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Role of Magnetic Resonance Imaging in Evaluation of Post Traumatic Ankle Joint

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ABSTRACT

Background: The ankle joint injuries are common emergency and account for about 10% of all visits to emergency departments. This is usually due to a sprain related to sports, walking, fall, or road traffic accident. Ankle joint has a complex three-dimensional anatomy, so MRI is considered the modality of the choice in evaluating patients with ankle problems. MRI provides precise information about soft tissue, skeletal and extra-skeletal lesions.

Objectives: To evaluate the role of magnetic resonance imaging (MRI) in the detection of abnormalities and injuries associated with post traumatic ankle joint.

Patients and methods: A descriptive cross-sectional study was conducted from July 2019 to April 2021. Sixty patients with post-traumatic ankle joint complaints underwent MRI examination during this period. All patients performed MRI examination in the Radiology Department, Menoufia University Hospital after signing informed consent.

Results: Out of 60 patients, nine (16%) were diagnosed with ligamentous injuries, 29 (48.3%) were diagnosed with tendon injuries and 35 (58.3%) were diagnosed with bone injuries. Nine (15%) were fractures, one (1.7%) was bone necrosis and 34 (56.7%) were bone contusions. 55 (91.7%) had joint effusion and 11 (18.3%) had sinus tarsi syndrome.

Conclusion: MRI is the modality of choice in evaluating ankle injuries because of its high soft tissue contrast resolution and multi-planar capabilities. It is an ideal modality for global evaluation of the osseous and soft tissue structures of the ankle.

Keywords: Ankle joint, MRI, Traumatic Injuries.

INTRODUCTION

The Ankle joint injuries are common and make up approximately 10% of all emergency department visits. They are frequent in men aged 12 to 24 years. However, women older than 30 years have higher rates. This is usually due to a sprain related to sports, walking, falling, or road traffic accident [(1)]. The increased sports activities these days have increased the number and type of sports-related injuries [(2)]. About 10,000 people are suffering from an ankle injury every day in the United States with most of these being sprains [(3)]. A sprain can be defined as disruptions of the ligaments of the joint, but there are other associations as bone fractures, avulsion, and contusions can be present. It usually happens due to the inversion of the ankle, but eversion can also cause ankle injury [(4)].

This injury is often taken for granted due to its frequency and most patients are treated with conservative management successfully, but about 30% of the patients with ankle sprains remain with chronic lateral ankle instability and residual pain, which requires a surgical procedure [(5)].

Ankle joint has a complex three-dimensional anatomy, so magnetic resonance imaging (MRI) is considered the modality of the choice in evaluating patients with ankle problems due to its multiplanar capabilities, excellent soft-tissue contrast, bone marrow imaging capability, non-invasiveness, and lack of ionizing radiation [(6)]. Plain radiographs are still the initial and most valuable imaging study of any patient with a musculoskeletal injury. Lack of familiarity of radiologists with local pathology and complex anatomy of this region may explain the less popularity of MRI of the ankle [(2)].

MRI can provide precise information about cartilage, tendon, ligament, bone marrow, joint effusion, skeletal and extra-skeletal masses. It has superiority in soft tissues over any other modality; this makes it a useful tool for surgeons to diagnose and to make treatment plans [(7)].

Future improvements in MRI technique may help the surgeon to limit the extent of dissection by localization of the area of interest and MRI may then be used to monitor healing or response to treatment. MRI is not a replacement of plain radiography but is a valuable adjunct [(8)].

The aim of this work was to evaluate the role of MRI in the detection of abnormalities and injuries associated with post traumatic ankle joint.

PATIENTS AND METHODS

This study was conducted at the MRI Unit, Department of Radiodiagnosis and Interventional Radiology, Menoufia University in the period from July 2019 to April 2021. The study included 60 patients with post traumatic ankle symptoms referred from the orthopedic department. They included 31 males and 29 females with age distribution from 4 to 73 years, with a mean age of 34.6 years.

Inclusion criteria: Our study included any patient with ankle pain following traumatic insult, with no age or sex predilection.

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Exclusion criteria:

We excluded patients with a history of non-traumatic ankle pain, patients who had surgeries to the ankle joint, patients with metabolic diseases, ankle joint tumors and any electrically, magnetically or mechanically activated implant (e.g. cardiac pacemaker, insulin pump biostimulator, neurostimulator, cochlear implant, hearing aids, intracranial aneurysm clips (unless made of titanium), ferromagnetic surgical clips or staples), metallic foreign body in the eye and metal shrapnel or bullet.

All patients were evaluated by careful history taking, clinical examination and MRI examination. The examination was performed by MR scan Toshiba Excelart Vantage Titan (Toshiba Medical Systems Corporation, Otawara, Tochigi, Japan) 1.5 Tesla MR Set closed magnet / Extremity coil.

Patient positioning and coils:

The patient lied in supine position with feet pointing towards the magnet (feet first supine) with the ankle and foot in a neutral position in the standard extremity coil. Plantar flexion of 20 to 30 degrees has been done for reducing the "magic angle" artifact. Pads have been used to support the ankle and prevent movement during the examination. The laser beam localizer has been centered over the ankle joint.

MRI scanning protocol of the ankle joint: (Table 1)

- Ankle joint MRI scanning protocol took 45 to 60 minutes. A three-plane localizer has been taken at the beginning to localize and plan the sequences. Localizers of T1 weighted low resolution scans have been taken in less than 25 sec. The straight sagittal sequences in the ankle region were obtained at first. Sagittal images allow recognition of the proper plane of the ankle joint, which is essential to adjust the Achilles tendon, articular cartilage, subtalar joint, tarsal sinus and plantar fascia.

- The second pulse sequence to be obtained was the axial images in fast spin echo T2 weighted images (T2WIs). T2WIs in the axial plane demonstrated the bright signal of soft tissue edema, fluid in synovial sheath and joint effusion. The extension of this effusion outside the joint capsule is considered a strong indirect evidence of rupture of anterior talofibular (ATFL) and posterior talofibular (PTFL) ligaments. Axial T1 weighted images (T1WIs) and proton density (PD) fat sat sequences were obtained to assess the joint recesses. The axial images visualized the tibiofibular ligaments as well as the flexor and extensor tendons.

T1WIs and T2WIs were taken in the coronal planes. T1WIs allowed further evaluation of the articular cartilage. The deltoid and the lateral collateral ligaments were evaluated properly at the coronal planes. T1WIs and T2WIs confirmed what seen in axial and sagittal images. Short-time inversion recovery (STIR) pulse sequence was done in sagittal planes to detect abnormal marrow signal and to differentiate marrow edema (which appears very bright at STIR) from other lesions, which appear hypointense in T1WIs such as focal sclerosis.

Table (1): Protocol of MRI Ankle joint

Plane	Sequences	TR	TE	Slice thickness	Gap	Matrix	FOV	Fat Sat	TI
Axial	**T1WI**	400-600	15-25	3.5mm	0.5mm	256x256	15-17	OFF	---
	T2WI	4000-5000	110	3.5mm	0.5mm	256x256	15-17	OFF	---
	PD Fat Sat	3000-4000	15-20	3.5mm	0.5mm	320x256	15-17	ON	---
Sagittal	**T1WI**	400-500	15-25	4 mm	0.5mm	256x256	15-17	OFF	---
	T2WI	4000-5000	110	4 mm	0.5mm	256x256	15-17	OFF	---
	STIR	4000-5000	110	4 mm	0.5mm	256x256	15-17	OFF	130
	T2* GRE	400-500	10-15	4 mm	0.5mm	256x256	15-17	OFF	---
Coronal	**T1WI**	400-500	15-25	4 mm	0.5mm	320x256	16-17	OFF	---
	T2WI	4000-5000	110	4 mm	0.5mm	320x256	16-17	OFF	---

FOV, field of view; STIR, short tau inversion recovery; TE, time of echo; TI, time of inversion; TR, repetition time; T1WI, T1-weighted image; T2WI, T2-weighted image; PD fat sat, proton density fat saturation, T2* GRE, T2 gradient echo.

Ethical consent:

An approval of the study was obtained from Menoufia University Academic and Ethical Committee. Every patient signed an informed written consent for acceptance of the study. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis

All images were interpreted on the computer workstation by two expert radiologists blinded to the patients' history and the diagnosis was established, then data were collected, tabulated and statistically analyzed using an IBM compatible personal computer with Statistical Package for the Social Sciences (SPSS) version 23 (SPSS Inc., IBM SPSS statistics for windows, version 23.0, Armnok, NY: IBM Corp.). Two types of statistical analysis were performed: Descriptive statistics e.g. qualitative data were expressed as number (N), percentage (%), while quantitative data were expressed as mean ($\bar{x}$), standard deviation (SD) and range (minimum-maximum). Analytic statistics e.g. Chi-square test (χ^2) was used to study association between qualitative variables. Whenever any of the expected cells were less than five, Fischer's Exact test was used. Significant test results were quoted as two-tailed probabilities. Significance of the obtained results was judged at the 5% level ($P \leq 0.05$).

RESULTS

The study included 60 patients (31 males and 29 females) with a mean age of 34.6 ± 15.95 years old ranging between 4 and 73 years, 38.3% of the patients were < 30 years and 61.7% of them were > 30 years**.** All patients had a history of traumatic ankle injuries; 17 cases (28.3%) of acute onset complained of pain (7 cases, 41.2%), swelling (one case, 5.9%) and combined pain with swelling (9 cases, 52.9%). 43 cases (71.7%) of chronic onset complained of pain (39 cases (90.7%), instability no cases and combined pain with instability (4 cases (9.3%)**.**

Our study showed that 55 cases representing (91.7%) of total cases had joint effusion, bone lesions with 35 cases representing (58.3%), tendon injuries 29 cases (48%), sinus tarsi 11 cases (18.3%) and the ligament injuries with 9 cases (16%) of total cases (Figure 1).

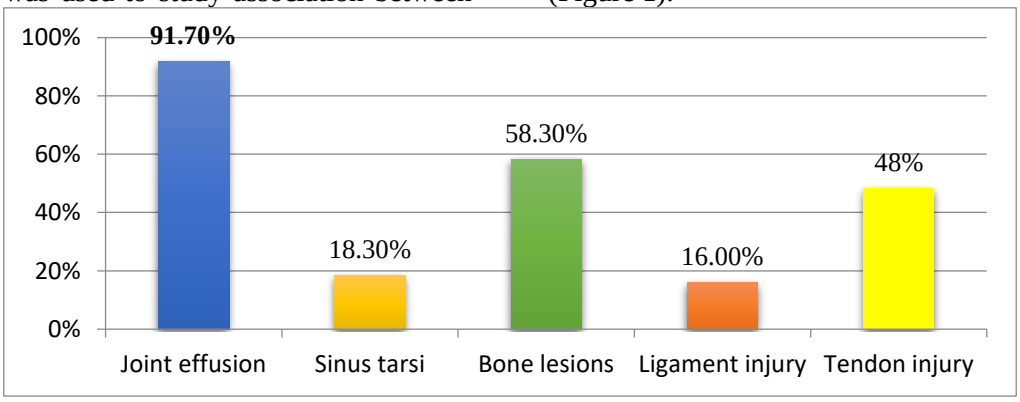


Figure (1): Column chart representing classification of MRI pathological findings

From the involved patients, 35 patients had bone injuries; 34 patients (56.7%) had bone marrow contusion, 9 patients (15%) had bone fractures and only one patient (1.7%) had bone necrosis**.** The bone fractures included in this study can be divided into talus dome osteochondral defect (OCD) 5 cases (8.3%), physis (Salter Harries) fracture 1 case (1.7%), calcaneal fracture 2 cases (3.3%), distal tibial fracture 1 case (1.7%) and combined calcaneal with distal tibial fracture one case (1.7%) (Figure 2).

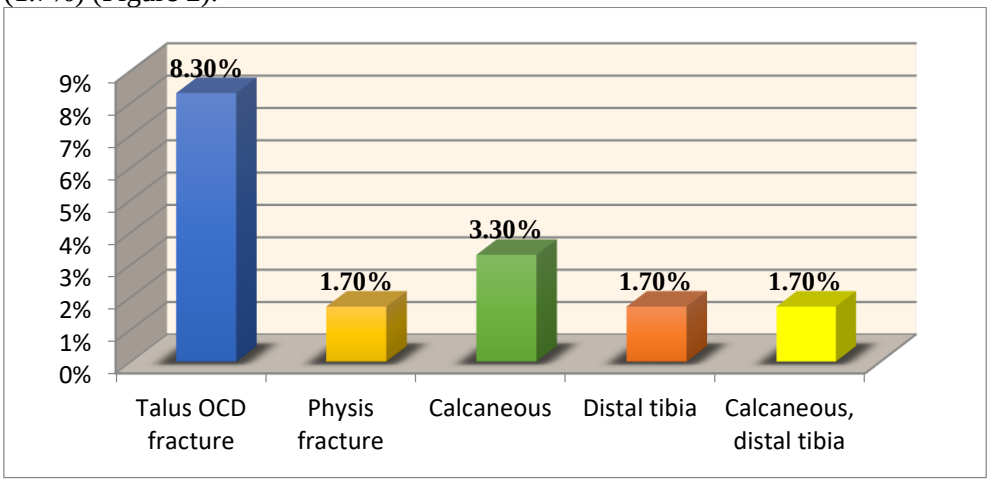


Figure (2): Column chart representing bone fractures

Nine out of 60 patients had ligament injuries, 6 patients had ATFL injuries, while 4 patients had Deltoid ligament injury (Figure 3). Five patients (8.3%) had ligament sprain, 3 patients 5% had ligament tear and one (1.7%) patient had combined tear with sprain**.**

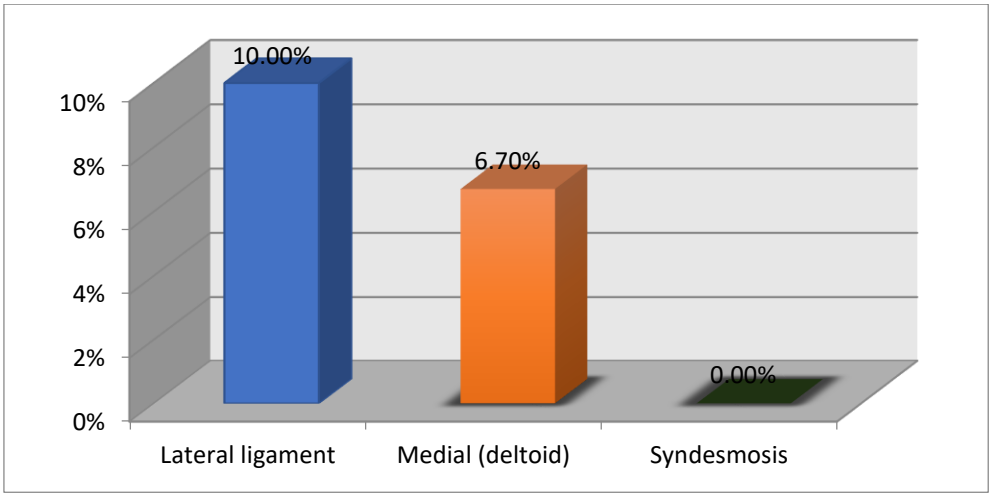


Figure (3): Column chart representing ligament injuries according to site

Of 60 patients, 29 patients (48.3%) had tendons injuries, 16 patients (26%) had tenosynovitis, 10 patients (16.7%) had tendinosis, one patient (1.7%) had tear and 2 patients (3.3%) had combined tear with tenosynovitis and tear with tendinosis (Figure 4).

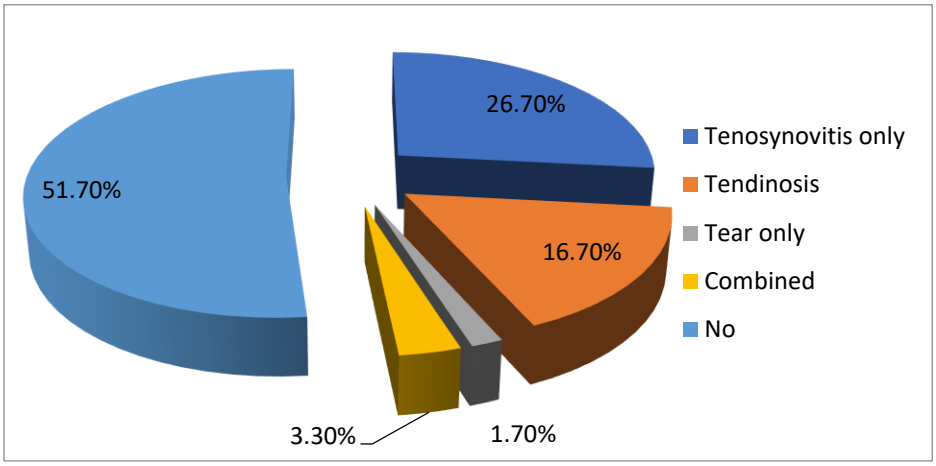


Figure (4): Pie chart representing tendon injury according to type

Achilles tendon was the most injured tendon at the study of 13 patients (21.7%); 12 cases (20%) of tendinosis and one case of complete tear (1.7%) (Figure 5).

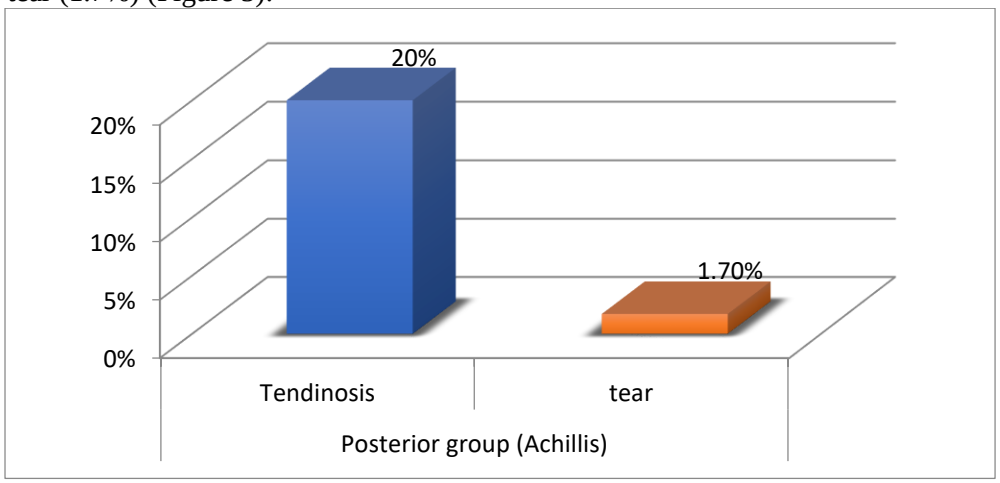


Figure (5): Column chart representing posterior group (Achilles) injuries.

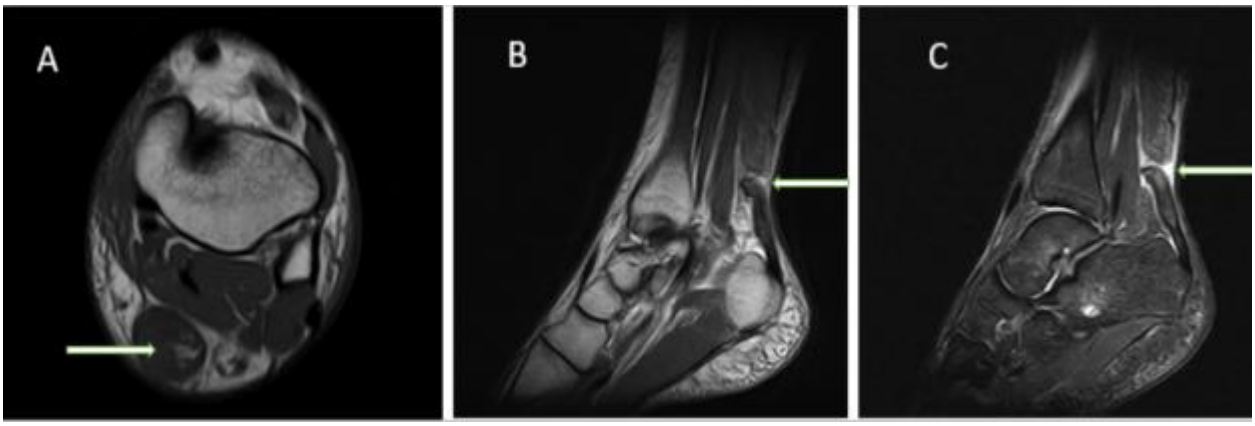
Regarding the relation between the age and MRI findings among the study group, the sinus tarsi, bone contusions and necrosis, tenosynovitis and Achilles tendinosis were found more in patients above 30 years. The joint effusion, bone fractures, all ligamentous injuries, tendon tear and combined tendon injuries were found more in patients below the 30 years**.** The joint effusion, bone fractures and contusions, ligamentous injuries, tenosynovitis and tendon tear were more common in male patients. While the sinus tarsi, bone necrosis, Achilles tendinosis and combined tendon injuries were more common in females. The joint effusion, sinus tarsi, bone necrosis and contusion were more in chronic onset than in acute. While, bone fractures, ligamentous injuries and tear were more in acute cases. Bone necrosis, Achilles tendinosis and combined tendon injuries were only seen in chronic cases (Table 2).

Table (2): Comparison between acute and chronic onset of trauma regarding MRI findings

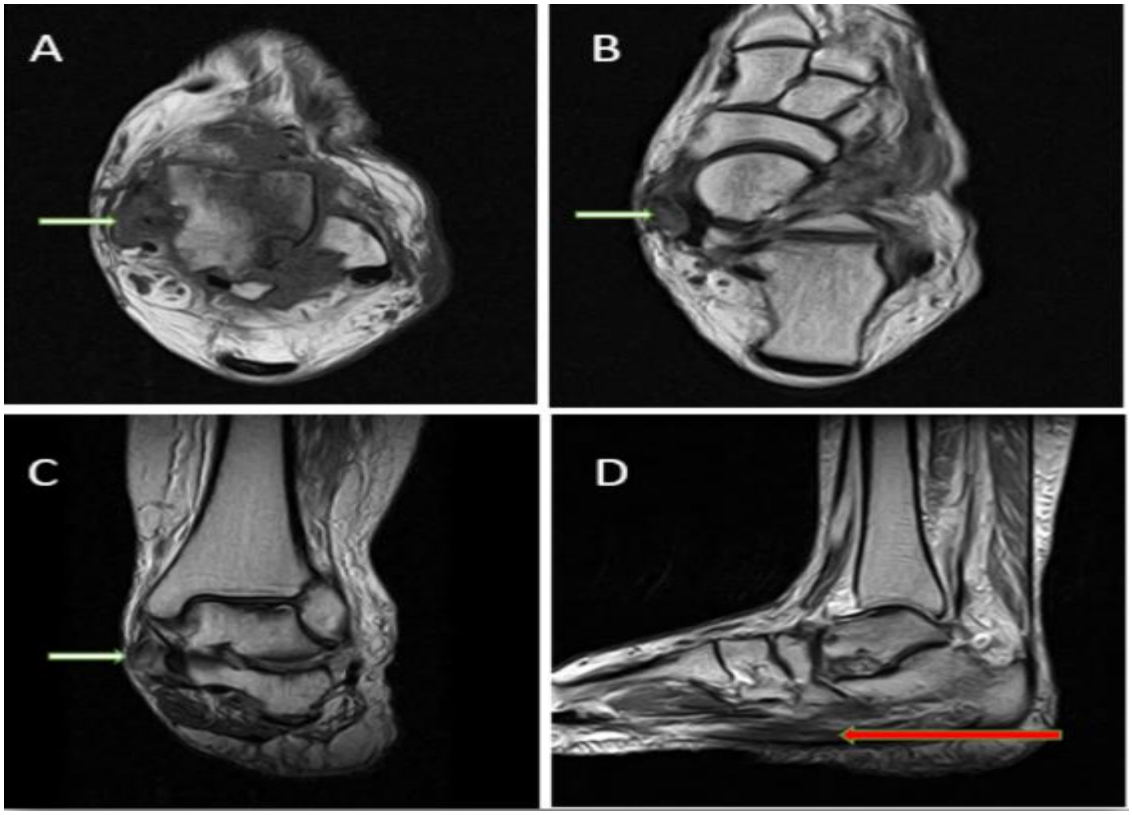
		Onset of trauma				P-value
		Acute (n= 17)		Chronic (n=43)		
		No	%	No	%	
Joint effusion:						
Yes		15	88.2	40	93	0.616
No		2	11.8	3	7	
Sinus tarsi:						
Yes		3	17.6	8	18.6	1
No		14	82.4	35	81.4	
Bone lesions	**Fracture:**					
	Yes	4	23.5	5	11.6	0.256
	No	13	76.5	38	88.4	
	Necrosis:					
	Yes	0	0	1	2.3	1
	No	17	100	42	97.7	
	Contusion:					
	Yes	7	41.2	27	62.8	0.128
	No	10	58.8	16	37.2	
Ligament injuries:						
Tear		3	17.6	0	0	
Sprain		3	17.6	2	4.7	**0.002***
Tear& Sprain		1	5.9	0	0	
NO		10	58.9	14	95.3	
Tendon injuries:						
Tenosynovitis		6	35.3	10	23.3	0.086
Tendinosis		0	0	10	23.3	
Tear		1	5.9	0	0	
Combined		0	0	2	4.7	
No		10	58.8	21	48.8	

Combined: tenosynovitis with tear and tenosynovitis with tendinosis

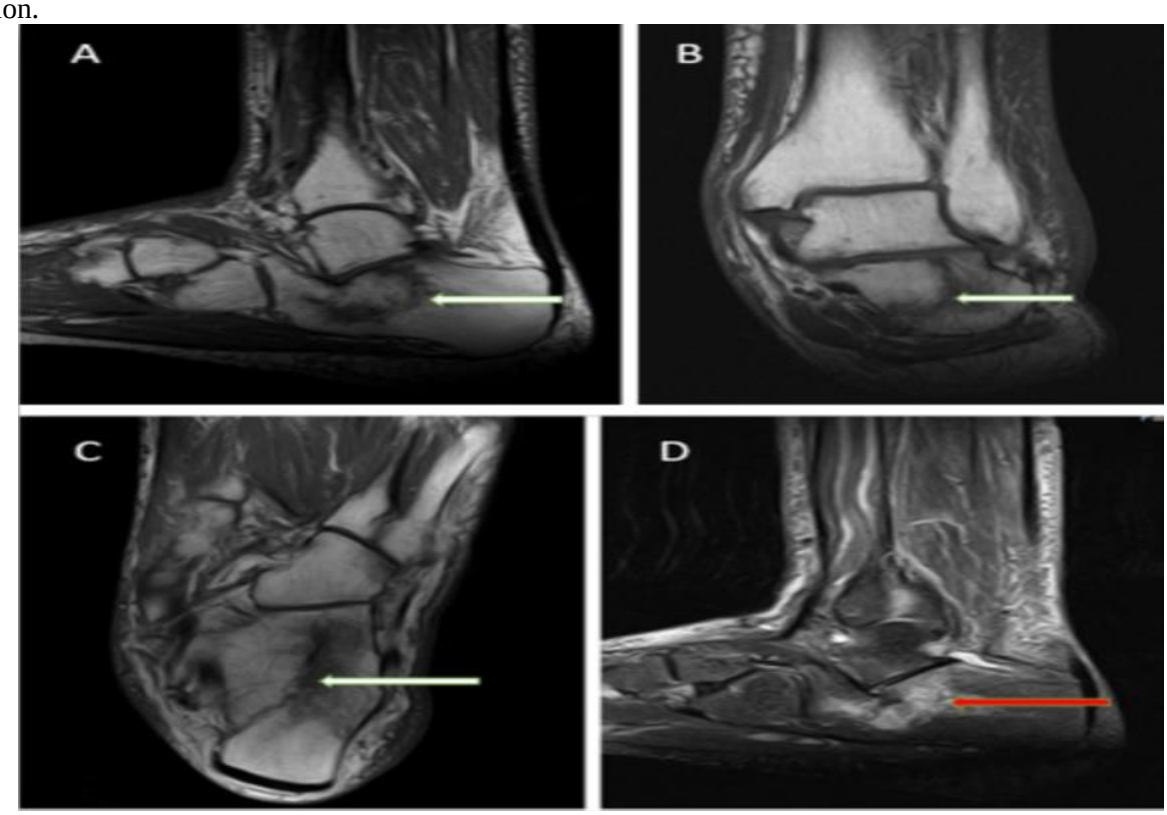
Illustrative Cases:



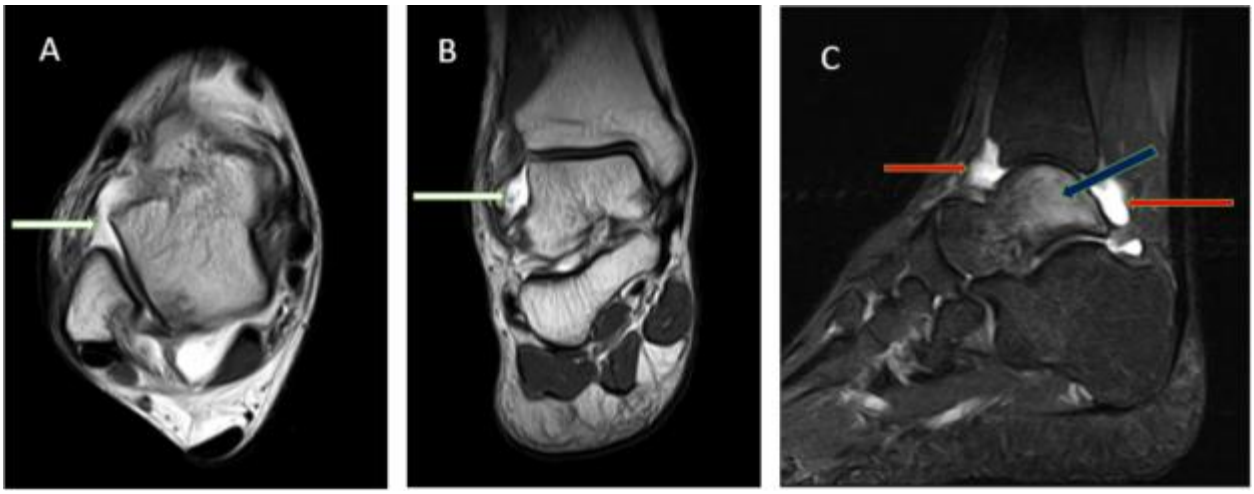
Case (1): Male patient of 24 years old with sudden onset of pain and swelling in left Achilles region following audible snap, he had history of local trauma at the same region. MRI findings: (A) Axial T1W ankle MR image showed complete discontinuity of Achilles tendon fibers and surrounding abnormal low and high signal at the tendinous gap representing fluid and hemorrhage (arrow). (B) Sagittal T2W and (C) Sagittal STIR images demonstrated the same finding with retracted ends and surrounding abnormal hyperintense signal at the tendinous gap (arrow). Diagnosis: Achilles tendon complete tear.



Case (2): Female patient of 45 years old with left ankle pain and flat foot, she had a history of repeated minor ankle trauma. MRI findings: (A) and (B), axial T1W and T2W ankle MR images showed thick inhomogeneous tibialis anterior tendon (arrow). (C) Coronal T2W MR image demonstrated thick inhomogeneous tibialis anterior tendon presenting discontinuity of its fibers at inframalleolar and proximal to its insertion (arrow). (D) Sagittal T2W MR image demonstrated loss of the planter arch of the left foot (red arrow). Diagnosis: Tibialis posterior chronic tear and dysfunction.



Case (3): Male patient of 67 years old with left ankle pain, he had a history of falling from height.
MRI findings: (A), (B) and (C), sagittal, coronal and axial T1W ankle MR images showed low signal intensity fracture line involving the calcaneal body reaching the articular surface (arrow). (D) Sagittal STIR image demonstrates high signal-intensity bone marrow edema surrounding the fracture line (red arrow). Diagnosis: Intra-articular calcaneal bone body fracture.



Case (4): Female patient of 18 years old with right ankle pain, she had history of ankle inversion. MRI findings: (A) and (B), axial and coronal T2W ankle MR image showed discontinuity of anterior talofibular ligament fibers (ATFL) (white arrow) with surrounding hyperintense fluid signal denoting that it is complete tear. (C) Sagittal STIR image demonstrated high signal-intensity bone marrow edema at the dome of the talus bone (blue arrow). Note the hyperintense fluid signal at the anterior and posterior ankle joint recesses (red arrow). Diagnosis: Grade III anterior talofibular ligament (ATFL) injury (complete tear).

Case (5): Male patient of 20 years old with right ankle pain. He had history of recent ankle eversion. MRI findings: (A) Coronal T2WI demonstrated deltoid ligament intrasubstance abnormal hyperintense signal with no bony avulsion (arrow). (B) Coronal T1WI demonstrated deltoid ligament intrasubstance abnormal hypointense signal with no bony avulsion (arrow). Diagnosis: Deltoid ligament grade I injury (deltoid ligament sprain).

DISCUSSION

Various ankle pathologies are seen with ankle joint trauma as it is a major joint of body weight bearing [(9)]. MRI is considered the tool of choice for evaluating the traumatic ankle injuries as it is multiplanar and has a superiority in soft tissues, so gives accurate information about cartilage, tendon, ligament, bone marrow, joint effusion, skeletal and extra-skeletal masses. It is the current standard imaging modality to diagnose the ankle joint problems [(10)].

Our study included 60 patients with different complaints after ankle trauma to evaluate the role of MRI in detecting the various traumatic ankle pathologies. All patients underwent MR scan according ankle joint protocol after precise history taking and clinical examination.

The duration of the pathologies based on the patient's clinical history was classified into acute and chronic with the majority of the patients 43 cases (71.7%) presenting with chronic complaints. Chronic

pain; 39 cases (90.7%) was the commonest symptom as a chronic complaint and the acute pain and swelling; 9 cases (52.9%), were the commonest symptoms as an acute complaint.

MR scan of the tendon showed abnormal signal that might be due to tendinosis, partial tear, or degeneration, and all of these are considered in the differential diagnosis. While, applying their classification, **Bencardino *et al.*** [11] found MRI for diagnosing ruptures of the tendons was sensitive in 95% of cases and specific in 100%. MRI had 96% accuracy in detecting tendon rupture.

Twenty-nine cases of tendon disorders were diagnosed in this study representing about 48.3% of the total ankle injuries. Although it is the strongest tendon in the human body, all literature agreed that the Achilles tendon is the most commonly injured ankle tendon. The site of pathological findings is typically within the critical zone; a zone of relative hypovascularity 2-6 cm from the calcaneal insertion [12]. In agreement with **Hartgerink *et al.*** [13] our study coincides with this hypothesis as Achilles tendon injuries represented 48% of all diagnosed ankle tendon injuries and ranged in severity from tendinosis to tear. Additionally, our results are in agreement with **Narváez *et al.*** [2] who stated that Achilles insertional tendinosis is more than the non-insertional type where all cases of Achilles tendinosis, which are 12 cases, represented the insertional type and ten cases of them were associated with calcaneal bone marrow contusion.

In our study, 13 cases were diagnosed as Achilles tendon injuries with female predominance in tendinosis. However, the only case of tendon tear was male patient and it was a high-level tear. In contrast with **Tuite** [12] who stated that Achilles tendon injuries are more common in males. **Ham and Maughan** [14] observed that the peak age of occurrence of Achilles tendon injuries was between 30 to 40 years old. In our study, we found that they were more common in age > 30 years old.

Of the three medial tendons of the ankle, the tibialis posterior (TP) tendon is the most prone to tear, especially along the portion that curves around the medial malleolus [15]. In our study, 11 cases of TP tendon pathology were diagnosed by MRI; one of them was complete tear in middle age female patient associated with loss of the foot arch and sinus tarsi syndrome. The other lesion was tenosynovitis. Tenosynovitis is the most common pathology for the TP tendon, and our study agrees with that [16].

Of the remaining medial ankle tendons, the flexor digitorum longus (FDL) tendon is rarely affected by traumatic insults. Traumatic injuries of flexor hallucis longus (FHL) tendon have been reported more frequently than the FDL. In contrast, our study included ten cases of FDL tenosynovitis and five cases of FHL tenosynovitis, which were diagnosed by MRI.

Tenosynovitis is the most common traumatic pathology that affects the FHL tendon and it mostly occurs between the sesamoid bones of the first metatarsal, where it is subjected to repetitive impact, and under the base of the first metatarsal bone in the region of Henry's knot, where the FDL tendon crosses under the FHL tendon. Rupture of the distal FHL tendon is a very uncommon injury [16].

Although the anterior ankle tendons are rarely affected with pathology in comparison with the other ankle tendons, our study included one case with tibialis anterior, one case of extensor Hallucis longus and one case of extensor digitorum tenosynovitis.

Our study also included five cases of peroneal pathology; only one case with peroneal tenosynovitis associating lateral ankle sprain.

Peroneal tenosynovitis is an overuse injury relatively common in athletic individuals. Peroneal tendinosis represents a more advanced overuse injury that develops over a period of several weeks or months. Peroneal tendon tears are uncommon pathologies and our study had no cases of them.

Nine cases of ligamentous injuries were diagnosed in our study representing 16% of the encountered total ankle joint injuries. They were more common in patients < 30 years old and had statistically significant with acute injuries. Isolated ATFL was the most frequently injured ligament representing 60% of the whole ligamentous injuries followed by the deltoid ligament (40%) and this coincided with different literatures evaluating ankle ligaments. **Helms *et al.*** [17] stated that ATFL is the most commonly torn ankle ligament during lateral ankle sprain as it is the weakest ligament followed by calcaneofibular ligament (CFL) that is seen in 70% of ankle sprains. Only one case was associated with peroneal tendon injury and one case was also associated with talar dome OCD.

The PTFL and deltoid ligaments are the strongest ankle ligaments and the least to be injured accounting about 5% of ankle ligamentous injuries for deltoid ligament [2]. However, our study included four cases of deltoid ligament sprain (grade I injury) showing loss of striated pattern in T1WIs and no cases of PTFL, CFL or syndesmotic ligament injuries [18]. Our study showed that one case of deltoid ligament injury was associated with talus dome OCD and one case associated with ATFL tear. These findings coincide with **Chhabra *et al.*** [19]. One case associated with TP tendon injury and this agrees with **Sawant and Sanghvi** [15].

Fifty-five cases of joint effusion were diagnosed in our study representing 91.7% of the different diagnosed pathologies with chronic onset predominance. Our results coincide with those of **Jacobson *et al.*** [18] who concluded that MRI was more sensitive than ultrasonography in detection of ankle effusion. MRI could detect intra-articular fluid of 1 ml, while sonography could reproducibly detect 2 ml of fluid.

MRI generally is used to diagnose fractures only when conventional radiographs are normal or inconclusive. The ability of MRI to show fractures is exquisite and is particularly useful for Talar dome OCD,

stress and insufficiency fractures throughout the ankle. Any soft tissue abnormalities also are evident and also for bone marrow contusions [17].

In our study, MRI could diagnose 35 cases of bone lesions representing 58.3% of all cases, nine cases had different fractures including five cases of osteochondral lesions of the talus in different grades as well as one case of tibial Salter Harris fracture, two cases of calcaneal fracture, one case of tibial plafond fracture and one case of combined fracture. We had also one case of bone necrosis and 34 cases of bone marrow contusions.

Talar dome OCD was more at chronic ankle injuries representing 60%, and this finding does not agree with **Kharat *et al.*** [20].

Our study included 11 cases of sinus tarsi syndrome representing 18.3% of different ankle pathologies with female predominance and statistically significant in patients with age > 30 years old with chronic onset.

CONCLUSION

Our study showed that MRI is the modality of choice in evaluating ankle injuries because of its high soft tissue contrast resolution, and multi-planar capabilities. It provides a non-invasive tool for the diagnosis of ankle injuries that are often difficult to diagnose with other modalities. MRI gives superiority in assessing soft tissue structures around the ankle such as tendons, ligaments, nerves, and fascia and to detect occult bone injuries. MRI is considered an ideal modality when global evaluation of the osseous and soft tissue structures of the ankle is needed.

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Conflict of interest: Nil.

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