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ORIGINAL ARTICLE

High resolution ultrasonography and magnetic resonance imaging in the evaluation of tendino-ligamentous injuries around ankle joint

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KEYWORDS

Magnetic resonance imaging;
Ultrasonography;
Ankle;
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Injuries

Abstract *Purpose:* The aim of this study was to rule out the diagnostic accuracy of both ultrasonography (US) and magnetic resonance imaging (MRI) for the assessment of tendino-ligamentous pain around the ankle joint.

Patients and methods: This study included 35 patients (25 females and 10 males) complaining of unilateral ankle pain (acute or chronic), and they were subjected to plain X-ray (to exclude osseous pathology), US and MRI examinations.

Results: The study included 35 patients where 20 patients showed tendon pathology that was diagnosed into 21 pathological entities by both US and MRI imaging modalities with no difference in interpretation between them. 21 patients had pathological ligaments which were diagnosed by both ultrasound and MRI. However, two ligamentous lesions were diagnosed as partial tear by US, while MRI diagnosed them as complete tear. Associated findings were also diagnosed as retrocalcaneal bursitis in two patients, joint effusion in four patients and joint synovitis in three patients.

Conclusion: US is an excellent tool for imaging soft tissue abnormalities, as it allows rapid, inexpensive detailed examination of the structures of the ankle joint. US and MRI are two complementary tools of investigation with the former being used as primary effective tool of investigation and the latter is done to confirm the diagnosis.

1. Introduction

The ankle joint 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. Imaging plays a crucial role in the evaluation of ankle ligaments (1). Ankle pain is often due to an ankle sprain but can also be caused by ankle instability, arthritis, gout, tendonitis, fracture, nerve compression (tarsal tunnel syndrome), infection and poor structural alignment of the leg or foot. Ankle pain can be associated with swelling, stiffness, redness, and warmth in the involved area (2,3).

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Ligaments on each side of the ankle also provide stability by tightly strapping the outside of the ankle (lateral malleolus) with the lateral collateral ligaments and the inner portion of the ankle (medial malleolus) with the medial collateral ligaments. The ankle joint is surrounded by a fibrous joint capsule. The tendons that attach the large muscles of the leg to the foot, wrap around the ankle both from the front and behind (1).

MRI has been proven to provide excellent evaluation of ligaments and tendons around the ankle, with the ability to show associated intraarticular abnormalities, joint effusion, and bone marrow edema. US performed with high-resolution linear-array probes has become increasingly important in the assessment of ligaments and tendons around the ankle because it is low cost, fast, readily available, and free of ionizing radiation. US can provide a detailed depiction of normal anatomic structures and is effective for evaluating ligament integrity (4). In addition, US allows the performance of dynamic maneuvers, which may contribute to increased visibility of normal ligaments and improved detection of tears. It can facilitate accurate identification, localization and differentiation between synovial, tendinous and entheseal inflammation as well as joint, bursal and soft tissue fluid collection (4,5).

1.1. The aim of this study

The aim of this study was to investigate the diagnostic accuracy of both ultrasonography and magnetic resonance imaging for the assessment of tendino-ligamentous pain around the ankle joint.

2. Patients and methods

2.1. Study population

This prospective study had been approved by Kasr El-Aini Hospital, Research and Ethical committee, Cairo University.

A prospective analysis with US and MRI was performed on thirty-five patients in the age range between 18 and 60 years, complaining of unilateral ankle pain. Consent was obtained from all patients before doing this study. All patients were referred to the Radiology department from the outpatient clinic of the Orthopedics department between September 2014 and February 2015.

Inclusion criteria: patients complaining of unilateral ankle joint pain (acute or chronic).

Exclusion criteria: previous ankle surgery, interventional intra-articular procedures (previous arthroscope, injections), systemic inflammatory disorders (collagen diseases), diagnosed osseous lesions.

All patients were subjected to history taking and clinical provisional diagnosis.

They underwent plain X-ray (to rule out osseous lesions to exclude these patients), real-time high resolution ultrasonography and MRI for the affected ankle joint.

2.2. Imaging studies

2.2.1. Plain radiograph

All patients were subjected to plain X-ray in AP and lateral views to exclude any osseous lesions.

2.2.2. Ultrasonographic examination

All patients had standardized ultrasonography of the injured ankle joint. Excess gel was used. Ultrasound examinations were performed using one of the following devices either GE Logic pro6 (12 MHz) or GE Logic 3 (12 MHz), USA.

Technique of the examination (Fig. 1)

Guided by De Maeseneer et al. (1), the ultrasonographic examination began with the patient in supine position (Fig. 1a). Longitudinal scanning of the ankle was first performed to get an overall view of the tibio-talar joint and to detect joint effusion. Then, the ankle joint syndesmosis and anterior inferior tibiofibular ligament (AITFL) were assessed on transverse plane at anterolateral aspect of the distal tibia. Finally, while the patient in the same position, individual evaluation of the extensor tendons of the ankle was performed in both longitudinal and transverse planes starting from medial to lateral (tibialis anterior tendon, then extensor hallucis longus tendon (EHL), and most laterally extensor digitorum longus (EDL) tendon).

Thereafter, slight inversion of the foot was performed (Fig. 1b) while the patient in the same position to examine the lateral collateral ligaments and peroneal tendons. The Anterior talo-fibular ligament (ATFL) was first examined in oblique transverse plane from the tip of lateral malleolus, antero-medially and slightly downward, till the talus. Then, the Calcaneo Fibular ligament (CFL) was examined in oblique longitudinal plane from the lateral malleolar tip downward and slightly backward to the lateral surface of the calcaneus. Regarding the peroneal tendons, they were examined from their supra-malleolar musculo-tendinous junction, and then just behind the lateral malleolus till their infra-malleolar course in both longitudinal and transverse planes. Dynamic examination was obtained in eversion and dorsiflexion position to detect tendon dislocation or subluxation.

The patient was then asked to laterally rotate the lower limb (Fig. 1c) while lying supine to examine the deltoid ligament and flexor tendons. The former was examined in longitudinal scanning from its origin in the tip of the medial malleolus till its insertion into the talus, calcaneus, and navicular bones. The ankle flexor tendons were examined similar to the extensor tendons in longitudinal and transverse planes from medial to posterolateral (tibialis posterior tendon, then flexor digitorum longus tendon, and most laterally flexor hallucis longus tendon).

Finally the patient is asked to lie prone (Fig. 1d) and rest on his/her toes. The Achilles tendon was examined from its musculo-tendinous junction to its calcaneal insertion in both longitudinal and transverse planes.

Power-Doppler imaging was used to detect tissue hyperemia.

Ultrasound analysis

The ability to delineate the tendons and ligaments around the ankle joint was assessed.

We referred to standard reference values for musculoskeletal ultrasonography (6) (Table 1).

Regarding the tendons pathologies, they were diagnosed by the following sonographic appearances:

- Tendinosis (Fig. 2.1A, B) appeared as hypoechoic with loss of the normal echogenic fibrillar appearance of the tendon

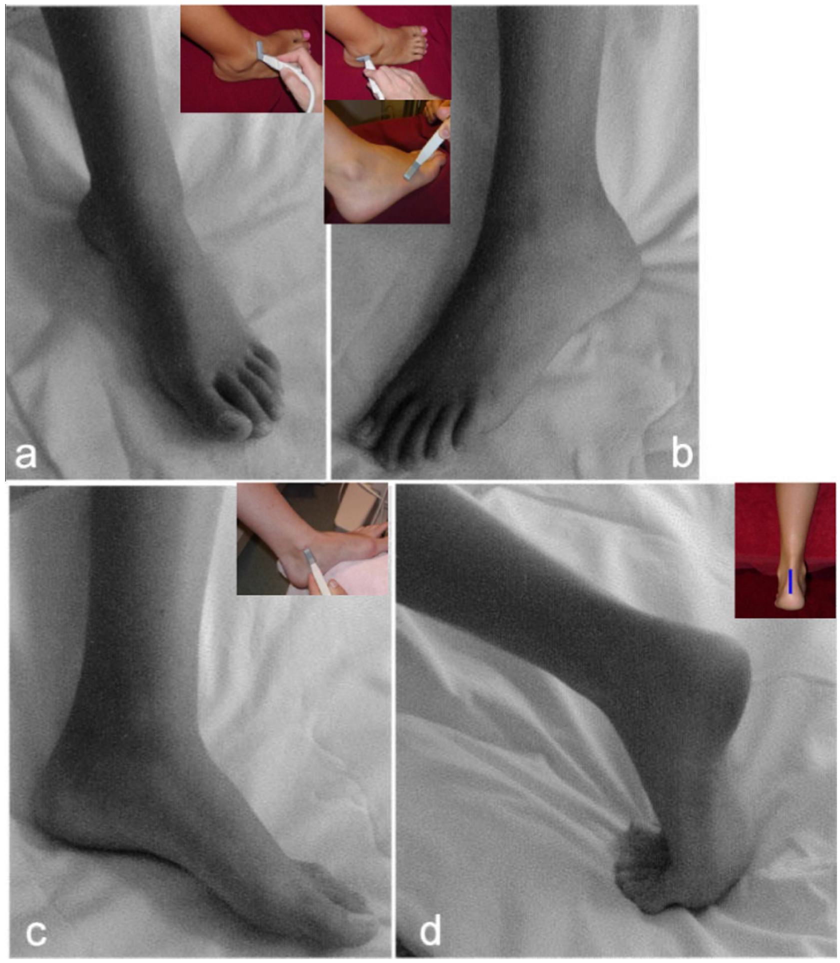

Fig. 1 Position of the patient and the transducer for routine US examination of the ankle tendons and ligaments. a: Anterior aspect. b: Lateral aspect. c: Medial aspect. d: Posterior aspect (13).

and tendon thickening. Power or color Doppler imaging may show hyperemia of neovascularity.

- Tenosynovitis (Fig. 3.1A, B) was diagnosed when there was increased fluid distending a tendon sheath, with or without hypervascular synovium surrounding the tendon. The fluid typically encircles the tendon forming a "halo" around it.
- Partial tears (Fig. 4.1A–C) appeared as hypoechoic thickening or thinning of the tendon and as contour irregularities or waviness without tendon discontinuity.
- Complete rupture of the tendon (Fig. 5.1A, B) 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.

Regarding the ligamentous pathologies, they were diagnosed by the following sonographic appearances:

- In acute sprain the ligament showed enlargement and loss of the normal fibrillar echogenicity, anechoic zone crossing the ligament or replacing one end of the ligament, anechoic band following the superficial border of the ligament, representing, avulsion of the bony insertion or anechoic zone forming a subcutaneous pouch and edema of the subcutaneous tissues, with lymphatic distension.
- Ligamentous injuries can be classified into three degrees:
  - o First degree injuries: US showed a thickened ligament with a relatively hypoechoic appearance, depending on the interstitial edema, and a hypoechoic line underscoring the superficial part of the ligament. The ligament was continuous with a regular outline.
  - o Second degree injuries: The normal echotexture appears altered. The ligament is thickened, inhomogeneous and shows an irregular outline; a minimal discontinuity of the ligament can be observed.
  - o Third degree injuries (Figs. 6A and 7A): US allows a full thickness lesion to be detected, with possible retraction of the fibers and hemorrhagic collection filling the gap.
  - o A dynamic examination was useful in doubtful cases.

- Both tenosynovitis and peri-tendinitis have overlapping radiographic appearance. On ultrasonography, tendon sheath widening, loss of the normal fibrillar echotexture, and loss of definition of tendon margins are the abnormalities that characterize tendinosis and tenosynovitis. It revealed as synovial sheath filled with fluid, appearing as a hypoechoic or anechoic zone around the tendon.

Table 1 Standard reference values for musculoskeletal ultrasonography for major tendons around the ankle joint (6).

Anatomic structure	Ultrasound plane	Exact localization	Mean value (mm)	Minimum (mm)	Maximum (mm)
Tibialis anterior tendon: transverse diameter	Ankle: anterior transverse	At tibio-talar joint	8.2	5.0	14.2
Tibialis anterior tendon: sagittal diameter	Ankle: anterior transverse	At tibio-talar joint	2.5	1.1	4.5
Tibialis anterior tendon: hypoechoic rim	Ankle: anterior transverse	At tibio-talar joint	0.8	0.1	2.8
Tibialis posterior tendon: transverse diameter	Tibialis posterior tendon: transverse diameter	Directly below level of medial malleolus	8.4	3.1	14.1
Tibialis posterior tendon: sagittal diameter	Tibialis posterior tendon: transverse diameter	Directly below level of medial malleolus	2.8	1.3	6.0
Tibialis posterior tendon: hypoechoic rim	Tibialis posterior tendon: transverse diameter	Directly below level of medial malleolus	1.2	0.2	3.8
Peroneus longus tendon: transverse diameter	Ankle: lateral transverse	Directly below level of lateral malleolus	6.0	2.5	12.3
Peroneus longus tendon: sagittal diameter	Ankle: lateral transverse	Directly below level of lateral malleolus	3.0	0.8	6.1
Peroneus longus tendon: hypoechoic rim	Ankle: lateral transverse	Directly below level of lateral malleolus	1.1	0.2	4.1
Peroneus brevis tendon: transverse diameter	Ankle: lateral transverse	Directly below level of lateral malleolus	4.3	1.8	13.0
Peroneus brevis tendon: sagittal diameter	Ankle: lateral transverse	Directly below level of lateral malleolus	2.5	0.5	4.2
Peroneus brevis tendon: hypoechoic rim	Ankle: lateral transverse	Directly below level of lateral malleolus	0.9	0.2	2.2
Achilles tendon: transverse diameter	Ankle: posterior transverse	2 cm proximal of calcaneus	14.3	8.2	20.6
Achilles tendon: sagittal diameter	Ankle: posterior longitudinal	2 cm proximal of calcaneus	4.3	2.6	6.7
Achilles tendon: hypoechoic rim	Ankle: posterior transverse	2 cm proximal of calcaneus	1.0	0.2	4.4

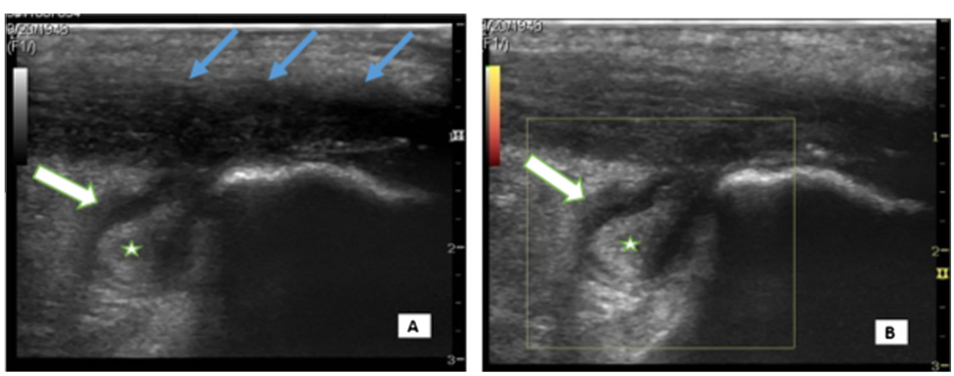

Fig. 2.1 (A) Longitudinal US image of the right Achilles tendon showing thickened hypoechoic distal portion of the tendon (blue arrows) with pre-Achilles bursa (white arrow) which is seen distended with echogenic fluid (*) (complicated, bursitis). (B) No increased vascularity on power Doppler imaging (chronicity).

2.2.3. MRI examination

- All patients had MR imaging of the affected ankle(s) on a high field-strength scanners.
- MRI was performed using one of the following devices either GE Signa HDxt (1.5 T) (USA) or Philips Achieva (1.5 T) (The Netherlands). Knee coil was used in all cases.

Technique:
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 (Figs. 8A–8C)

- The patients were examined by different pulse sequences including T1, T2, proton density, gradient echo and STIR. The examinations were done in different planes.

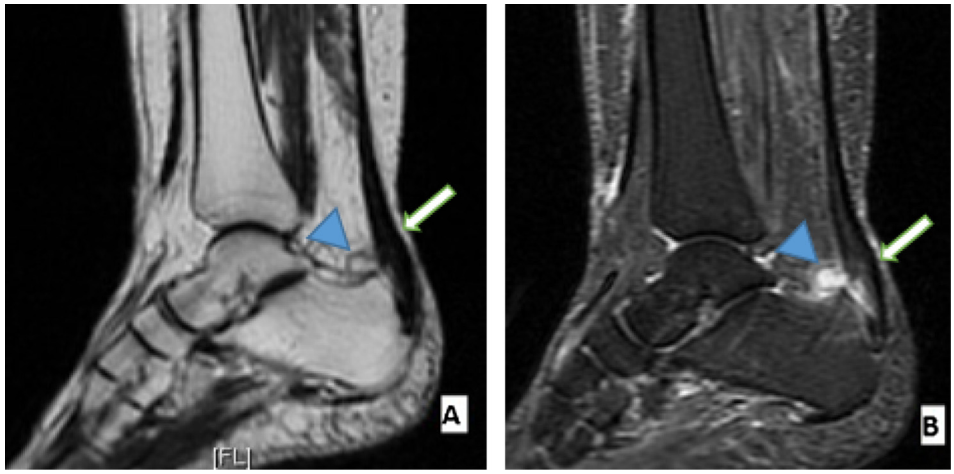

Fig. 2.2 Achilles tendinosis. (A) Sagittal T2 and (B) STIR images of the right ankle showing thickened distal Achilles tendon (white arrows) and increased its signal with comma-shaped pre-Achilles retro-calcaneal bursa (blue arrow head).

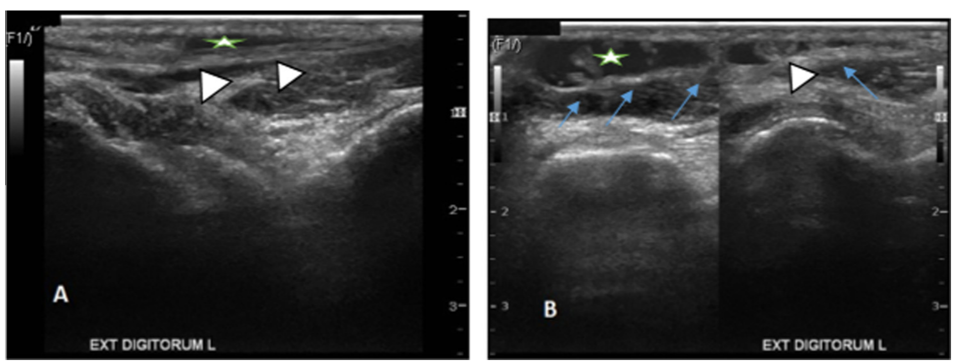

Fig. 3.1 EDL tenosynovitis. (A) Longitudinal and (B) transverse US images of the left EDL tendon showing distension of its synovial sheath (blue arrows) by anechoic fluid (yellow star). Intact tendon substance (white arrow heads).

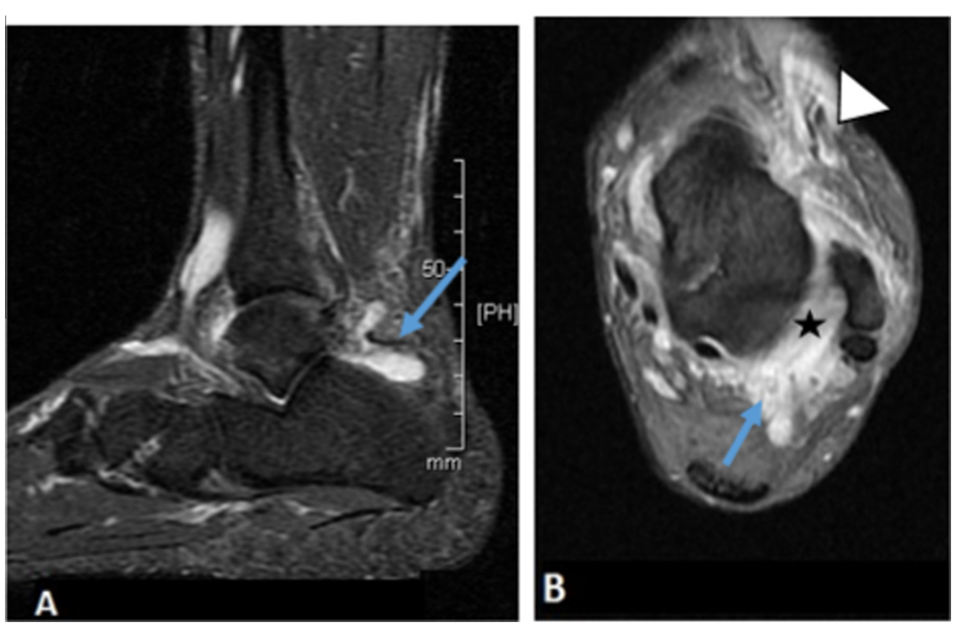

Fig. 3.2 EDL tenosynovitis. (A) Sagittal STIR and (B) axial MERGE images showing protrusion of the fluid-filled synovium (blue arrow) through thickened posterior ligament complex (black star), and fluid signal within the synovial sheath of the EDL tendons as well with normal girth and signal of the tendon (white arrow head).

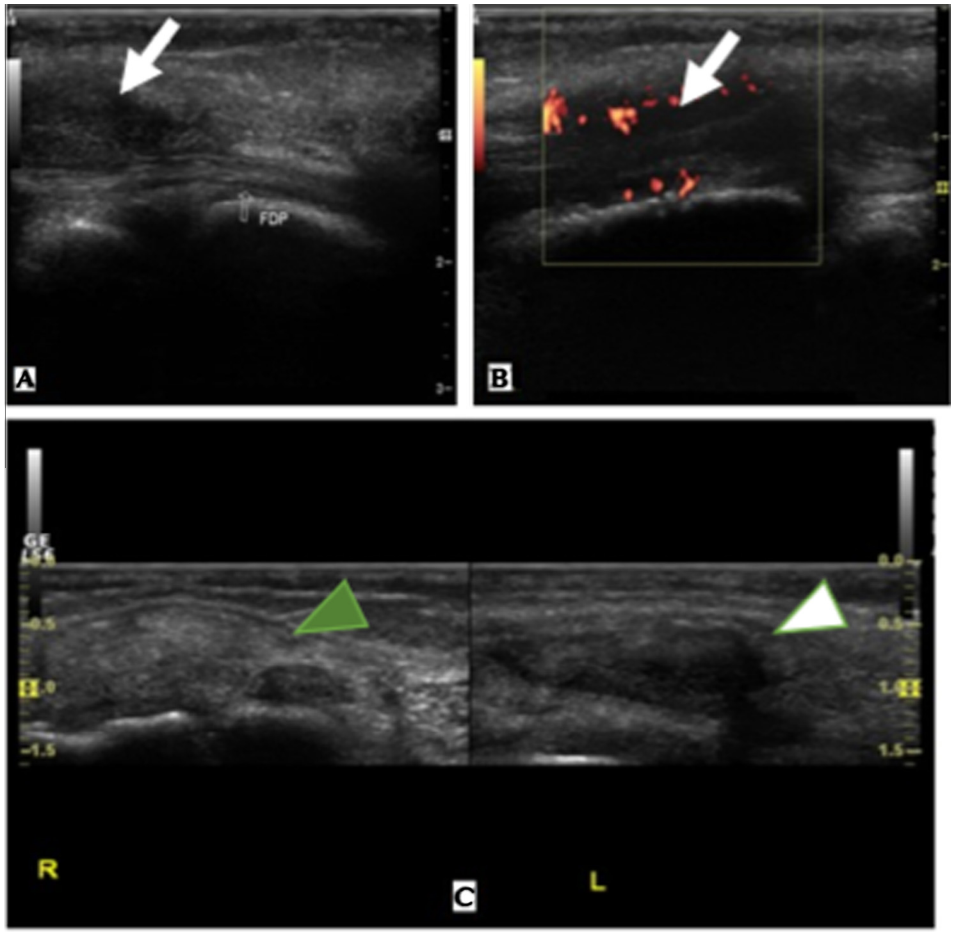

Fig. 4.1 (A) Oblique longitudinal US image showing marked thickening and heterogeneous hypoechoic pattern of the tibialis posterior tendon (white arrow) with no loss of its fibers continuity. (B) Applying power Doppler revealed increased vascularity. (C) US split screen image comparing the pathological left TP tendon (white arrow head) to the normal right one (green arrow head).

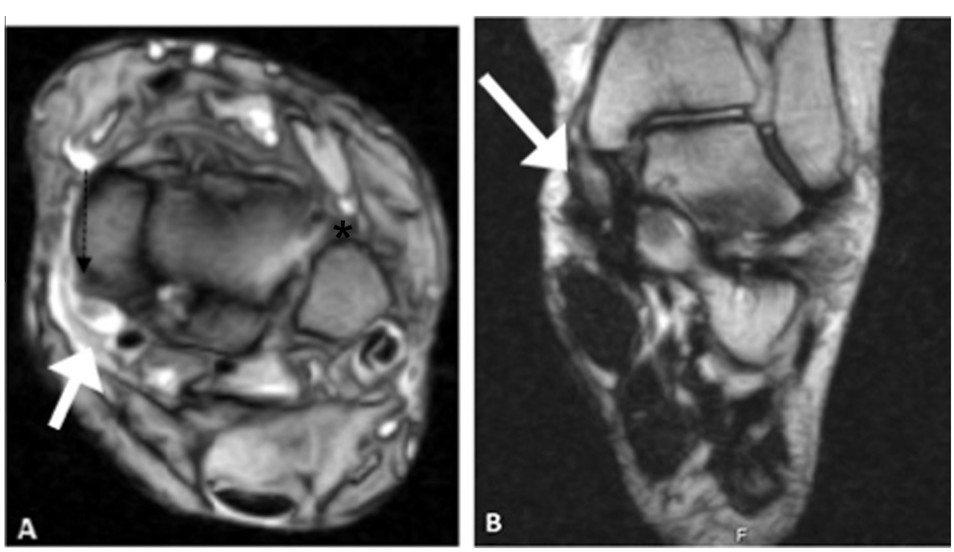

Fig. 4.2 Tibialis posterior partial tendon tear. (A) Axial gradient and (B) oblique coronal T2 MR images of the left ankle showing loss of the normal dark signal of the tibialis posterior tendon replaced by bright T2/gradient signals (white thick arrows). Degenerative changes are also noted at the opposing posterior aspect of the medial malleolus with small osteophyte (*).

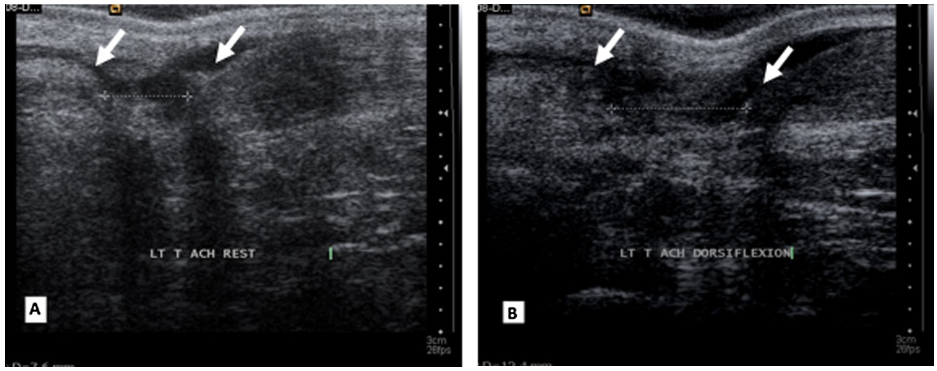

Fig. 5.1 Achilles tendon complete tear. Longitudinal US images of the left Achilles tendon with complete rupture. The gap (between white arrows) between two stumps is seen filled with unclear fluid (A) at rest and (B) during dorsiflexion.

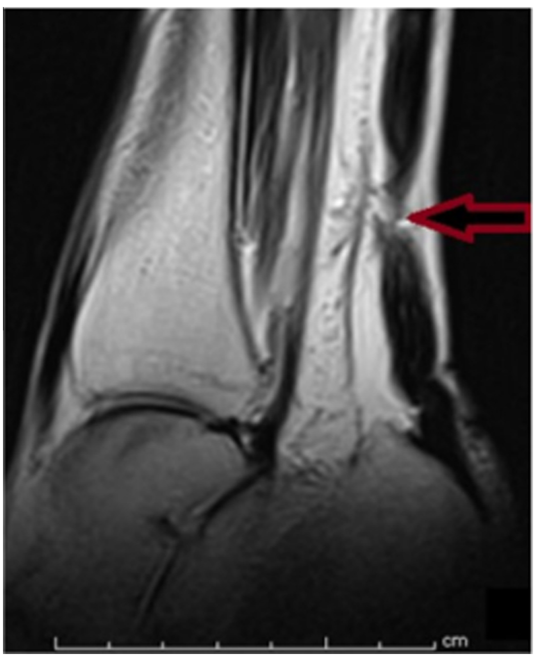

Fig. 5.2 Achilles tendon complete tear. Sagittal T1 image showing a gap between the two ends of the torn left Achilles tendon (complete rupture) (red lined arrow), filled with intermediate to low T1 signal.

- Our usual protocol of examination was Sagittal T1WIs, Axial T1WIs T2WIs and proton density images, coronal T1WIs as well as Sagittal or coronal STIR.
- Other parameters applied include slice thickness ranged from 3 to 5 mm, matrix 256/192 or 512/224, number of excitation 2 to 3 and field of view ranged from 12 to 16 cm, better kept < 14 cm.
- Results obtained from the ultrasonographic examination were compared to those obtained from MR examination for each patient.

MRI analysis

Regarding the tendino-ligamentous pathologies, they were diagnosed by the following appearances:

Fig. 6A Posterior tibio-talar ligament complete tear. US image with the probe is in the coronal plane showing the disrupted deltoid ligament (DL) underneath the medial malleolus (MM) with loss of its attachment to the talus.

Most ankle sprains occur on the lateral aspect and few at the medial aspect of the ankle. Magic angle effects can create false positive MR examinations.

Ankle sprains

On MR images, grade I injuries presented with subtle thickening and slightly increased signal intensity. Grade II lesions were thickened with increased signal intensity involving 50% of the ligament.

Discontinuity of the ligament was most easily detected in grade III.

Medial Ankle Sprain (Fig. 6B): Deltoid ligament injuries usually demonstrate inflammatory or edematous changes without complete ligament disruption. The ligament demonstrates homogenous intermediate signal intensity, a finding that was consistent with injury.

Lateral ankle sprain:

Acutely injured (Fig. 7B), it showed increased signals within which the presence of hemorrhage and edema is reflected. Joint fluid may be seen extending beyond the normal confines of the ligament.

Chronically injured, the ligament may be wavy or thickened with fibrotic low signal appearance or may be attenuated. High signals in the chronically injured ligament may reflect the presence of granulation tissues.

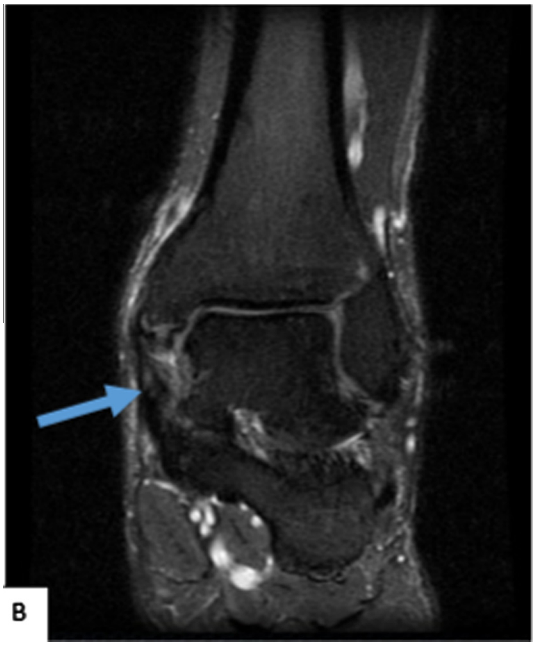

Fig. 6B Posterior tibio-talar ligament complete tear. Coronal T2 fat suppressed MR image showing indistinct posterior tibio-talar ligament with abnormal bright signal seen along its normal anatomic course (blue arrow).

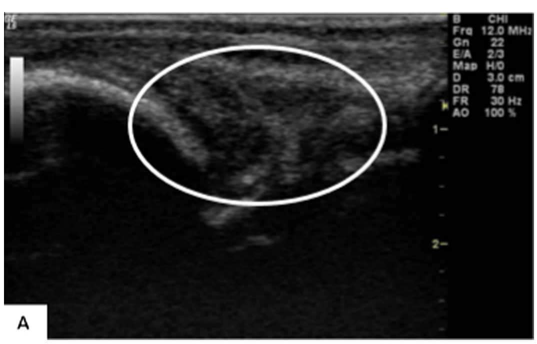

Fig. 7A Calcaneo-fibular ligament complete tear. US image showing abnormal heterogeneous hypo echogenicity at the region of the calcaneo-fibular ligament (within the oval ring).

Both tenosynovitis and peri-tendinitis 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, the tendon may remain enlarged and have decreased signal intensity in both T1 and T2-weighted images (Figs. 2.2A, B, 3.2A, B and 4.2A, B).

Tendon rupture (Fig. 5.2)

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.

Fig. 7B Calcaneofibular ligament complete tear. Axial T2 fat suppressed MR image showing discontinuous calcaneofibular ligament with abnormal bright signal seen along its normal anatomic course (white lined arrow).

3. Results

This study included 35 painful ankle joints shown in Table 2 by the age, sex, and lateralization of the examined patients.

Tendinous injuries:

The study showed 20 patients with tendon pathology that were diagnosed into 21 pathological entities by both ultrasound and MRI imaging modalities with no difference in interpretation between them (100% sensitivity for tendon pathology). The distribution and classification of different tendinous pathological entities in this study are shown in Tables 3–5 and Fig. 9.

Ligamentous injuries:

The distribution and incidence of different pathological ligamentous lesions in the present study are shown in Fig. 10 and Tables 6–8. Our study showed that ultrasound could detect all of the ligamentous lesions identified at MRI (100% sensitivity for pathological ligament). However, two ligamentous lesions that were interpreted as partial tear by ultrasound were diagnosed as complete tear by MRI.

Associated pathology (Table 9) shows 4 cases with ankle joint effusion, 3 cases with posterior synovitis and 2 cases with retro-calcaneal bursitis.

The examinations were corrected by two radiologists with good musculoskeletal experience. Both were blinded to the results of the other.

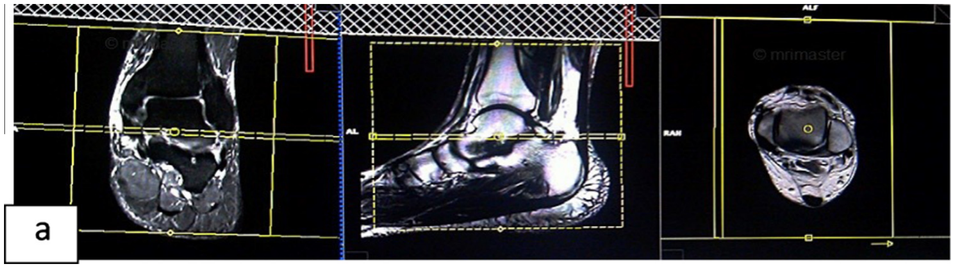

Fig. 8A Showing MRI protocol. Showing Plane the axial slices on the coronal plane; angle the position block parallel to the mortise joint.

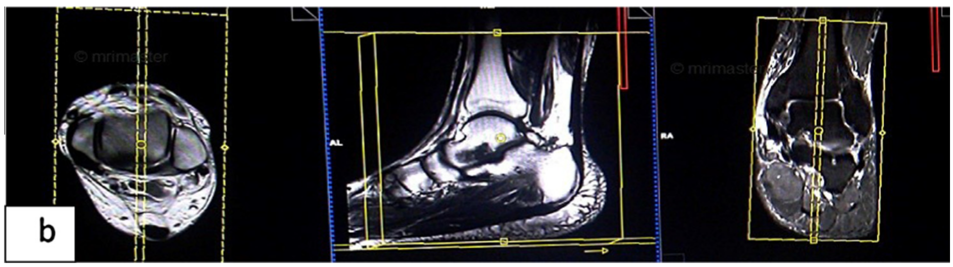

Fig. 8B Showing MRI protocol. Showing Plane the sagittal slices on the axial plane; angle the position block parallel to the medial and lateral malleoli.

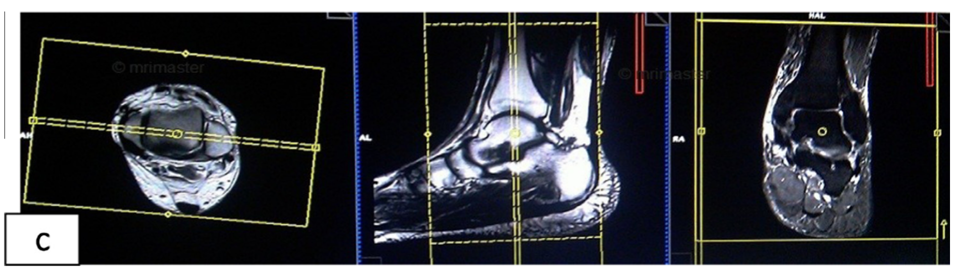

Fig. 8C Showing MRI protocol. Showing Plane the coronal slices on the axial plane; angle the position block perpendicular to the medial and lateral malleoli.

Table 2 Age, sex, and lateralization distribution of the patients.

Age in years		Sex		Lateralization	
Range	Mean	Female	Male	Left	Right
18–60	37	25	10	19	16

Table 10 collective table shows the distribution of all 51 diagnosed pathologies (21 tendon pathologies, 21 ligament pathologies, and 11 associated pathologies) by all imaging modalities of total 35 cases of the study.

4. Discussion

The ankle is commonly affected in trauma as well as overuse disorders and inflammatory conditions. Various imaging techniques may be used to assess the ankle, including CT, MRI, and sonography (1). Imaging plays a crucial role in the evaluation of ankle tendons and ligaments. Magnetic resonance imaging has been proven to provide excellent evaluation of ligaments around the ankle, with the ability to show various types of soft tissue and bone abnormalities. Ultrasonography (US) performed with high-resolution linear-array probes has

Table 3 Distribution of different tendinous pathological entities diagnosed in this study.

Tendon	No. of cases	No. of pathological entities diagnosed by all imaging modalities	No. of pathology diagnosed by MRI	No. of pathology diagnosed by U/S
Achilles	11	11	11	11
TP	2	3	3	3
FDL	1	1	1	1
FHL	1	1	1	1
TA	1	1	1	1
EDL	1	1	1	1
Peroneal	3	3	3	3
Total	20	21	21	21

Table 4 Distribution and classification of different tendinous pathological entities.

Pathology	Frequency
Achilles tendon	11
Tendinosis	5
Enthesopathy	1
Partial tear	3
Complete tear	2
Tibialis posterior tendon	3
Partial tear	2
Exudative tenosynovitis	1
Peroneal tendons	3
Tendinosis	1
Partial tear	1
Exudative tenosynovitis	1
Tibialis anterior tendon	1
Tendinosis	1
Flexor hallucis longs tendon	1
Exudative tenosynovitis	1
Flexor digitorum longus tendon	1
Exudative tenosynovitis	1
Extensor digitorum longus tendon	1
Exudative tenosynovitis	1
Total	21

Table 5 Incidence of different tendinous injuries.

Tendon	No. of pathological entities	%
Achilles	11	52.4
TP	3	14.3
FDL	1	4.75
FHL	1	4.75
TA	1	4.75
EDL	1	4.75
Peroneal	3	14.3

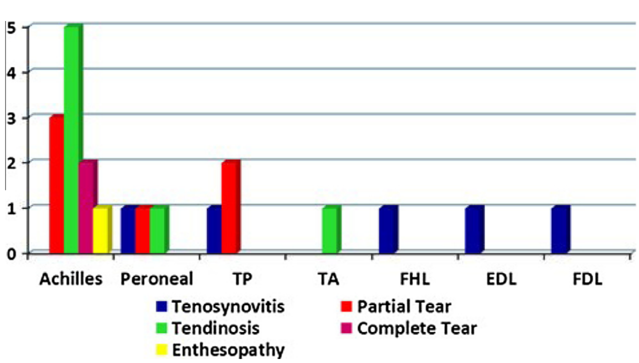

Fig. 9 Showing Chart (1): Distribution and classification of different tendinous pathological entities in this study.

become advanced in the assessment of ligaments around the ankle joint. US can provide a detailed depiction of normal anatomic structures and is effective for evaluating ligament and tendon integrity (4).

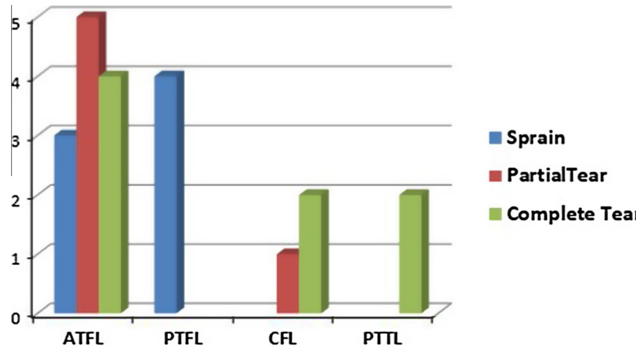

Fig. 10 Showing Chart 2: Distribution and pathological classification of ligamentous injury in this study.

Table 6 Distribution of different ligamentous pathological entities diagnosed in this study.

Ligament	Frequency
Lateral ligament complex	19
ATFL	12
CFL	3
PTFL	4
Medial (deltoid) ligament	2
PTTL	2
Total	21

Table 7 Distribution and pathological classification of ligamentous injury diagnosed in this study.

Injury	Frequency	Distribution				%
		ATFL	PTFL	CFL	PTTL	
Sprain	7	3	4	0	0	33.3
Partial tear	6	5	0	1	0	28.6
Complete tear	8	4	0	2	2	38.1

Tendinopathy is a common musculo-skeletal injury in the upper and lower limb. In the past, diagnostic US has been at the forefront of research in tendinopathy and has emerged as the gold standard in imaging. In the development of high-frequency probes the main advantages of this non-invasive imaging tool include fine depictions of tendon fibrillar appearance, dynamic and point of care examination, and guided intervention. However, the main disadvantage of diagnostic ultrasound examination is that it is operator dependent. In tendinopathy, the sonographer has to interpret gray scale and power Doppler tendon appearances and decide on what images are acquired and archived (7,8).

Therefore, an algorithm can be devised to take this into account. If a clinician has suspicion for 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

Table 8 Correlation between US and MRI findings in 14 ligamentous injuries diagnosed as partial and complete tears.

Modality	Pathology	No. of cases		Total
U.S. Diagnosis	Partial tear	ATFL	6	14
		CFL	2	
	Complete tear	ATFL	3	
		CFL	1	
		DL	2	
MRI Diagnosis	Partial tear	ATFL	5	14
		CFL	1	
	Complete tear	ATFL	4	
		CFL	2	
		DL	2	

Table 9 Correlation between US and MRI findings in detection of ankle joint effusion, retrocalcaneal bursitis and synovitis in 35 cases subjected to both imaging modalities.

Modality	Effusion	Retrocalcaneal bursitis	Synovitis
	No. of cases		
US	4	2	3
MRI	4	2	3

algorithm, sonography may be considered the first line of imaging for joint problems after radiography (1,9).

The aim of this study was to compare the diagnostic accuracy of both ultrasonography (US) and magnetic resonance imaging (MRI) for the assessment of soft tissue as well as the tendino-ligamentous causing pain around the ankle in musculoskeletal disorders.

Our study included thirty-five patients complaining of unilateral ankle pain. All patients were subjected to plain X-ray, real-time high resolution ultrasonography and MRI of the affected ankle.

Twenty-one entities of tendon injury were diagnosed in this study which represented about 29.2% of the pathological entities encountered. There were 11 cases of Achilles tendon injuries representing 52.4% of the tendinous injuries. 18.2% of these cases (2 cases) were presented with complete rupture of the Achilles tendon. Their ages ranged between 35 and 60 years. This is matched with Klauser et al. and Liffen (8,9) who reported that Achilles tendon ruptures are commonly affecting the middle aged individuals and abnormal tendons. The rest of Achilles tendon injuries in our study were presented with partial tear, tendinosis, and enthesopathy representing 27.3%, 45.4% and 9.1% of the Achilles tendon injuries, respectively.

Although it is the strongest tendon in the human body, Liffen, 2014 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 (8). Our results coincide with this hypothesis as Achilles tendon injuries represented 52.4% of all diagnosed ankle tendons' injuries and ranged in severity from tendinosis, partial tear to complete tear.

In our study, ultrasound was capable in detecting all Achilles tendon injuries identified at MRI (100% sensitivity).

Table 10 Distribution of all 51 diagnosed pathologies by all imaging modalities of total 35 cases of the study.

Cases	Pathology diagnosed	No. of cases	No. of pathological entities
1–4	Achilles tendinosis	4	4
5	Achilles enthesopathy	1	1
6–8	Achilles tendon partial tear	3	3
9–10	Achilles tendon complete tear	2	2
11	Achilles tendinosis Retrocalcaneal bursitis	1	2
12	Peroneal tenosynovitis ATFL[a] complete tear CFL[a] complete tear Ankle joint effusion	1	4
13	Peroneal tendinosis	1	1
14	Tibialis posterior partial tear	1	1
15	TP[a] tendon partial split tear TP[a] tenosynovitis	1	2
16	TA[a] tendinosis ATFL[a] partial tear. Ankle joint effusion	1	3
17	FHL[a] tenosynovitis ATFL[a] partial tear Ankle joint effusion	1	3
18	ATFL[a] partial tear Retro-calcaneal bursitis	1	2
19	PB[a] tendon longitudinal split tear	1	1
20	PTTL[a] complete tear	1	1
21–23	ATFL[a] sprain	3	3
24	ATFL[a] partial tear Ankle joint effusion	1	2
25	ATFL[a] partial tear CFL[a] partial tear	1	2
26–28	ATFL[a] complete tear	3	3
29	ATFL[a] complete tear	1	1
30	PTTL[a] complete tear	1	1
31	PTFL[a] sprain Posterior joint synovitis	1	2
32	CFL[a] complete tear	1	1
33	Posterior ligamentous complex sprain Synovitis EDL[a] tenosynovitis	1	3
34	PTTL[a] sprain Synovitis	1	2
35	FDL[a] tenosynovitis	1	1
Total		35	51

[a] Abbreviation: ATFL, Anterior Talo-fibular Ligament; CFL, Calcaneo-fibular ligament; TP, Tibialis Posterior; TA, Tibialis Anterior; PB, Peroneus Brevis; PTTL, Posterior talo-fibular ligament; EDL, Extensor Digitorum Longus; FDL, Flexor Digitorum longus; FHL, Flexor Hallucis Longus.

Follow-up for Achilles tendon injuries, the MRI was 100% sensitive in diagnosis of surgically proved complete tears. Regarding characterization of Achilles lesions, ultrasound succeeded to classify Achilles injuries similar to MRI regarding tendinosis, partial tear, and complete tear. Similarly, Liffen (8) and Margetic et al. (10) reported that ultrasound was has been used as a first-line approach for assessing Achilles tendon disorders and stated that it has 100% sensitive in detecting Achilles tendon injuries in 26 cases.

In our study, tibialis posterior tendon showed 3 pathological entities (6% of all cases, 4.2% of all pathologies, and 14.3% of all pathological tendons). 2 cases of partial tear represent 66.66% of pathological TP tendons, and 1 case of tenosynovitis represents 33.33% of pathological TP tendons.

Of the three medial ankle tendons, the tibialis posterior tendon is the most frequently affected. In our study, only three cases of tibialis posterior tendon pathology were diagnosed by ultrasound and MRI. Although there was small number of tibialis posterior tendon pathology in our study group, our results were similar to the results achieved by Liffen (8) and Fessell and Jacobson (11) who correlated ultrasound findings in tibialis posterior tendon injuries with surgical findings and showed that ultrasound allowed correct diagnosis in all of the 17 cases of tendon diseases, including tendinosis, tenosynovitis, partial and complete tear.

In our study, ultrasound was capable in detecting all tibialis posterior tendon injuries identified at MRI (100% sensitivity). However, regarding characterization of TP tendon lesions, ultrasound succeeded to classify TP tendon injuries similar to MRI regarding partial tear, and tenosynovitis with an exception of only one case of partial tear which was diagnosed by MRI and interpreted by US as tibialis posterior tendinosis. Margetic et al. (10) and Mansour et al. (12) stated that the use of either sonography or MRI had demonstrated a high degree of differentiation in helping to distinguish partial thickness from tendinosis. However, this distinction may not be of great clinical importance since a partial thickness tear or tendinosis, in the absence of a full thickness tear, is usually treated with non-surgical means.

Of the remaining medial ankle tendons, the FDL tendon is rarely affected by pathological changes, but can be detected by ultrasonography (10–12). Our study included one case of FDL tenosynovitis which was diagnosed by US and approved by MRI study.

Our study included only one case of FHL tenosynovitis which was diagnosed by US and approved by MRI study. The pathology of FHL tendon has been reported more frequently than the FDL tendon. Because of its deep location and changes in its direction, the FHL tendon can be difficult to evaluate with US (11).

Although the anterior ankle tendons are rarely affected with pathology in comparison with the other ankle tendons (13), our study included 1 case with tibialis anterior tendinosis and 1 case with EDL tenosynovitis. This agreed with Narvaez (14) 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 3 pathological entities (6% of all cases, 4.2% of all pathologies, and 14.3% of pathological tendons): 1 case of tenosynovitis, 1 case of tendinosis, and 1 case of partial split tear of peroneus brevis tendon, each representing 33.33% of pathological peroneal tendons.

Longitudinal split tears of the peroneus brevis tendon have been increasingly reported as a source of lateral ankle pain and disability. Lee et al. (15) 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 (12) also reported that MR imaging is useful in identifying the appearance of longitudinal split tears of the peroneus brevis.

Twenty-one cases of ligamentous injury were diagnosed in our study representing 51% of total cases and 29.2% of the whole encountered pathological entities. Anterior talofibular ligament (ATFL) was the most frequently injured ligament representing 57.2% of the whole ligamentous injuries followed by the posterior talo-fibular ligament (PTFL) (19%) and calcaneo-fibular ligament (CFL) (14.3%). Deltoid ligament was the least ligament injured (9.5%). This coincides with different literatures evaluating ankle ligaments. Cheng et al. (16) stated that anterior talo-fibular ligament is the most commonly torn ankle ligament followed by calcaneo-fibular ligament, and in 70% of ankle sprains, only the anterior talo-fibular ligament is torn, while the calcaneofibular ligament is also torn in 20% of cases. The deltoid ligament is the strongest ankle ligament and least to be injured.

Although rupture of ATFL may be an isolated injury, CFL and PTFL ruptures are not found in the presence of an intact ATFL. Stoller (17) stated that, combined ATFL and CFL tears occur in 40% of ATFL tears, and CFL tears without ATFL tears are quite unusual.

Thus, after inversion ankle injury, visualization of an intact ATFL virtually excludes rupture of any of the lateral collateral ligaments (18). In our study, ATFL injury was associated with two cases diagnosed as having CFL injury. Similar results were also achieved by Martinoli (13).

In our study, correlation between the ability of ultrasonography against MRI in detection of ligamentous tears yielded a sensitivity of 100%. Our results were nearly similar to the results achieved by Cheng (16), who showed that sonography succeeded to diagnose 14 out of 15 anterior talofibular ligament tears with a sensitivity of 93%. Similarly, Petra et al. (10) reported that US results agreed in 100% of the cases with operative findings for ATFL and 92% for CFL. However, D'Erme (19) indicated that MR imaging was superior to sonography in diagnosis of ankle collateral ligaments injuries. On the other hand, Milz et al. (20) yielded promising improvement of sonographic accuracy by using high frequency transducers (13 MHz); they concluded that sonography can identify normal ankle ligaments with high accuracy and it showed the greatest accuracy in evaluation of the anterior talofibular and calcaneofibular ligament (90% and 87%, respectively). This agreed with Sconfienza et al. (4) where they reported that US has shown valuable results in the evaluation of the normal and pathological anatomic structures of the ankle and provides an imaging modality alternative to MR imaging and MR arthrography. Use of a standardized imaging technique that allows dynamic imaging may play an important role in the assessment of the anatomic structure and main pathological patterns of the ankle.

In our study, the lateral collateral ligament complex is affected in 90.5% of all ankle ligament injuries. Artul and Habib (21) also reported that the lateral collateral ligament complex is affected in 80–90% of all ankle ligament injuries.

In conclusion, in agreement with Mansour and Jain (12) and Bekerom et al. (18), this study showed that imaging plays a major role in the management of ankle problems. Plain films are useful as an initial screen test for diffuse ankle pain and detection of gross bony lesions. Ultrasonography and MRI are two complementary tools of investigation. 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.

On conclusion, our study aimed to compare the diagnostic accuracy of both ultrasonography and magnetic resonance imaging for the assessment of tendons and ligaments around the ankle joint.

Our results showed that:

- ***Tendinous pathology:***
  - Achilles tendon is the most commonly injured ankle tendon, followed by tibialis posterior and peroneal tendons, while those of the anterior compartment were the least encountered ones.
  - Tendinosis was the most encountered tendon pathology followed by partial tear and tenosynovitis.
  - Compared to MRI, ultrasonography in our study yielded 100% sensitivity for tendinous injuries.
- ***Ligamentous injuries:***
  - Anterior talo-fibular ligament was the most frequently injured ligament (57.2%) of the whole ligamentous injuries and in most cases it was isolated injury. This was followed by the posterior talofibular ligament (19%) and calcaneofibular ligament (14.3%). Deltoid ligament was the least ligament injured (9.5%).
  - In our study, ATFL injury was associated with 66.7% of cases diagnosed as having CFL injury.
  - Correlation between the ability of ultrasonography, against MRI in detection of ligamentous tears yielded a sensitivity of 100%.
- ***Limitations and recommendations***

The ligaments and tendons image protocol was produced based on the available literature, clinical experience and a service evaluation. However, the protocol has no other evidence to support its use. In addition, the protocol is designed for the tendon and ligament diagnostic ultrasound examination. The data collection included patients with history of trauma only. Therefore, would the protocol be relevant and applicable to other pathology of the tendon?

A recommendation is that further pilot studies are performed in all types of tendon pathology to validate this protocol.

Conflict of interest

The authors declared that there is no conflict of interest.

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