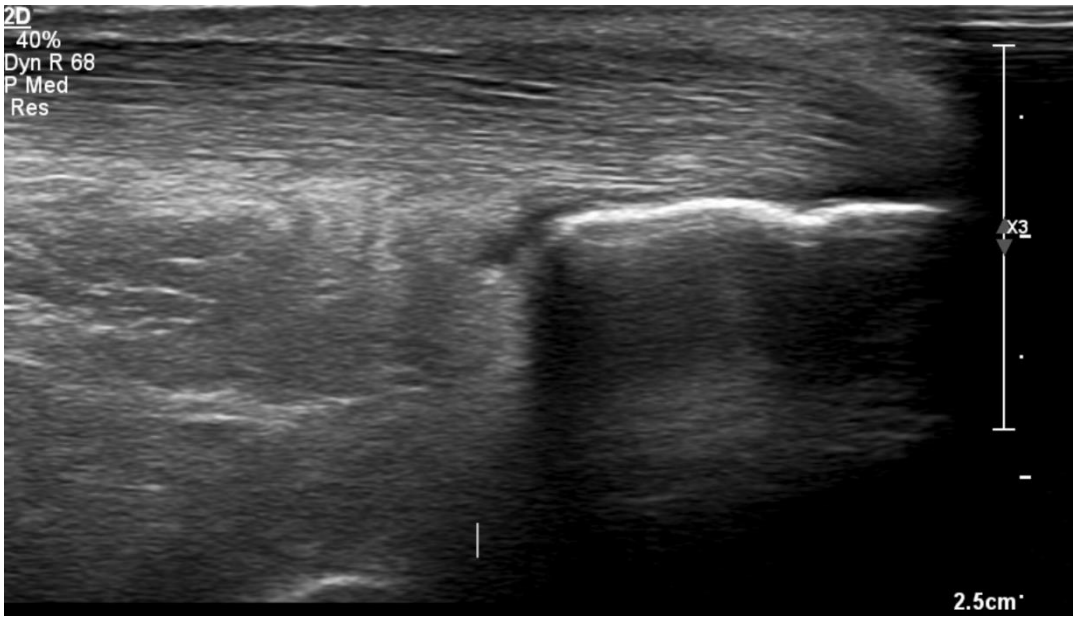


C

Figure (3): 52 yrs old female patient with reumatoid arthritis complaining of morning stiffness and limitation of movements of her hand showing 3.A. STIR MRI axial image showing Mild tenosynovitis of extensor degitorum and extensor indices proprius tendons. B. Ultrasound transverse view showing mild tenosynovitis of 4th compartment tendons (extensor degitorum and extensor indices prop. Tendons).



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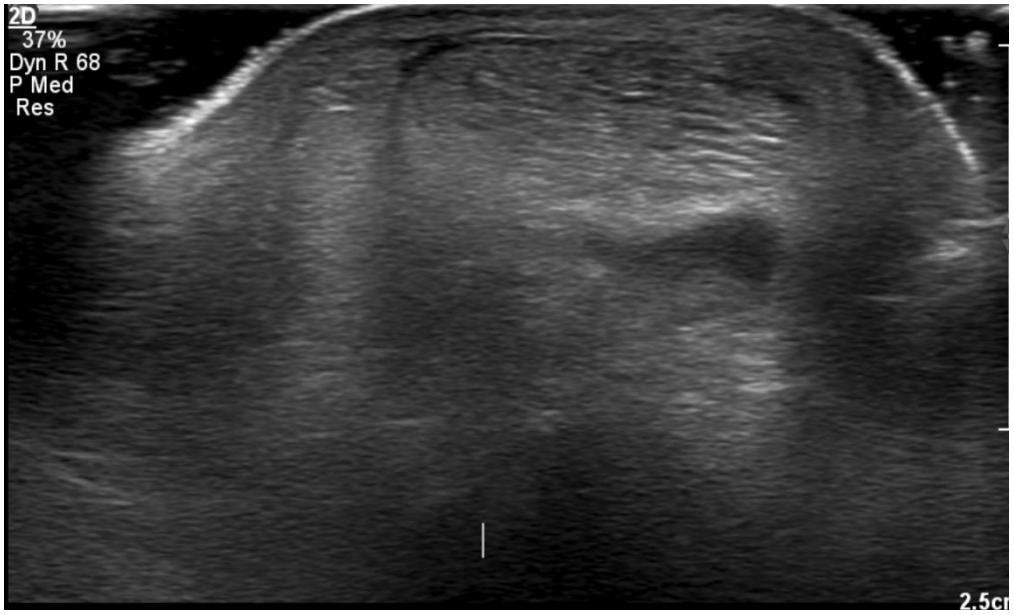
2D
37%
Dyn R 68
P Med
Res
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B


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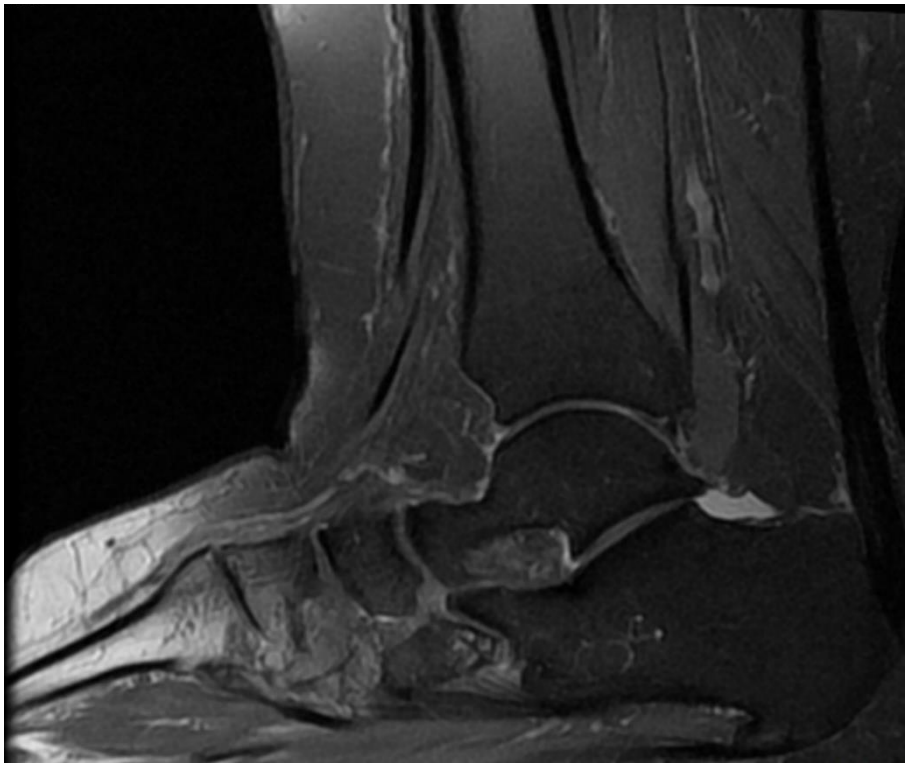

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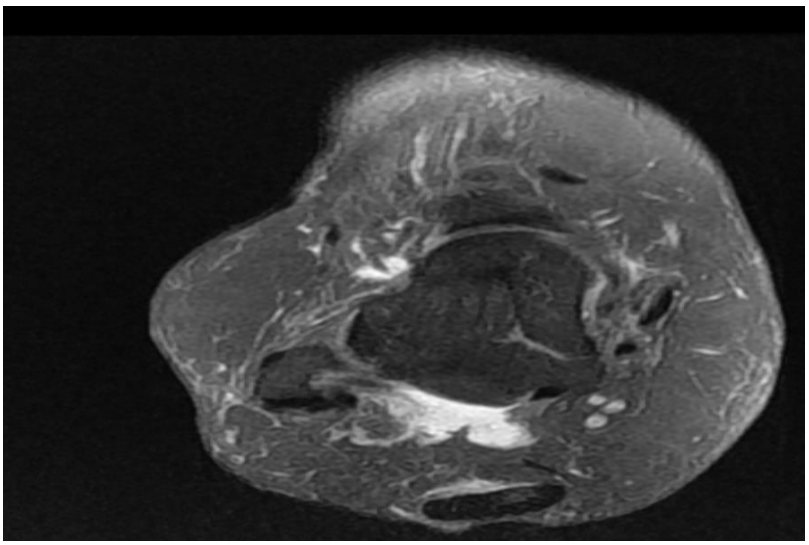

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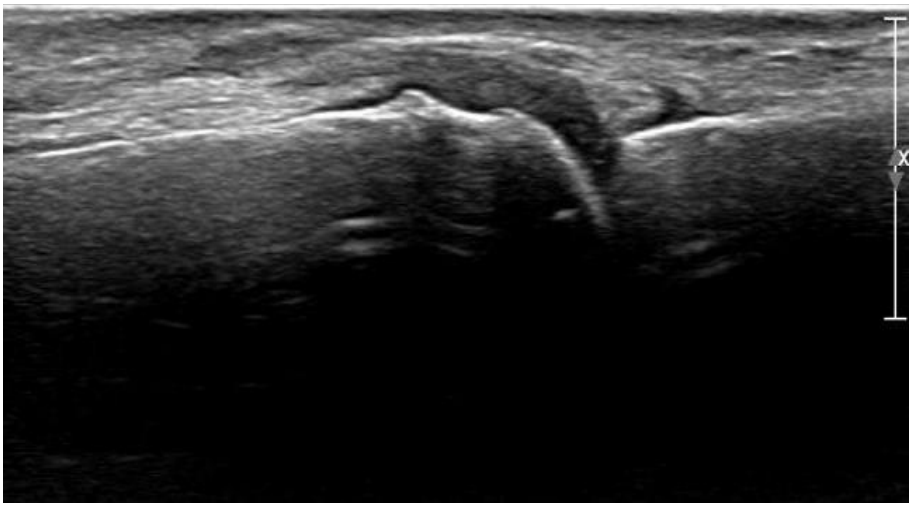
Figure (4): 50 yrs old male patient with chronic psoriasis, complaining of limitation of movements of his ankle joint. 4. A., B. & C Ultrasound images longitudinal, transverse & longitudinal views showing tendoachilis peritendinopathy & retrocalcaneal bursitis. D & E STIR MRI ankle joint sagittal & axial images showing tendoachilis peritendinopathy & retrocalcaneal bursitis.



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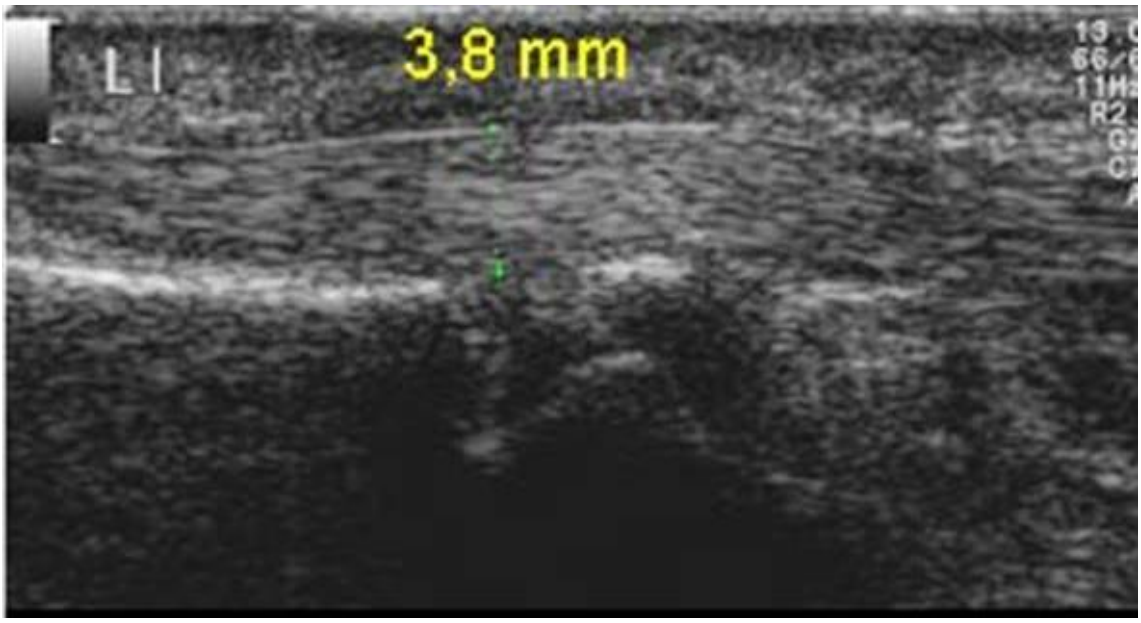

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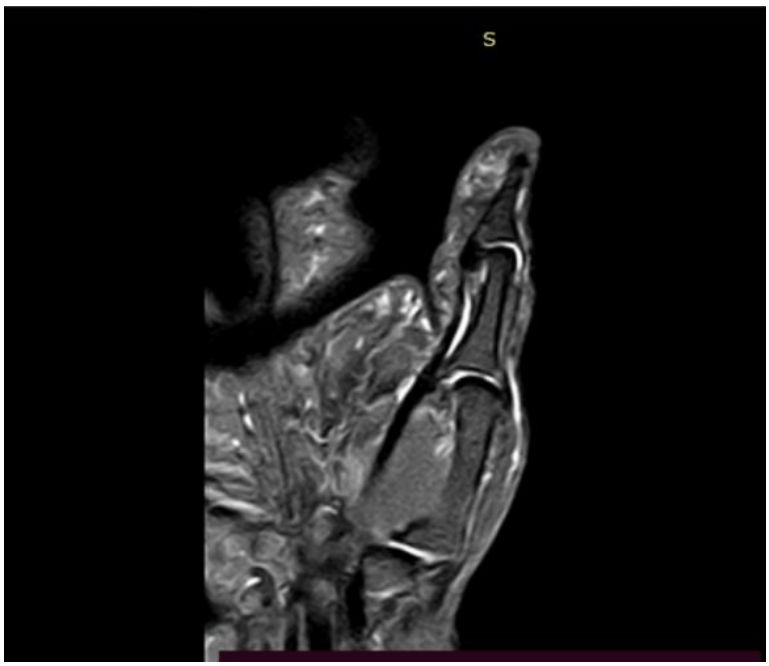

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Figure (5): 51 yrs female patient with rheumatoid arthritis, complaining of morning stiffness & limitation of movements of her hand. 5. A. Ultrasound longitudinal images showing mild OA changes & synovial thickening of 1st carpo-metacarpal joint. B. ultrasound longitudinal view image showing flexor policis longus tenosynovitis (trigger finger). C. STIR MRI coronal view image showing mild osteoarthritic changes & synovial thickening of 1st Metacarpo-phalangeal joint. C. & D. (STIR MRI axila view image) showing mild flexor policis longus tenosynovitis (trigger finger).

However, the evaluation of soft tissues, which may be impacted from the outset of the disease, is not possible with radiographic imaging. Ultrasound (US) and magnetic resonance imaging (MRI) of the musculoskeletal system are new imaging modalities that play a significant role in the diagnosis, therapy selection, and disease monitoring of inflammatory disorders of the joints [6].

Concerning radiological findings in detection Joint effusion Kappa statistics revealed significant good agreement among US & MRI in detection of joint effusion (kappa =0.792, p<0.001). Comparison between MRI and US regarding detection of joint effusion showed 87.5 % sensitivity, one hundred percent specificity, one hundred percent PPV, one hundred percent NPV, and 90.91% overall accuracy. The findings of our study are corroborated by those of Draghi et al. [7], who found that ultrasound (US) was more accurate than magnetic resonance imaging (MRI) in detecting knee joint effusion in 78 of 96 participants (sensitivity = 81.3%, specificity = 100%, PPV = 100%, NPV = 77.5%, p = 0.001).

A systematic review conducted by Maricar et al. [8] that included 10 papers. Eight of them focused on the dependability of clinical assessments in comparison to ultrasonography effusion, and four on the validity of such assessments. Visible swelling had an intra-observer kappa of 0.37 (suprapatellar) to 1.0 (prepatellar), 0.47 (bulge sign), and 0.37 (balloon sign). Visible swelling had a kappa of 0.02 (prepatellar) to 0.65 (infrapatellar), a balloon sign kappa of 0.11 to 0.82 (patellar tap: 0.02 to 0.75), and a bulge sign kappa of 0.04 to 0.14 (bursa: 0.97). Observers with more experience had higher rates of reliability and diagnostic accuracy. Specificity increases with greater effusion size, and there aren't a lot of studies comparing the sensitivity of different clinical tests, which ranges from 18.2-85.7%.

Concerning radiological findings in detection of hands and feet muscles tenosynovitis Kappa statistics revealed significant excellent agreement between US & MRI in detection of for example, peroneal muscles tenosynovitis (kappa =1.00, p<0.001). Comparison between MRI and US regarding detection of Peroneal tendons tenosynovitis revealed one hundred percent sensitivity, one hundred percent specificity, one hundred percent PPV, one hundred percent NPV & one hundred percent overall accuracy.

Twenty individuals with tendon disease were studied by El-Liethy et al. [9], who found that diagnostic interpretations for twenty-one pathological entities were identical using ultrasound and MRI imaging modalities (100% sensitivity for tendon pathology). US & MRI confirmed the presence of abnormal ligaments in 21 cases. Contrary to what was seen by MRI, US revealed only partial tears in two ligamentous lesions. Two patients additionally had retrocalcaneal bursitis, four had joint effusion, and three had joint synovitis as a comorbidity.

Regarding radiological findings in Talar head marrow contusion Kappa statistics revealed that two positive cases for talar head marrow contusion in MRI could not be detected by US with no agreement between US & MRI in detection of talar head marrow contusion. Comparison between MRI and US regarding detection of talar head marrow contusion showed 0 % sensitivity, 100 % specificity, 90.9 % NPV, and 90.9% overall accuracy.

In our current study Kappa statistics revealed significant excellent agreement between US & MRI in detection of bony calcaneal spur (kappa =1.00, p<0.001). Comparison between MRI and US regarding detection of bony calcaneal spur exposed 100 % PPV, 100 % NPV, 100 % sensitivity, 100 % specificity & 100% overall accuracy.

Our study is inconsistent with Abdelaziz et al. [10] who reported that The sensitivity of US for detecting a calcaneal spur was low, and it was completely insensitive for detecting bone marrow edema.

Both ultrasound and magnetic resonance imaging (MRI) concur, however, that in cases, plantar fascial thickness was significantly greater than in controls. The diagnostic accuracy of US was 93.3% for the identification of focal thickening and fascial aberrant signaling, with a sensitivity of 92.6 & a specificity of 100%.

Concerning radiological findings in detection of planter fasciitis Kappa statistics revealed significant excellent agreement between US & MRI in detection of planter fasciitis (kappa =1.00, p<0.001). Comparison between MRI and US regarding detection of planter fasciitis shown a sensitivity of 100%, a specificity of 100%, a PPV of 100%, an NPV of 100%, and an accuracy of 100% overall.

When it comes to ankle discomfort, our findings are consistent with those of Shalaby et al. [11], who found that US may be utilized as a preliminary diagnostic tool. Only when the results of an ultrasound are inconclusive or negative should an MRI be performed. Synovitis, arthritis, plantar fasciitis, tendon and ligamentous lesions were all detectable with US. Overall, its accuracy was 92.8%, its sensitivity was 95.4%, and its specificity was 83.3%. Ultrasound was not very helpful in identifying AVN, bone marrow oedema, or fractures.

Ali et al. [12] also showed that ultrasound was able to detect a variety of ankle lesions (tendinous and ligamentous injury, plantar fasciitis, joint effusion, bursitis, ganglion cysts, tarsal tunnel syndrome) with 100% sensitivity and specificity for tendons pathology and 80% sensitivity and 100% specificity for ligamentous injuries, and overall accuracy of 95% compared to MRI. All bone lesions that showed as positive on MRI were negative on US.

Concerning radiological findings in Tenosynovitis of hands & feet muscles for example, 4th extensor compartment tendons (EDL & EIP tendons), Kappa statistics revealed significant excellent agreement between US & MRI in detection of Tenosynovitis of 4th extensor compartment tendons (EDL & EIP tendons) (kappa =1.00, p<0.001). Comparison between MRI and US regarding detection of Tenosynovitis of 4th extensor compartment tendons (EDL & EIP tendons) indicated 100 % PPV, 100 % NPV, 100 % sensitivity, 100 % specificity &100% overall accuracy.

Bruyn et al. [13] examined the tendons of the wrist extensors (compartments 2, 4, and 6), the flexors of the third and fourth fingers (MCP), the tibialis posterior tendon, and the peronei. Grey scale (GS) tendon damage, peritendinous power Doppler (PPD) signal strength, intratendinous power Doppler (IPD) signal strength, and overall positive and negative agreements and -values were determined. GS tenosynovitis with intraobserver κ-values ranging from 0.53 to 0.55 (P< 0.0005), PPD signal from 0.61 to 0.64 (P< 0.0005), IPD signal from 0.65 to 0.66 (P< 0.0005), and GS tendon damage from 0.44 to 0.53 (P< 0.0005). Interobserver reliability showed a high degree of consistency, with a range of 97 to 100% for PPD signal, 97 to 100% for IPD signal, and 97 to 100% for GS tendon injury, with GS tenosynovitis falling in the 80 to 89% range. Findings were obtained regardless of scanning method.

Conclusion

Both ultrasound & MRI findings showed an excellent agreement and high accuracy in detection of inflammatory pathology of peripheral joints. However, two positive cases for talar head subchondritis in MRI could not be detected by US and two positive cases for talar head marrow contusion in MRI could not be detected by US.

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