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High resolution ultrasonography in ankle joint pain: Where does it stand?

Mennatallah Hatem Shalaby [a,*], Sherin M. Sharara [a], Mohammed H. Abdelbary [b]

[a] Department of Radiodiagnosis, Faculty of Medicine, Ain Shams University, Egypt
[b] Department of Diagnostic & Interventional Radiology, Faculty of Medicine, Helwan University, Egypt

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ABSTRACT

Background: The ankle is frequently injured in trauma, overuse syndrome and inflammatory processes. Different imaging modalities assess the ankle, including plain radiography, computed tomography (CT), magnetic resonance imaging (MRI), and ultrasonography (US).
Purpose: Our objective is to assess the role of high resolution US as a valuable tool in the depiction of causes of ankle joint pain.
Patients and methods: The study included 28 patients presented with ankle pain ranging in age from 17 to 60 years. They were examined by US and findings were correlated with MRI.
Results: US was capable to detect various lesions (synovitis, arthritis, plantar fasciitis, tendon and ligamentous lesions). It had a sensitivity of 95.4%, a specificity of 83.3% and an overall accuracy of 92.8%. US had a limited value in detection of avascular necrosis (AVN), bone marrow oedema and fractures.
Conclusion: US can be used as a first step diagnostic tool in cases of ankle pain. MRI should be spared to cases with negative or equivocal US findings.

1. Introduction

Usually, the ankle joint's lesions are due to trauma, inflammatory disorders or overuse syndrome. Different imaging modalities are used to evaluate the ankle joint including plain radiography, CT, US and MRI [1].

US is a rapid, available, safe and non invasive tool. It has a low cost in comparison to CT and MRI. It doesn't have the risk of ionization radiation as in CT and plain radiography nor the contraindications of cardiac pacemakers and metallic implants as in MRI. Colour and power Doppler (PD) add essential data about the related vascular structures [2].

Another privilege of US is that it is done in real time which aids the radiologist to identify the pain location and to compare with the opposite side [3].

Moreover, US permits the dynamic assessment of tendons and muscles. It can evaluate the whole tendon length as well as tendon function and possible subluxation. Compression also helps to differentiate tendinopathy from tendon tearing [4].

MSK US can be a helpful imaging modality for evaluation of MSK lesions. It is a fact that MRI is more frequently performed for MSK lesions than US, yet both of them have pros and cons and can be considered as complementary to each other. As for US, there has been marked improvement in its capability to detect multiple MSK lesions with increased resolution [5].

However, some pitfalls of MSK US exist, most important of which lie in its narrow field of view and limited penetration, which might lead to improper assessment of bone and joint structures. MSK US can also be limited by the variations in the quality and cost of the US machine itself. It is also operator dependent limited by the skill of the operator [6].

The purpose of this study is to evaluate the role of high resolution US in the evaluation of the causes of the ankle joint pain as compared to MRI.

2. Patients and methods

This study comprised 28 patients, ranging in age from 17 to 60 years with a mean age of 34.9 ± 12 years. The study was conducted during the period from July 2015 till July 2016 and approved by the local research ethical committee at the Faculty of Medicine, Ain Shams University.

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* Corresponding author.
E-mail address: Mennatshalaby@yahoo.com (M.H. Shalaby).

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2.1. Patients' selection criteria

Inclusion criteria:

- Ankle joint pain, (either acute or chronic), (post traumatic or non traumatic).
- No age or sex predilection

Exclusion criteria:

- Patients who had previous ankle surgery for tendons or ligaments repair.
- Patients who had contraindications to MRI such as those with cardiac pacemakers.

All patients were subjected to the following:

- Detailed history.
- Clinical evaluation of the affected ankle joint.

2.2. Methods

2.2.1. High resolution US examination

No special preparation was needed. The patient's position changed according to the examination site. Philips HD11 and Esaote my lab60 US machines were used with a superficial 7–10 MHz transducer. The US examination was done in a compartmental way.

(1) *Anterior compartment:* the patient lied in a supine position. Longitudinal scanning of the ankle was first performed to get a comprehensive view of the tibio-talar joint and to depict any joint effusion or any intra-articular loose bodies with separate assessment of the extensor tendons of the ankle and anterior tibio-fibular ligament (ATFL).
(2) *Lateral compartment:* slight inversion of the foot was performed while the patient lied in the supine position to evaluate the lateral collateral ligaments and peroneal tendons. Dynamic examination was done in both eversion and dorsiflexion positions to note any tendon dislocation or subluxation if clinically suspected.
(3) *Medial compartment:* the patient was asked to rotate his lower limb laterally in the supine position to assess the deltoid ligament and flexor tendons.
(4) *Posterior compartment:* The patient was asked to lie in a prone position and rest on his/her toes. The Achilles tendon (AT) was examined from its musculo-tendinous junction to its calcaneal insertion in both the longitudinal and transverse axes with full evaluation of the surrounding structures.
(5) *Sole of the foot:* the probe was positioned inferiorly in the sagittal plane at the plantar aspect of the foot to evaluate the plantar fascia.

2.2.2. Gold standard test (MRI examination)

After the US examination, the patient was scheduled to do MRI of the ankle joint within a maximum of 2 days.

Technique of MRI examination:

There is no special patient preparation. Ankle MRI was performed using a 1.5-T unit (Signa, GE Healthcare) with a dedicated extremity surface coil, a field of view of 12–16-cm, slice thickness of 3–5-mm with a 1-mm gap, and matrix of 256 × 192–512. All patients were imaged in a supine position with the foot in 20° plantar flexion. Imaging is done in axial, coronal and sagittal planes in line with the top of the table. T1-weighted (repetition time msec/echo time/msec = 600/20) and T2-weighted (2000/20, 80) and STIR sequences (1500/20; inversion time msec = 100–150). In post contrast studies, 0.1 mmol/kg Gadolinium was injected and T1 FAT SAT sequence was taken in axial and coronal planes. Contrast was used in 3 patients with synovitis and septic arthritis.

2.2.3. Additional procedures

Some additional procedures were done for few patients, where fine needle aspiration was done for 1 patient (septic arthritis), CT scan was done for one patient (suspected fracture), complementary hand and finger US done for 1 patient and (SLE patient with marked arthritis and synovitis) and complementary post contrast MRI was done for 3 patients (septic arthritis and synovitis).

2.3. Statistical analysis

Analysis of data was done by IBM computer using SPSS (statistical program for social science version 16) as follows:

- Description of quantitative variables as mean, SD and range.

Table 1
The spectrum of US imaging abnormalities.

Variable	Number	%
Tendon abnormalities (tenosynovitis, tear, tendinopathy)	7	25
Ligamentous injury	2	7.1
Effusion, synovitis	3	10.7
Soft tissue abnormalities (cellulitis, plantar fasciitis)	6	21.4
Soft tissue masses	3	10.7
Bone pathology	2	7.1
Joint space Pathology (OA., septic arthritis	2	7.1
Normal	6	21.4

(OA: osteoarthritis).
N.B. Three patients had combined pathology.

Fig. 1. Pie chart showing distribution of ankle pain among the studied group.

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Table 2
False negative cases by US.

Final diagnosis by MRI	No	%
Bone marrow oedema	1	3.6
Talar dome AVN	1	3.6
Bone fracture	1	3.6
Ligament pathology	1	3.6

Table 3
Findings of additional procedures.

Procedure	Diagnosis by US	Number of cases
Fine needle aspiration	Septic arthritis	1
Hand and finger US	SLE	1
Post contrast MRI	Synovitis & septic arthritis	3
CT	Suspected fracture	1

- Description of qualitative variables as number and percentage.
- Fisher exact test was used to compare qualitative variables.

Validity parameters
- Sensitivity.
- Specificity.
- PPV (positive predictive value).
- NPV (negative predictive value).
- Accuracy.

P value > 0.05 insignificant.
P < 0.05 significant.
P < 0.001 highly significant [7].

3. Results

The study included 5 (17.9%) males and 23 (82.1%) females. Their age ranged from 17 to 60 years with a mean age of 34.9 + 12 years.

Chronic ankle pain was the most common presenting symptom in 20 patients (71.4%) whereas 8 (28.6%) patients presented with acute ankle pain. The second most presenting symptom was ankle joint swelling either painful (26.7%) or painless (13.3%).

The lateral ankle compartment was the most common affected compartment (30%) of cases. The distribution of the site of ankle pain is illustrated in Fig. 1.

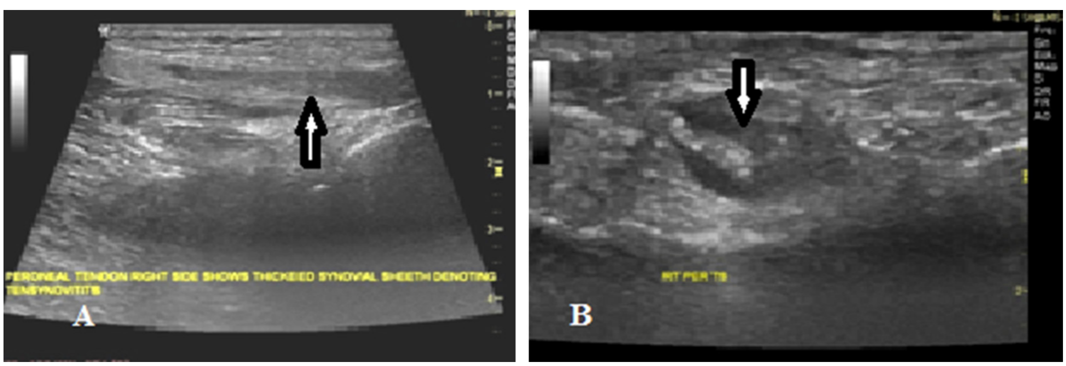

Fig. 2. Peroneal tenosynovitis A. Transverse and B. Longitudinal US images of peroneal tendons show hypoechoic thickening (white arrow) around peroneal tendons.

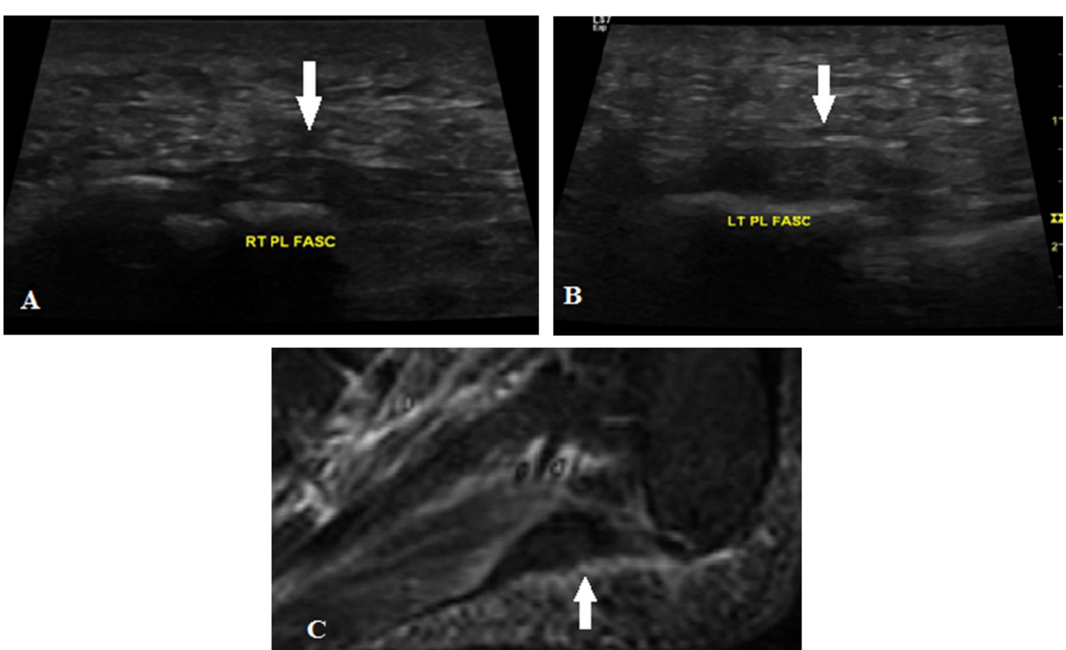

Fig. 3. A and B longitudinal US images at mid heal level show thickened hypoechoic plantar fascia (white arrow) bilaterally setting the diagnosis of plantar fasciitis (white arrow). C. corresponding sagittal STIR image shows thickened proximal plantar fascia (white arrow) with slight perifascial oedema.

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Positive history of trauma was encountered in 35.7% of cases.

Abnormal US findings were encountered in 22 cases (78.6)%. Three patients had combined pathology. The spectrum of US imaging abnormalities is summarized in (Table 1).

As compared to MRI as a gold standard; the sensitivity of US was 95.4%, specificity was 83.3%. There was only one false positive case where a bone fracture was suspected with negative corresponding bony abnormality on CT and MRI. There were 4 false negative cases; the missed pathology is listed in Table 2.

US had a PPV of 95.4% and NPV of 83.3% of with overall accuracy of 92.8%.

The additional procedures done helped to confirm the US diagnosis in 5 patients and to rule out a suspected fracture in one patient as listed in Table 3.

4. Discussion

US has been popular for MSK system assessment for many years, yet high resolution ankle US is not used on widely. This might be due to limited research on US in comparison to MRI, relative lack of expert radiologists as well as the difficulty in detecting the anatomical structures and lesions on given US images [8].

A privilege of US that has been reported by Jacobson, 2009 [9] is its effectiveness in assessing soft tissue lesions found near metallic implants. Despite the improvements in CT and MRI in suppression of the metallic artefacts, yet US proved to be ideal in this entity as in the setting of presence of abscess or a tendon near a metallic plate or screw.

Our case series included 28 patients presented with ankle joint pain, whatever its course was either acute (28.4%) or chronic (71.4%) and ankle joint swelling either painful (26.7%) or painless (13.3%) with history of trauma in 35.7% with no age or sex predilection.

Thirty percent of our cases presented with anterolateral ankle pain which is in line with Chan et al. [10] who assumed that almost 75% of sports related ankle injuries affect the lateral ligamentous complex. The ATFL is the most frequently affected ligament being the weakest ligament in the lateral compartment [11,12].

We detected a spectrum of different lesions by US ranging from inflammatory and infectious lesions to ligamentous injury up to tendinous injury.

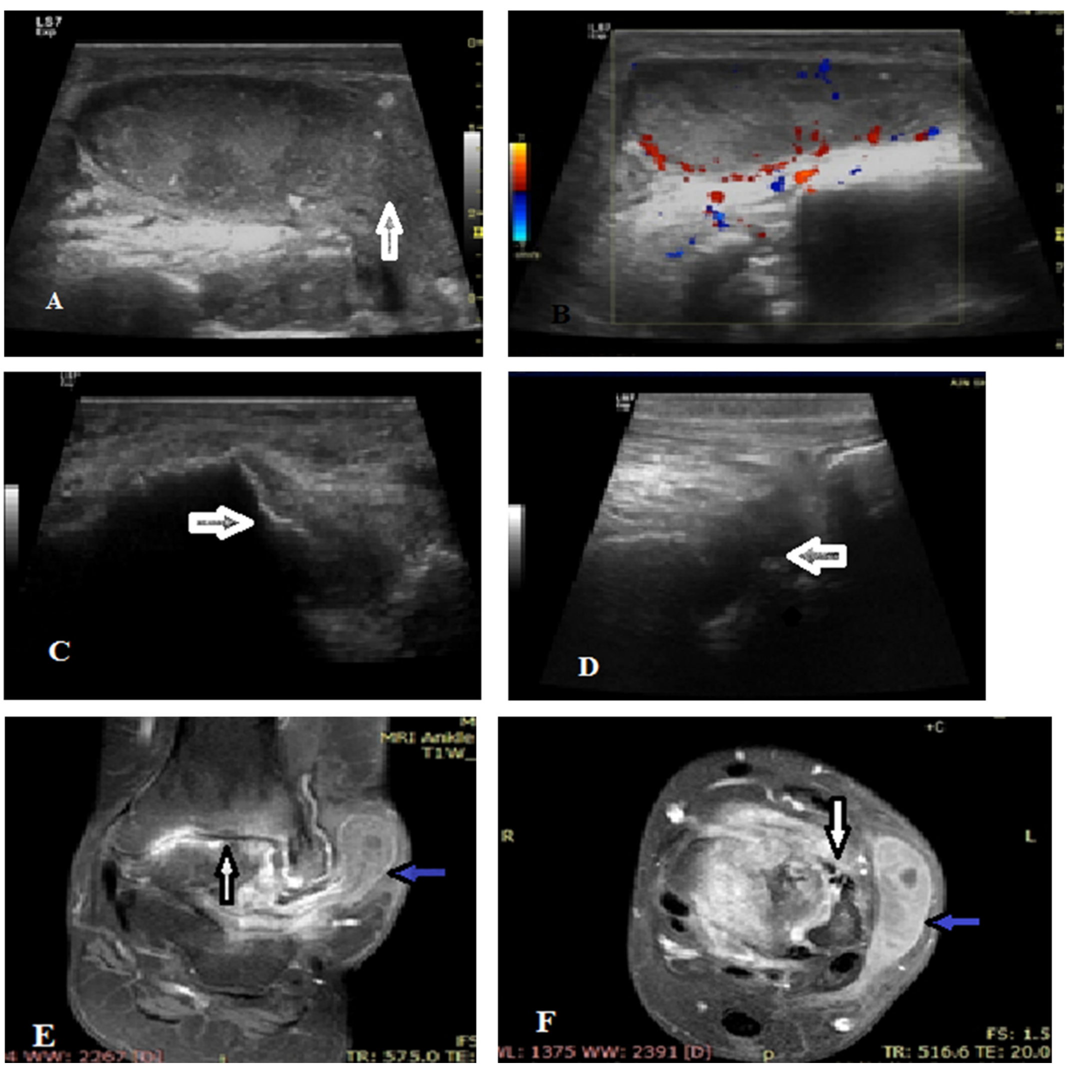

Fig. 4. A. Transverse US image shows a localized ehogenic collection around the lateral mallolus the white arrow points to the site of connection between the lateral mallolus collection and joint space with marginal flow at CD in B, C. Transverse US image showing bone surface irregularity (white arrow). D. Longitudinal US image showing anterior recess collection (white arrow). E. Coronal T1W post contrast study shows a narrowed joint space (white arrow), enhancing marrow oedema with enhancing localized collection at lateral joint space (blue arrow). F. Axial T1 post contrast Fat Sat image, the blue arrow points to the enhancing inflamed subcutaneous tissue with central non enhancing component, the white arrow points to the completely torn ATFL.

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Tenosynovitis was the most common lesion that we encountered in our case series. It was either an isolated finding or in combination with inflammatory arthritis. Most cases of arthritis or tenosynovitis belonged to female gender. This finding was consistent with the previous study performed by Artul and Habib [13]. Their US studies on the ankle joint reported either tenosynovitis or arthritis in >40% of their cases. More than two-thirds of their cases with tenosynovitis and 50% of cases with arhtritis were females [13] (Fig. 2).

In the study of Artul and Habib [13], plantar fasciitis was the second most common detected abnormality in US of the heel.

It is well established that plantar fasciitis is the most frequent cause of heel pain. Many reports confirmed the capability of US to confidently depict plantar fasciitis without further investigations [14].

Plantar fasciitis was noted in 5 cases of our study which represent 17.8% of the study population (Fig. 3). The diagnosis of plantar fasciitis is usually set if there are hypoechoic areas interfering with the regular hyperechoic fibrous appearance of the plantar fascia [15]. Thickening of the plantar fascia >4 mm is considered pathognomic [16].

In the current study we depicted 2 cases of ankle joint infection. One case was diagnosed as cellulitis where US showed typical cobble stone appearance of the subcutanous fat associated with increased vascularity.

The other case was septic arthritis, and was diagnosed on the basis of turbid joint effusion presence with pus filled abscess cavity around the lateral malleolus. This was associated with bony erosions and synovial hypertrophy (Fig. 4).

Chau and Griffith [17], also reported that US has the advent of early detection of septic arthritis before a remarkable cartilaginous damage has occurred. Moreover it allows early intervention through guided aspiration of the infected effusion, thus providing early treatment of the condition.

It is established that ankle joint osteoarthritis occurs in less than 1% of the population [18].The underlying aetiology tends to be idiopathic in the majority of the subjects, however post traumatic causes are one of the most common causes in the USA according to Furman et al. [19].

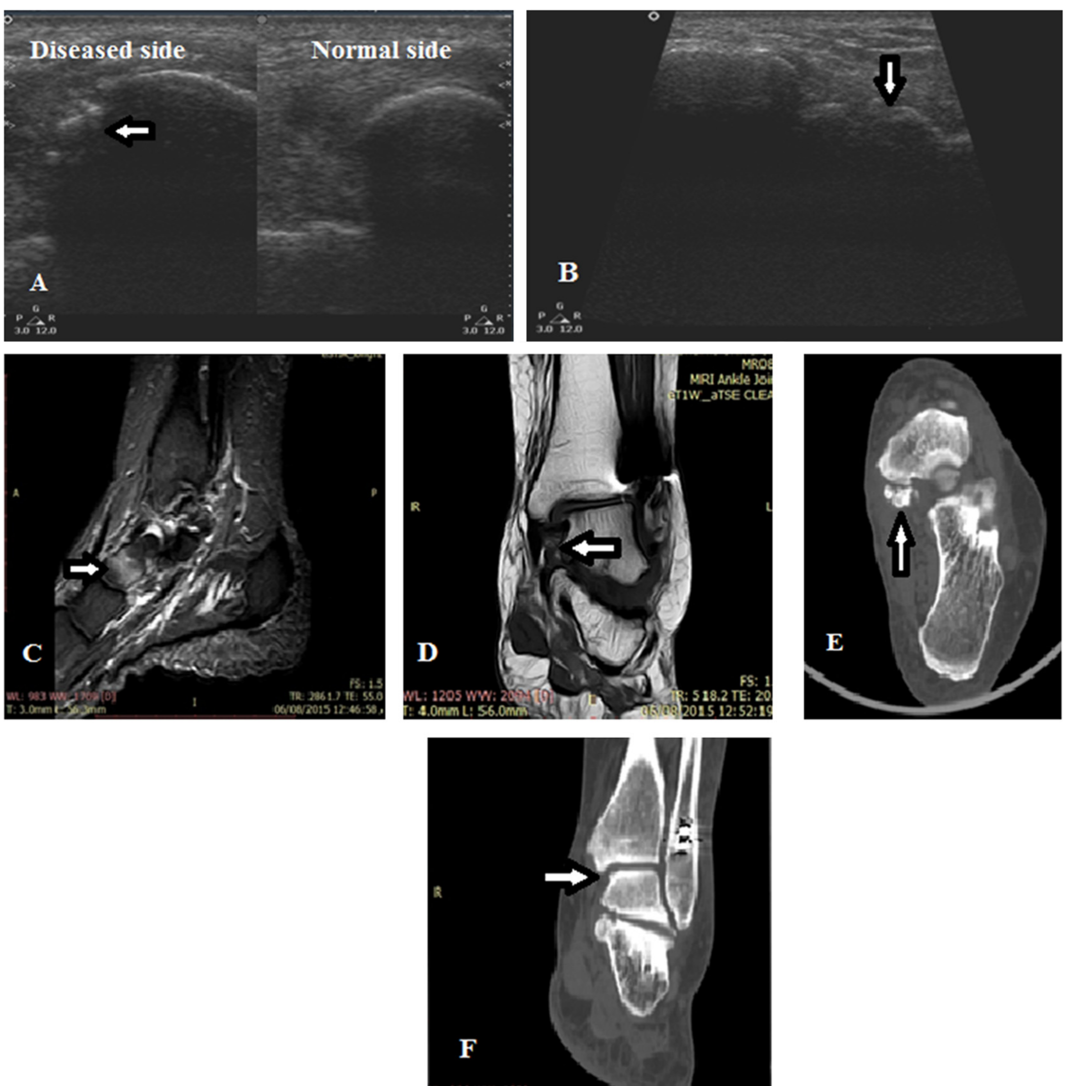

Fig. 5. A. Transverse US image showing osteoarthritic changes where the diseased ankle joint shows superimposed bone (white arrow) with irregular bony surface appearance while the contralateral side shows normal healthy ankle joint. B. Longitudinal US image shows osteophyte lipping going with osteoarthritic changes (white arrow). C. Sagittal STIR image shows navicular bone marrow oedema (arrow). D. Coronal T2WI shows intact deltoid ligament with normal signal of its fibers (white arrow). Fig. E. Axial CT image bone window shows multiple bony fragments noted at medial aspect of navicular bone the largest around 10 mm (white arrow). F. Coronal CT image bone window Osteoarthritic changes are noted by osteophyte lipping (white arrow).

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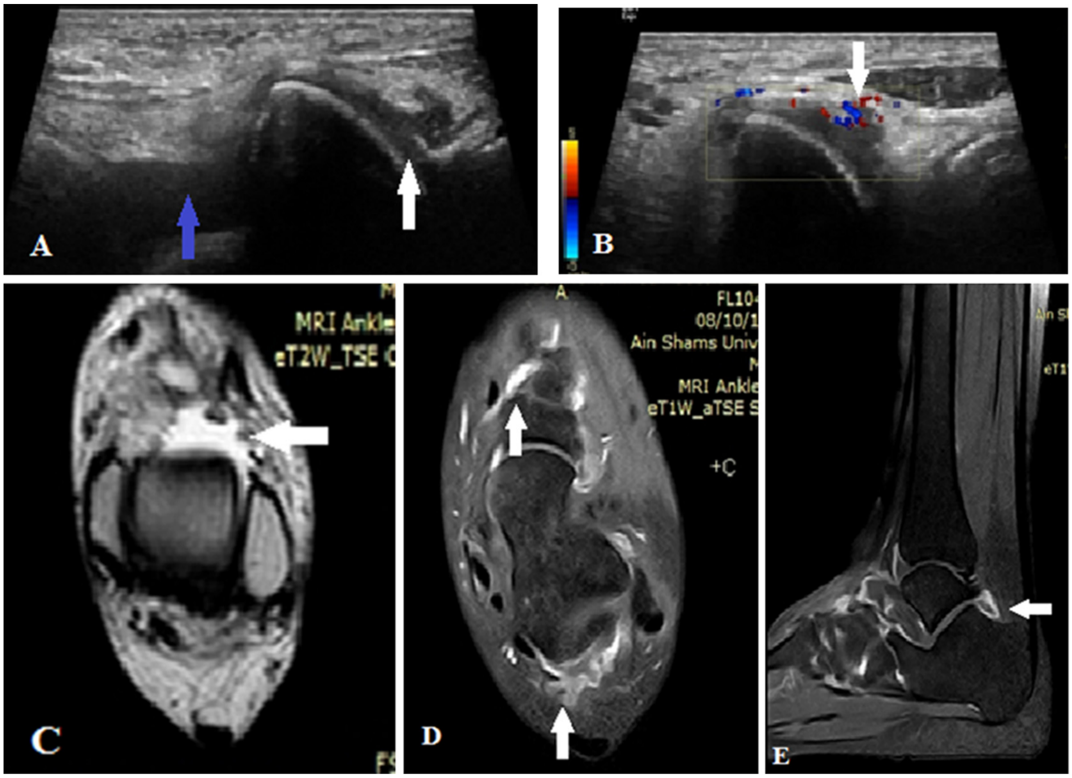

Fig. 6. A. longitudinal US image of anterior tibiotalar joint, blue arrow points to the mild ankle joint effusion, white arrow points to thickened hypoechoic synovium of the surrounding talus. B. Longitudinal power and CD image shows white arrow pointing to increased perisynovial vascularity. C. Axial T2WI shows ankle joint mild effusion at anterior joint space (white arrow). D & E. axial and sagittal T1WI FAT SAT post contrast images show enhancement surrounding thickened synovium (white arrows).

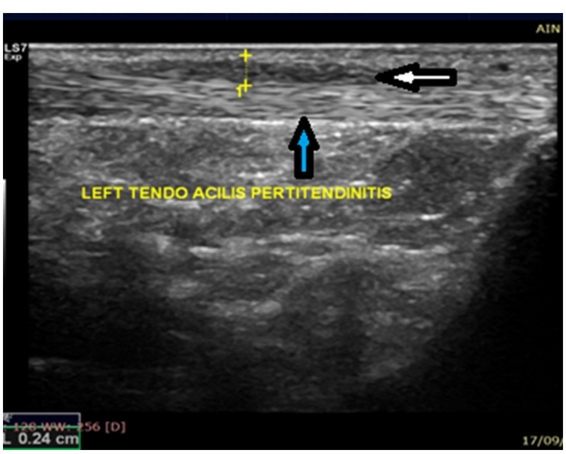

Fig. 7. US longitudinal image at posterior joint compartment shows focal thickened hypoechoic peritendon (white arrow) around normal achillis tendon (blue arrow).

Accordingly, this was in line with our results where we noted only one subject with idiopathic ankle osteoarthritis showing hypertrophic osteoarthropathy with thinning of the articular cartilage (Fig. 5).

In our study, synovitis was depicted in three cases. It was associated with arthritis as well as joint effusion and tenosynovitis (Fig. 6).

Wakefield et al. [20], stated that power and CD is an important differentiating tool between synovitis and synovial effusion.

Thickened synovium is almost always detected in inflammatory and septic arthritis. In this condition, the high resolution US readily depicts synovial thickness with high accuracy [21].

Tendinopathy with partial intra-substance tear was correctly diagnosed by US in two (6.7%) cases of our study population. The first case was Achilles tendinopathy and the other case presented with tibialis posterior tendon dysfunction (PTTD).

The spectrum of Achilles tendinopathy varies between tendinosis, tendinitis, peritendinitis, and partial or complete tendon tears. MSK US plays a vital role in differentiating these underlying causes from each other.

The AT characteristically has no tendon sheath. But, it has a peritendon whose blood supply lies within and outside the tendon [22].

In our study we depicted a case of tendo Achilles peritendinitis and was readily detected by US and confirmed by MRI (Fig. 7).

However, the available studies stated that long term tearing in AT might influence the sensitivity of US as the fibrotic scar tissue as well as the granulation tissue might conceal the gap caused by the tear [23].

In general, literature reports that US has a medium to high accuracy in characterization of Achilles tendinopathy or even better than MRI. It is highly encouraged in this clinical entity, but if US is negative, a complementary MRI is recommended especially if a partial tear is suspected [23].

We encountered two cases of ligamentous injury in our study. Deltoid ligament sprain was depicted in one case and MRI confirmed this finding (Fig. 8).

The available literature reports that US is useful in detecting ligamentous lesions such as tears in deltoid ligament and it even can replace the classic stress views on plain radiography [24].

Oae et al. [25] confirmed this data by matching the accuracy of the classic stress views, MSK US, and MRI in the depiction of ATFL lesions and correlated them with arthroscopic results. Results proved that accuracy of US was 91%, while those of stress views were 67% and an accuracy of 97% for MRI.

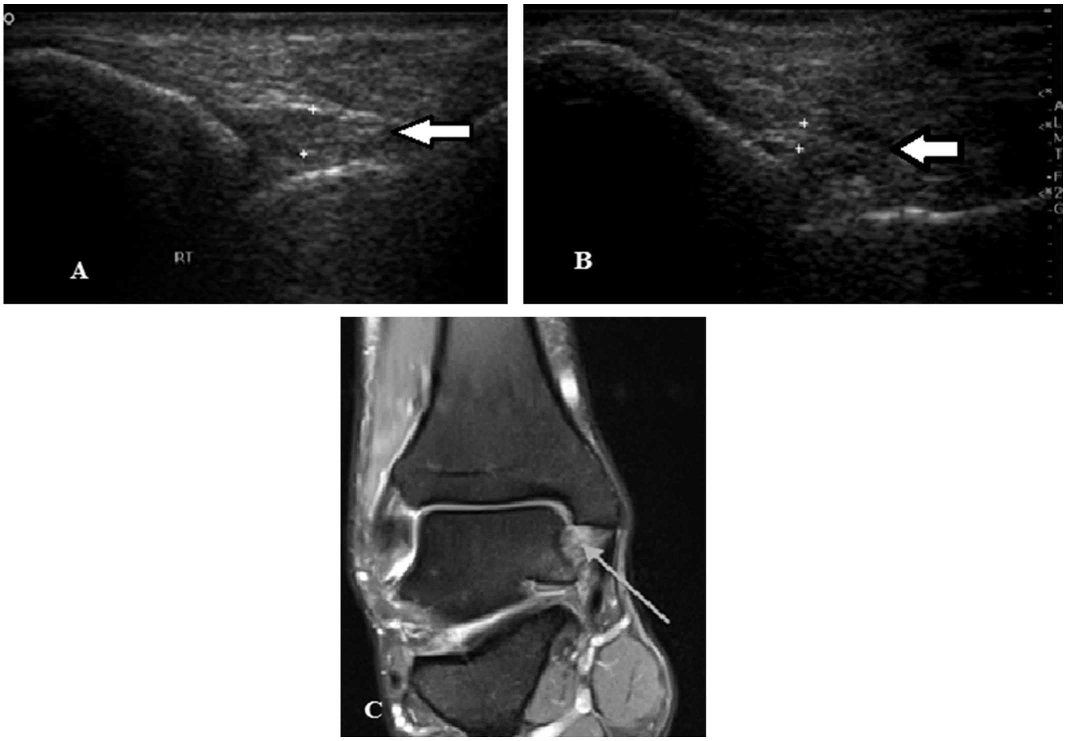

Fig. 8. A. US longitudinal image shows thickened hypoechoic tibiotalar portion of the deltoid ligament. B. US longitudinal image of the contralateral side to show normal appearance of the tibiotalar portion of deltoid ligament. C. Coronal STIR image shows a high signal inside tibiotalar portion of deltoid ligament denoting sprain as its fibers are intact (white arrow).

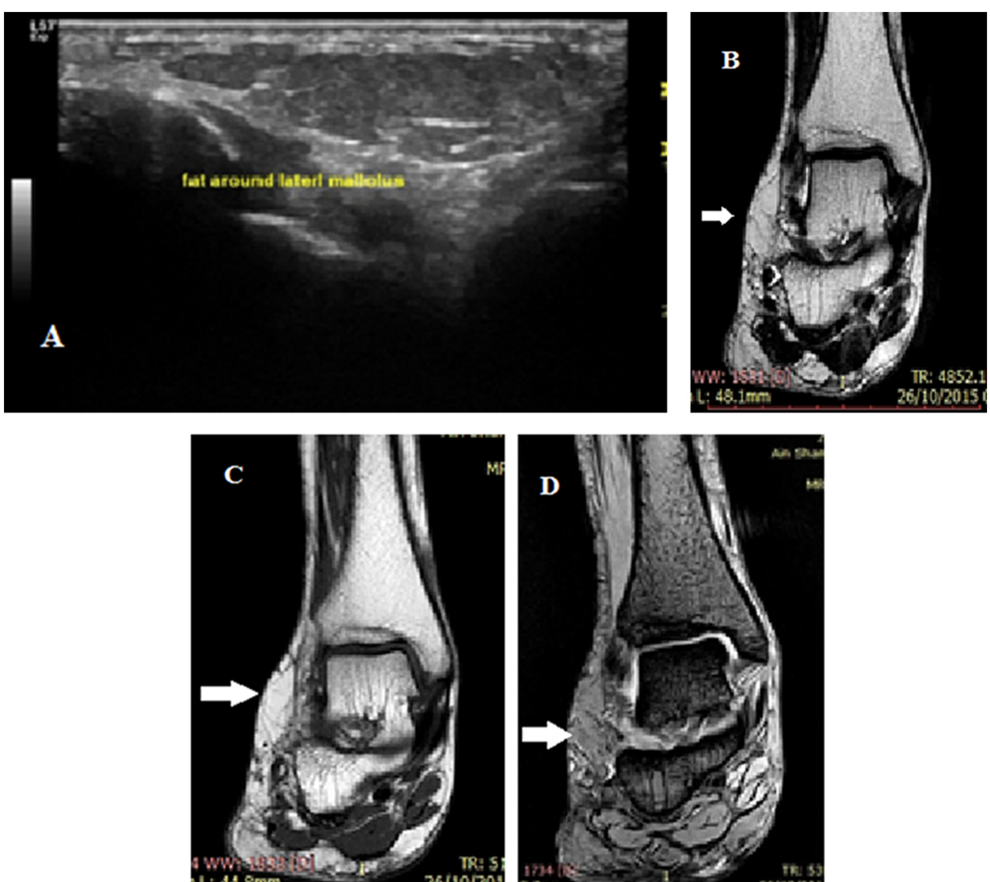

Fig. 9. A. Longitudinal US image around lateral malleolar swelling formed of fat lobules (fat echogenicity). MRI coronal images B. T2WI and C.T1WI and D. STIR images show a swelling that displays a fatty signal on both T1 and T2WIs with complete signal suppression at STIR images denoting a subcutaneous lipoma (white arrow).

However, the other case in the ligamentous entity was a torn ATFL and it was missed by US due to the associated septic arthritis. The assessment of the ligament integrity by US was difficult as the joint space was filled with pus. MRI proved the presence of torn ATFL in this case (Fig. 4).

Ganglion cysts are considered the most frequent swellings detected in the foot and ankle [26].

However, in our study we had one case only presenting with ganglion cyst, the other 2 cases of soft tissue masses were a case of subcutaneous lipoma and a case of focal Achilles peritendinitis (Figs. 7 and 9).

Post traumatic ankle joint pain was encountered in 2 cases of our study. Ankle joint mild effusion was found in one case. The other case had avascular necrosis of the talar dome that was missed on US examination and only detected by MRI.

This is considered as one of the limitations of our study where MRI has the upper hand in this entity where it accurately detects early marrow changes, loss of bone viability, site and size of the dead bone fragment [27].

Although, it has been reported that US is valuable in detecting foot and ankle farctures which might be missed on plain X ray, US missed a bony fracture in one subject, but was detected by CT which was additionally done [28].

We should also mention that our study had another limitation where the sample size wasn't enough to demonstrate all ankle pathologies causing ankle pain. Future research is needed to build up on our current study.

However, US could accurately diagnose a good number of cases with soft tissue abnormality. Our results showed that sensitivity of US was (95.4%) which was higher than specificity or better positive than negative with overall accuracy of (92.8%).

Although it remains operator dependent, yet the implementation of standardized protocols will minimize this pitfall and allow the presence of professional ultrasonographers. In comparison to other imaging modalities especially MRI, it is cheap, rapid, less invasive and with no risk of ionizing radiation if compared to plain radiography and CT.

It still can help in management when guided biopsies and aspirations are required.

5. Conclusion

In conclusion, MSK US is useful in detecting the underlying causes of ankle pain and still it has the potential to offer more valuable data if it is well mastered by the sonographers.

We recommend that it would be the first imaging modality to assess ankle pain. CT and MRI should be kept to conditions where US value is limited.

Conflict of interest

The authors declare that there is no conflict of interest.

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