

The role of High Resolution Ultrasonography in Diagnosis of Tendinous Lesions around the Ankle Joint

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Key points

- Ultrasonography showed high diagnostic accuracy in detecting most causes of ankle pain.
- Although MRI is the gold standard technique for ankle joint imaging, ultrasonography is cost effective, enables dynamic evaluation of tendons and ligaments, allows comparison with the contralateral side and it can be used as an alternative to MRI when MRI is unavailable or contraindicated.
- MRI may be warranted if a bony lesion is clinically suspected or the ultrasonography yielded negative results.

Abbreviation

TP: Tibialis Posterior; TA: Tibialis Anterior; PB: Peroneus Brevis; PL: Peroneus Longus; EDL: Extensor Digitorum Longus; FDL: Flexor Digitorum Longus; FHL: Flexor Hallucis Longus; US: Ultrasonography; MRI: Magnetic Resonance Imaging.

Abstract

Background :Ankle pain is a problematic complaint, considered to be the most frequent cause of orthopedic consultancy for ankle joint problems. This study aimed to highlight diagnostic accuracy of ultrasonography as a fast-imaging technique in assessment of patients with ankle pain.

Patients and methods:A prospective study conducted on 80 patients (50 males and 30 females) with ankle joint pain. All patients underwent ultrasonography and MRI examinations of the ankle.

Results: The study included 80 patients where 62 patients showed tendon pathology that was diagnosed into 15 pathological entities by both US and MRI imaging modalities. A total of 80 patients were included in the study; 18 patients showed no abnormalities, 10 patients showed positive MRI only, and 52 patients showed positive ultrasonography and MRI. Ultrasonography and MRI reported different findings of possible causes of ankle pain or related to it. Joint effusion was the most common finding (50% by MRI and 37.5 % by US) followed by tenosynovitis (27.5 %by MRI and 25 % by US) and tendinopathy (12.5% by both US and MRI). The overall accuracy of ultrasonography was 80.6% with 83.3% sensitivity.

Conclusion: US is an excellent tool for imaging soft tissue abnormalities, as it allows rapid, inexpensive, so it can be used to make a swift screening and assessment of painful ankle, and as an alternative to MRI when it is unavailable or contraindicated.

Keywords: Ankle Joint; Ultrasonography; Magnetic Resonance Imaging; Ankle pain.

1. Introduction

Ankle joint is liable to wide varieties of pathological conditions including a number of osseous abnormalities such as bone contusions, stress and insufficiency fractures, osteochondral fractures, osteonecrosis, and transient bone marrow edema as well as a variety of soft-tissue disorders of the ligaments (e.g., sprain), tendons (tendinosis, peri tendinosis, tenosynovitis, entrapment, rupture, dislocation), and other soft-tissue structures (e.g., anterolateral impingement syndrome, sinus tarsi syndrome, compressive neuropathies [e.g., tarsal tunnel syndrome, Morton neuroma], synovial disorders) ⁽¹⁾.

The ankle is the most frequently injured major joint in the body where ankle sprains are frequently encountered in individuals playing sports, in addition to occurring in the general population ⁽²⁾. Ankle pain can be associated with swelling, stiffness, redness, and warmth in the involved area ^(3,4).

MRI has been proven to provide excellent evaluation of ligaments and tendons around the ankle, with the ability to show associated intra articular abnormalities, joint effusion, bone marrow edema, synovitis, and soft-tissue thickening. MRI can also aid in assessing the degree of cartilage damage ⁽⁵⁾.

US is cost effective, enables dynamic evaluation of tendons and ligaments, allows comparison with the contralateral side ^(6,7) and is the best imaging modality for evaluating transient subluxations and dislocations of the tendons ⁽⁶⁾.

2. Aim of the work

To evaluate the role of Ultrasonography in diagnosis of tendinous lesions around the ankle.

3. Patients and method

3.1. Ethical Statement

The Research Ethics Committee approved this study and written informed consent was obtained from all patients before the study. The study was conducted based on the ethical principles of the Declaration of Helsinki.

3.2. Study Population

Our study was carried out in Radio diagnosis department, Zagazig University Hospital, and had been approved by the Zagazig University Institutional Review Board (I.R.B).

It was a prospective study, done during the period from May 2018 to May 2020.

We targeted 80 patients referred from the emergency and orthopedic surgery departments and outpatient clinics with a history of ankle problems.

Fifty Patients were males representing 62.5 % and thirty patients were females representing 37.5 % of all patients, their age ranged from 15 to 59 years old with mean age 35.1 years.

Forty-six Patients complained of left side ankle problems representing 57.5 % while thirty-two patients complained of right ankle problems representing 40 % and two patients had bilateral ankle complain representing 2.5 %.

Written consents were obtained from all patients before participating in the study.

3.3. Inclusion criteria:

- 1) Patients with history of trauma to the ankle.
- 2) Patients complaining from acute or chronic ankle pain.
- 3) Patients complaining from limitation of movement at the ankle joint.

3.4. Exclusion criteria:

- 1) Patients who had previous ankle surgery for tendon repair.
- 2) Patients incompatible for MRI examination e.g. pacemaker, metallic prosthesis.
- 3) Patients unwilling to complete the study.

3.5. Methods:

All patients were subjected to;

1) Clinical assessment:

Including:

Full history taking:

- A- Onset, mechanism of injury (in trauma patients).
- B- History of previous trauma.
- C- History of ankle pain, swelling or limitation of movement.

D- Local examination:

Clinical examination of the affected ankle focusing on: pain, swelling, joint stiffness or instability.

2) Imaging including:

A. Ultrasonography examination using Siemens (Acuson X300) machine by superficial linear high frequency transducer (7-10 MHZ).

All patients were examined in the longitudinal and axial scans to the affected side of all ankle compartments including tendons and a dynamic scan.

Examination of the ankle began with the patient in the supine position, with the knee flexed and the foot rested on the examination table.

The anterior joint was first examined in the longitudinal plane to assess a joint effusion. The evaluation of extensor tendons was done with the patient in the same position, the tibialis anterior was evaluated in both longitudinal and transverse planes from superior to inferior. The extensor hallucis longus was similarly examined and followed to its insertion at the great toe.

The medial aspect of the ankle was scanned after placing the patient in either in right or left oblique position. The tibialis posterior, flexor digitorum longus and flexor hallucis longus tendons were examined in both longitudinal and transverse planes.

The lateral aspect was assessed in both longitudinal and transverse planes. The peroneus longus tendon was examined to the cuboid groove, where it turns medially to course along the plantar foot. The peroneus brevis was examined to its insertion at the base of fifth metatarsal.

The posterior aspect, Achilles tendon, the patient was examined in the prone position with the foot hanging over the examination table. The tendon was examined from its origin to its insertion on the calcaneus in both transverse and longitudinal planes. Dynamic evaluation was done by active plantar flexion and dorsi flexion of the ankle.

B. Magnetic resonance imaging was performed in Zagazig University Hospitals and a private center, using Philips Achieva 1.5 T scanner and GE 1.5 T scanner respectively. Ankle coil or Knee coil were used.

Positioning:

Every patient lied supine with the ankle and foot in neutral position, and plantar flexion of 20–30 degrees has been advocated for reducing the “magic angle” artifact. No movement was allowed during examination by supporting the ankle using pads.

Protocol:

All patients were examined by multi-planner magnetic resonance imaging of the affected ankle with multiple planes, using multiple sequences (T1, T2, STIR, proton density and fat suppression), by using the following parameters:

- T1 weighted image: The repetition time= 500-600 msec, Echo time=20-25 msec
- T2 weighted image: The repetition time= 3000-4000 msec, Echo time=15-17msec
- Proton density image: The repetition time= 1000 msec, Echo time=10-30 msec
- STIR image: The repetition time= 5000 msec, Echo time=30 msec
- Fat suppression T2 weighted image: The repetition time= 3500-3600 msec, Echo time=90-100 msec
- Fat suppression proton density image: The repetition time= 2000-2500 msec, Echo time=40-50 msec
- Other parameters applied include slice thickness ranged from 3 to 5 mm, matrix 256/192 or 512/224, number of excitations 2 to 3 and field of view ranged from 12 to 16 cm, better kept <14 cm.

Images interpretation

Ultrasonography and magnetic resonance images are assessed and evaluated for any lesions according to:

- Number and site of lesions.
- Types of lesions:
 - Tendinitis, tenosynovitis, partial or complete tear.
- Associated lesions: e.g.
 - Joint effusion.
 - Bone marrow edema.
 - Subcutaneous edema.
- The findings obtained from ultrasonography were compared with MRI findings.

3.6. Statistical Analysis

- Data were statistically analyzed and presented in terms of frequencies percentage, sensitivity, specificity, negative and positive predictive values and accuracy.

- All data were analyzed using IBM SPSS statistics for Windows, version 19 (IBM Corp. Armonk, N.Y.USA)

4. Results

Patients

This study included 80 patients (50 men, 30 women; mean age, 35.1 ± 12.5 years; range, 15-59). Patients' demographic data and clinical characteristics are summarized in Table 1. The left ankle was more affected (47.5%). The main presentation was pain (100%). The mean duration of symptoms was 8.3 ± 3.1 months. Based on both US and MRI examinations, the most affected tendon is Achilles' tendon (24 cases) with the most frequently encountered lesion is Achilles' tendinopathy (10 cases).

Table 1. Patients' demographic data and clinical characteristics

Variable	Value
Total number	80
Age, years, mean $\pm$ SD (Range)	35.1 ± 12.5 (15-59)
Sex	
Male	50 (62.5)
Female	30 (37.5)
Location	
Right ankle	32 (40)
Left ankle	46 (47.5)
Bilateral	2 (2.5)
Presentations	
Pain	80 (100)
Trauma	58 (72.5)
Swelling	56 (70)
Duration of symptoms, months, mean $\pm$ SD (Range)	8.3 ± 3.1 (5-17)
Final diagnosis by MRI	
Tendinous lesions	62 (77.5)

Note. —Unless otherwise indicated, data are the number of patients or lesions and the percentage in parenthesis.

SD: standard deviation; MRI: magnetic resonance imaging

Image findings

Regarding the tendon's pathologies, they were diagnosed by the following sonographic appearances:

- * **Tendinopathy** (Fig.1A, B) appeared as hypoechoic with loss of the normal echogenic fibrillar appearance of the tendon and tendon thickening.
- * **Tenosynovitis** (Fig. 2 A, B) was diagnosed when there was increased fluid distending a tendon sheath, with or without hyper vascular synovium surrounding the tendon. The fluid typically encircles the tendon forming a “halo” around it.
- * **Partial tears** (Fig. 3 A, B) appeared as hypoechoic thickening or thinning of the tendon and as contour irregularities or waviness without tendon discontinuity.
- * **Complete rupture of the tendon** (Fig. 4 A) appeared as a focal defect between the torn tendon edges.
- * Dynamic examination enhanced detection of intermittent subluxation and assessed whether the spontaneous reduction was possible.

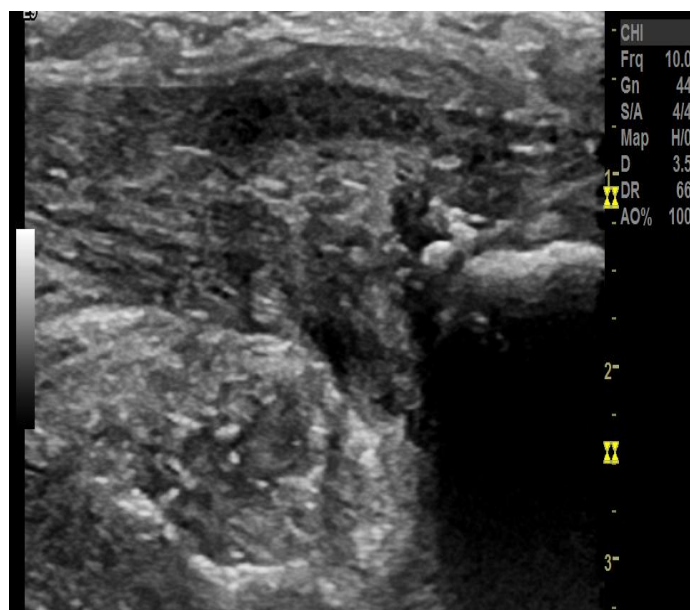


Figure 1 A

Figure 1B

Figure 1-A,B : longitudinal and transverse US scans of the right ankle showed increased caliber of the distal Achilles tendon with heterogeneous echogenicity of the tendon fibers .

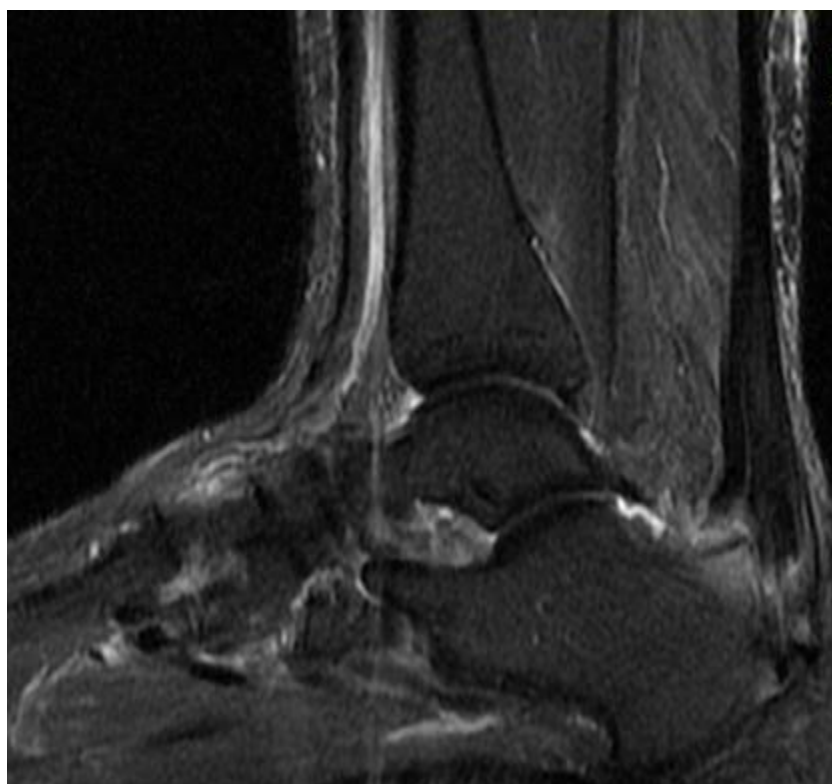


Figure 1- C and D :(sagittal T1WI and sagittal STIR) of the right ankle showed increased caliber of the distal 5cm of the right Achilles tendon with ballooning and convexity of its anterior aspect. Intra tendinous abnormal intermediate signal intensity is noted. Associated abnormal high SI BM edema is noted at postero-superior aspect of calcaneus.

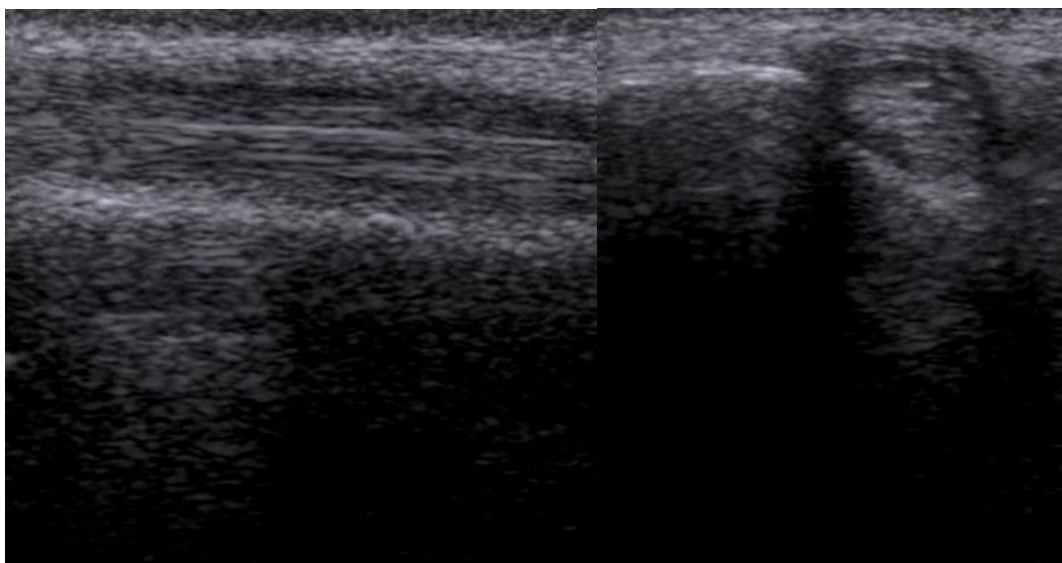


Figure 2-A ,B :longitudinal and transverse ultrasound scans of the medial aspect of the right ankle showed thickening of tibialis posterior tendon which was seen surrounded by a hypoechoic thin rim of fluid .

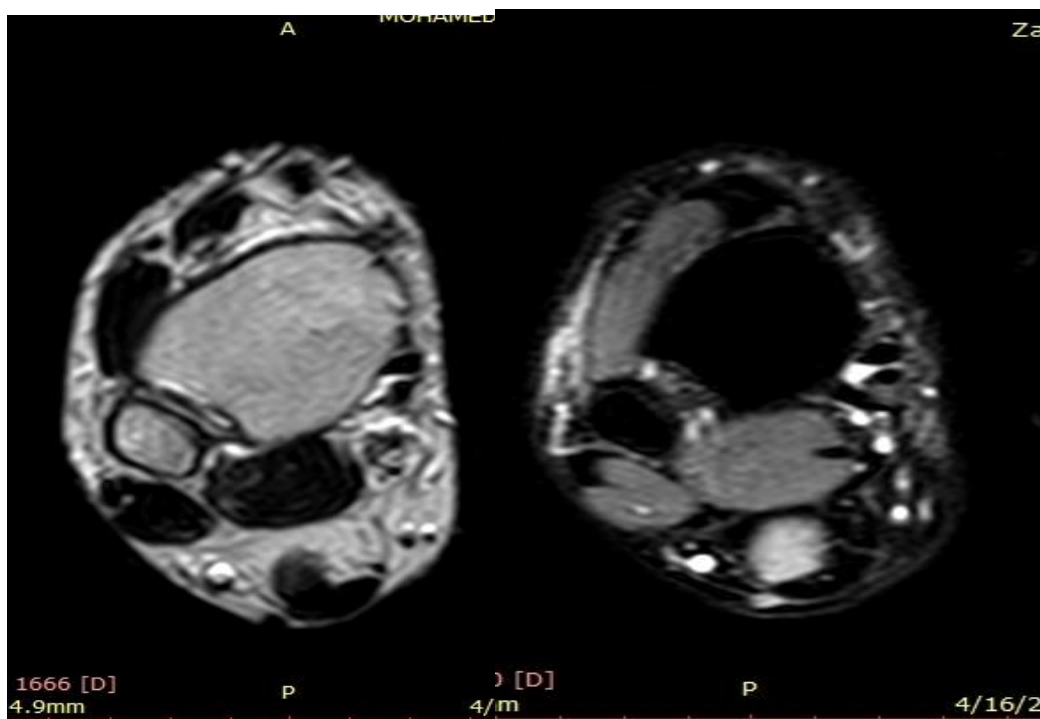


Figure 2 C and D: (axial T2WI and axial PD SPIR) of the right ankle showed abnormal high (fluid) signal intensity surrounding the right tibialis posterior and flexor digitorum longus tendons .

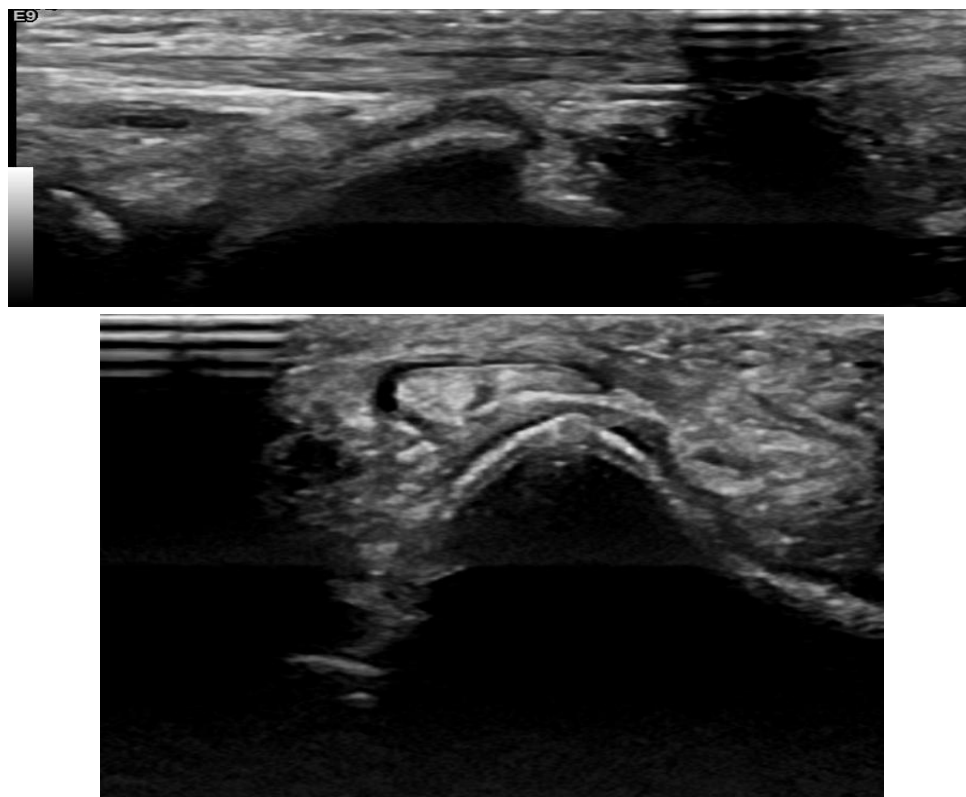


Figure 3-A ,B: longitudinal and transverse ultrasound scans of the lateral aspect of the left ankle showed the peronei tendons seen surrounded by a hypoechoic thin rim of fluid .

Table 2: Frequency of pathology per tendon affection detected by ultrasound compared to MRI

Lesions	Ultrasound (n=52)	MRI (n=62)
Achilles tendon		
Partial tear	4	6
Complete tear	6	4
Achilles tendinopathy	10	10
Achilles' tendinitis and retro-calcaneal bursal	2	2
effusion	2	2
Bilateral Achilles enthesopathy		
Peroneal tendons	6	6

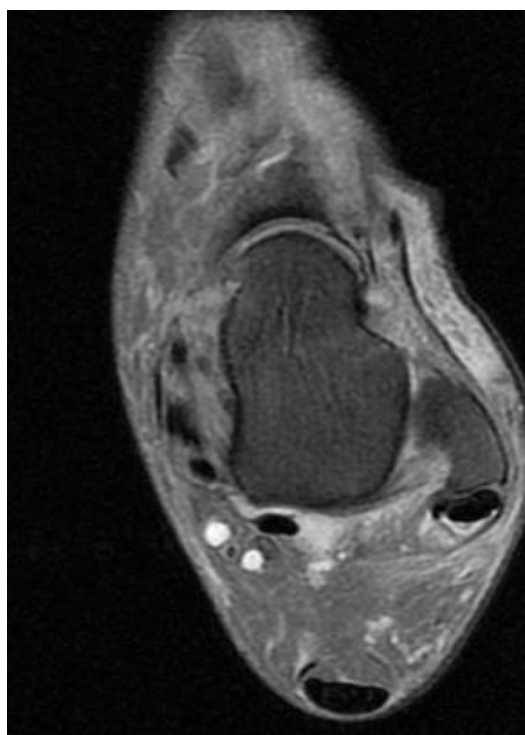
PL and PB tenosynovitis	4	4
PL tendinitis	2	4
PL partial tear	0	2
PB partial tear		
TP tendon	6	8
TP tenosynovitis		
TA tendon	2	4
TA tendinitis		
Flexor tendons	4	4
FDL and FHL tenosynovitis	0	2
FHL partial tear		
Extensor tendons	2	2
EDL and EHL tenosynovitis and a small synovial cyst	2	2
EDL and EHL tenosynovitis		

Note. —Data are the number of patients and the percentage in parenthesis.

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Table 3. Comparison between US and MRI diagnosis in different tendinous lesions

Pathology	Ultrasound diagnosis	MRI diagnosis
Tendon		
Tenosynovitis	20	22
Tendinopathy	10	10
Tendinitis	8	10
Partial tear	6	14
Complete tear	6	4
Enthesopathy	2	2
Total	52	62



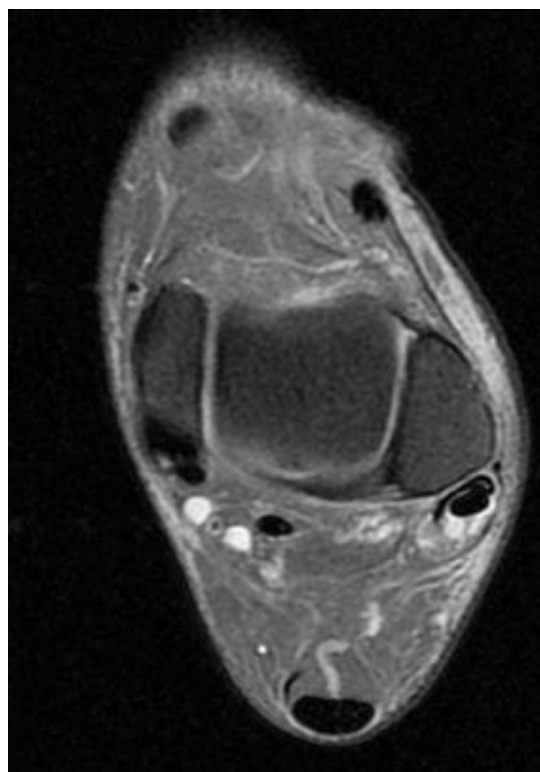


Figure 3 -C, D and E : (axial PD Fat Sat and coronal PD Fat Sat) of the left ankle showed abnormal high SI fluid surrounding peronii tendons with PB tendon cleavage into two parts seen surrounding the PL tendon in the form of C shape .High SI soft tissue edema affecting the lateral aspect of the ankle was also noted .

US Diagnosis: left Peronii tenosynovitis.

Additional MRI diagnosis: left PB tendon c shaped tear.

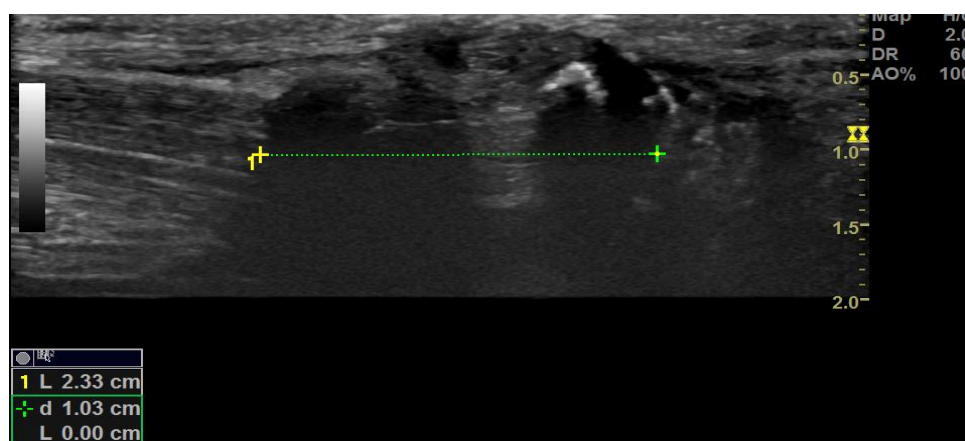
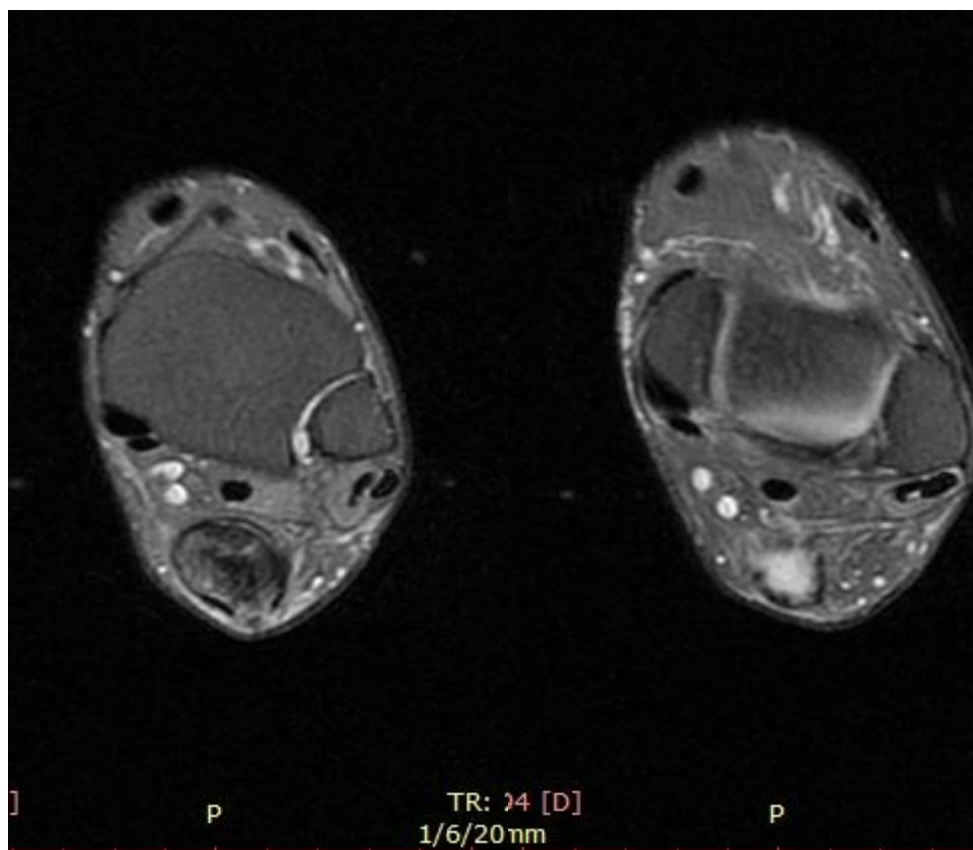


Figure 4-A : longitudinal US scan of the left ankle showed increased caliber of Achilles tendon with heterogeneous echogenicity of the tendon fibers with an area of complete loss of normal continuity of its fibers and a gap measuring 23 mm .



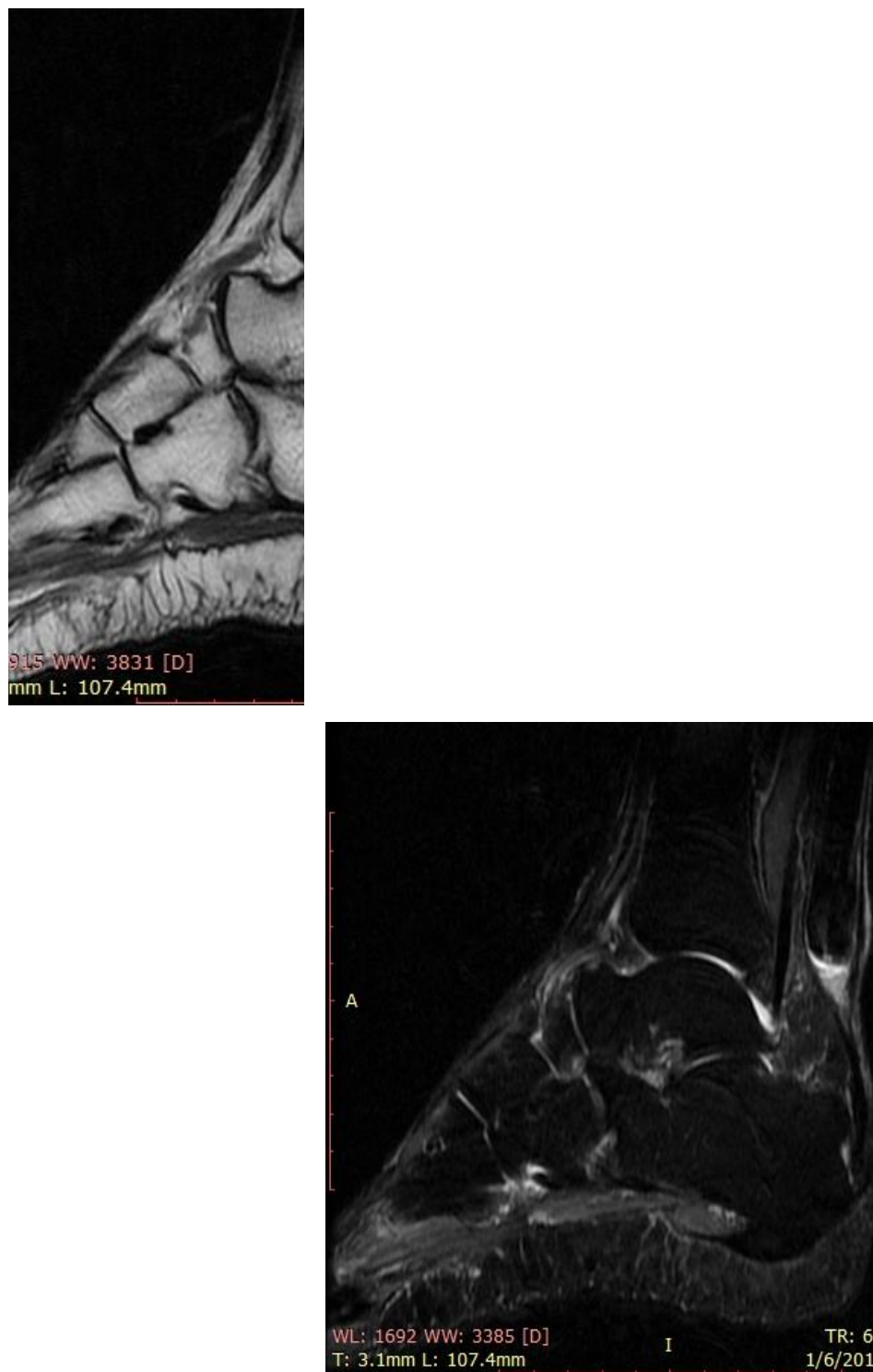


Figure 4 B, C and D: (axial PD Fat Sat, sagittal T2WI and sagittal STIR) of the left ankle showed marked thickening of left tendon Achilles with abnormal intermediate SI and near complete loss of normal continuity of the tendon fibers creating a gap of abnormal high SI, measuring 14 mm. Mild joint effusion.

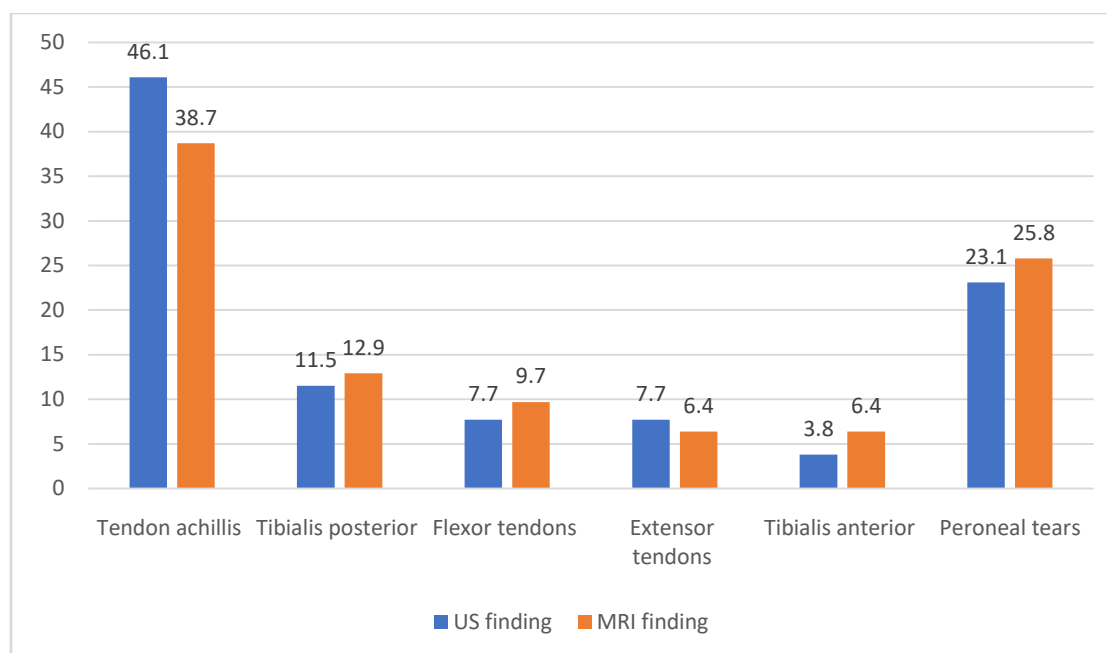


Figure 5: Bar chart showing frequency of tendinous lesions among the studied group by both US and MRI.

MRI imaging findings

***Both tenosynovitis and peri-tendinitis tendinitis** (Figs. 2 C, D) have overlapping radiographic appearance. On MR images, the fluid has low signal intensity on T1-weighted images and high signal intensity on T2-weighted images. The low signal intensity ring around the fluid on MR images represents the synovial sheath.

***In chronic tendinitis** (Figs. 1 C, D), the tendon may remain enlarged and have decreased signal intensity in both T1 and T2-weighted images.

***Tendon rupture** (Fig. 3 C, D, E and Fig. 4 B, C, D)

Three patterns of tendon rupture were seen on MRI:

In type I partial rupture, the tendon appeared heterogeneous and hypertrophied. In type II partial rupture, the tendon was stretched and attenuated in size. In type III tendon rupture, discontinuity or the presence of a gap is noted. Depending on the age of the rupture, the gap was filled with fluid, fat or scar tissue.

Validity of ultrasonography

Table 4 and Table 5 summarize validity of ultrasound in diagnosis of tendinous lesions around the ankle and Achilles' tendon lesions respectively using MRI as a reference standard. The sensitivity, PPV and accuracy of ultrasound for the diagnosis of tendinous lesions were 83.3 (50/60), 96.1 (50/52) and 80.6 (50/62), respectively. The sensitivity, specificity, PPV, NPV and accuracy of ultrasound for the diagnosis of Achilles tendon lesions were 91.7 (22/24), 94.7 (36/38), 91.7 (22/24), 94.7 (36/38) and 93.5 (58/62), respectively.

Table (4): Validity of US in diagnosis of tendinous lesions in comparison to MRI as gold standard:

Standard				
US	MRI		Total	P
	Present	Absent		
Present	50	2	52	<0.001 (HS)
Absent	10	0	10	
Total	60	2	62	
Sensitivity: 83.3 %		Specificity: 0%		
Predictive value positive: 96.1%		Predictive value negative: 0%		
Accuracy: 80.6%				

Table (5): Validity of US in diagnosis of lesions of tendon Achilles in comparison to MRI as gold standard:

US	MRI		Total	P
	Present	Absent		
Present	22	2	24	<0.001 (HS)
Absent	2	36	38	
Total	24	38	62	
Sensitivity: 91.7%			Specificity: 94.7%	
Predictive value positive: 91.7%		Predictive value negative: 94.7%		
Accuracy: 93.5%				

5. Discussion

Ankle joint is liable to wide varieties of pathological conditions ⁽¹⁾. The ankle is commonly affected in trauma, overuse disorders and inflammatory conditions. Various imaging techniques may be used to assess the ankle, including sonography, MRI and CT ⁽²⁾. Imaging plays a crucial role in the evaluation of ankle tendons and ligaments. Magnetic resonance imaging can provide excellent evaluation of various types of soft tissue and bone abnormalities of the ankle. Ultrasonography (US) performed with high-resolution linear-array probes can provide a detailed depiction of normal anatomic structures and is effective for evaluation of ligament and tendon integrity ⁽⁸⁾.

In the past, diagnostic US has been at the forefront of research in tendinopathy and has emerged as the gold standard in imaging. The main advantages of this non-invasive imaging tool include fine depictions of tendon fibrillar appearance, dynamic examination, and guided intervention. However, the main disadvantage of ultrasound examination is that it is operator dependent.

In tendinopathy, the sonographer has to interpret gray scale and power Doppler tendon appearances ^(9, 10). Therefore, an algorithm can be devised to take this into account. If a clinician is suspecting a focal tendon abnormality, such as tear, then ultrasound can be considered. If the clinician is suspecting something more than a focal tendon problem, then MRI should be considered. The drawback of this algorithm is that the decision on choice of imaging relies on the clinicians' suspicions of specific pathology.

As an alternative algorithm, sonography may be considered the first line of imaging for joint problems after radiography ^(2, 11).

The aim of this study was to assess the diagnostic accuracy of both ultrasonography and magnetic resonance imaging (MRI) for the assessment of the tendinous lesions around the ankle.

Our study included eighty patients with history of ankle complain. All patients were subjected to real-time high resolution ultrasonography and MRI of the affected ankle. In this study, the majority of the patients were males (62.5 %) with a mean age of 35.1 years.

sixty-two entities of tendon injury were diagnosed by MRI which represented 77.5 % of total cases. There were 24 cases of Achilles tendon lesions representing 38.7% of the tendinous lesions. 41.6 % of these cases (10 cases) were presented with Achilles tendinopathy by both US and MRI. This is matched with **Ibrahim and Elsaed**⁽¹²⁾ who reported that US is as good as MRI in the diagnosis of tendinopathy. 8.3 % of these cases (two cases) was presented with Achilles tendinitis with retro calcaneal bursal effusion by both US and MRI. As well as a similar 8.3 % of cases (two cases) was presented with Achilles enthesopathy. The rest of Achilles tendon lesions in our study were presented with partial and complete tears representing 16.6% and 25% of the Achilles tendon lesions by US respectively, 25 % and 16.6 % of all Achilles tendon lesions by MRI respectively. Ultrasound falsely diagnosed two cases of complete Achilles tendon tear which were diagnosed as partial by MRI with the sensitivity of US was 91.7%. This is also matched with **Ibrahim and Elsaed**⁽¹²⁾ who reported that MRI is more superior in the diagnosis of partial thickness tear.

Although it is the strongest tendon in the human body, **Liffen Neil**⁽¹⁰⁾ and **Refaat et al.**⁽¹³⁾ agreed that the Achilles tendon is the most commonly injured ankle tendon, with the site of pathological findings is typically a zone of relative avascularity 2–6 cm from the calcaneal insertion ⁽¹⁴⁾. Our results coincide with this hypothesis as Achilles tendon injuries represented 38.7% of all diagnosed ankle tendons' lesions and ranged in severity from tendinosis, partial tear to complete tear. In our study, ultrasound was capable in detecting all Achilles tendon lesions identified at MRI.

Regarding characterization of Achilles lesions, ultrasound succeeded to classify Achilles injuries similar to MRI regarding tendinopathy, enthesopathy and complete tear. Similarly, **Liffen Neil**⁽¹⁰⁾ and **Margetic Petra, Salaj Martina et al.**⁽¹⁵⁾ reported that ultrasound has been used as a first-line approach for assessing Achilles tendon disorders and stated that it has 100% sensitive in detecting Achilles tendon lesions in 26 cases.

As regard the medial compartment tendons the tibialis posterior tendon is the most frequently affected one, in our study, six cases were diagnosed by ultrasound as tenosynovitis of tibialis posterior tendon (7.5% of all cases and 11.5% of all pathological tendons). While MRI was capable of diagnosis of eight cases of tibialis posterior tenosynovitis (10% of all cases and 15.3 % of all pathological tendons) In our study, two cases of tibialis posterior tenosynovitis were missed by ultrasound and identified at MRI (75% sensitivity, 100 % specificity and 96.4% accuracy).

Our study included four cases of flexor tendons tenosynovitis which was diagnosed by US and approved by MRI study. They represented (5% of all cases and 7.7 and 6.4% of all pathological tendons by US and MRI respectively). Two cases of FHL partial tear were diagnosed by MRI and missed by ultrasound, this was in accordance with ⁽¹⁶⁾ and they attributed that to the deep location and changes in the direction which make the FHL tendon difficult to be evaluated with US ⁽¹⁶⁾. We did not diagnose any FDL tendon tear during our study, this agreed with **Refaat et al.**⁽¹³⁾ who reported that the FDL tendon is rarely affected by traumatic changes. This is also matched with **Ibrahim and Elsaeed**⁽¹²⁾ who reported that the pathology of FHL tendon has been reported more frequently than the FDL tendon.

Although the anterior ankle tendons are rarely affected with pathology in comparison with the other ankle tendons ⁽¹⁴⁾, our study included four cases with tibialis anterior tendinitis and two cases with EDL tenosynovitis. This agreed with **Narvaez**⁽¹⁷⁾ who reported that TA tendon injuries are uncommon and tenosynovitis and tendonitis are more common than tendon rupture.

In our study, peroneal tendons' lesions were diagnosed by both MRI and ultrasound imaging modalities. Peroneal tendons showed 16 cases of 3 pathological entities (20 % of all cases and 25.8% of pathological tendons by MRI, 15 % of all cases and 23.1% of pathological tendons by US): by MRI 6 cases of tenosynovitis, 4 cases of PL tendinitis, 4 cases of PL partial tear and 2 cases of PB partial tear (missed by ultrasound). Longitudinal split tears of the peroneus brevis tendon have been increasingly reported as a source of lateral ankle pain and disability. **Lee et al.**⁽¹⁸⁾ studied the longitudinal split tear of the peroneus brevis tendon and reported that MRI is useful in identifying the appearance of longitudinal split tears of the peroneus brevis tendon to differentiate this entity from other causes of chronic lateral ankle pain. **Mansour and Jain**⁽¹⁹⁾ also reported that MR imaging is useful in identifying the appearance of longitudinal split tears of the peroneus brevis.

6. Conclusion

In conclusion, Ultrasound is an excellent tool for imaging focal soft tissue abnormalities, and used as primary tool of investigation. MRI is an excellent technique for those cases where the diagnosis is uncertain as it can exclude most clinically relevant pathologies, especially when surgical interference is planned.

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