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Role of Magnetic Resonance Imaging in Evaluation of Traumatic Ankle Injuries

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Abstract:
Background*: Ankle trauma is commonly encountered and is most often a sprain injury affecting the ligaments. Accurate diagnosis and appropriate treatment rest on knowledge of complex ligamentous anatomy of ankle and the entire spectrum of pathologies. Magnetic resonance imaging (MRI) is the imaging modality of choice for diagnosing ligament pathologies because of its multiplanar capability and high soft tissue contrast. With MRI, it is possible to triage and attribute the cause of post traumatic ankle pain to bone, ligament, or tendon pathologies, which otherwise overlap clinically.*
Materials and Methods*: Fifty patients with clinical suspicion of traumatic ankle injuries referred to the Department of Radio-Diagnosis from November 2018 to May 2020 underwent MRI of ankle. The main source of data for the study were patients from Victoria Hospital, Bowring and Lady Curzon Hospital and Vani Vilas hospital attached to Bangalore Medical College and Research Institute, Bengaluru. All MR imaging examinations were performed on a Siemens 1.5-T MagnetomAvanto MR system. Protocol of MRI ankle used in the study: Axial T1W / TSE, Axial T2W / TSE, Axial - STIR / TSE, Sagittal T2W / TSE, Sagittal STIR / TSE, Coronal T1W / TSE, Coronal T2W / TSE, Coronal STIR / TSE images were obtained in all the patients.*
Results*: Among the 50 patients, 28% of the cases were found to be normal and 72% had findings. Ankle joint effusion (50%) was the most common finding seen, followed by ligament injuries (38%) tendon injuries (20%) and osseous injuries (20%). ATFL (45%) was the most commonly injured ligament followed by PTFL (17%) and deltoid ligament (14%) injuries. Sprain (53%) was the most common type of ATFL injury followed by complete tear (26%) and partial tear (21%). Tibionavicular (21%) and tibiocalcaneal (21%) were the most common ligaments injured in deltoid ligament. FHL (30%) and tibilalis posterior (30%) were the most common tendons injured. Bone contusion was the most common osseous injury (61%) followed by fractures (31%) and joint dislocation (8%).*
Conclusion: *MRI was found to be a key modality to evaluate various soft tissue injuries of the ankle and to arrive at an accurate diagnosis. Characterization of the lesions and awareness of the common pathologies will help the clinician arrive at an informed differential diagnosis. MRI is a non-invasive imaging modality with no radiation hazard, excellent resolution and multiplanar imaging capability. Use of prompt imaging will be helpful to accurately diagnose the soft tissue injuries of the ankle.*
Key Word*: Traumatic ankle injuries, Anterior Talofibular Ligament, Deltoid Ligament, magnetic resonance imaging*

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I. Introduction

Traumatic injuries of the ankle are one of the most common musculoskeletal injuries. Ankle injuries can happen at any age.[1] Ankle sprains are considered one of the most common lower limb injuries, affecting more commonly young athletes; the most common mechanism of injury is represented by inversion of the foot(less frequently eversion).[2] When patients present to their specialist with ankle or hindfoot pain, there are a variety of possible etiologies. Unfortunately, these different diagnoses have overlapping clinical signs and symptoms. For this reason, referring clinicians tend to rely on magnetic resonance imaging to clarify or solidify a diagnosis to guide treatment and management decisions. The soft-tissue contrast resolution and multiplanar capabilities of MR imaging make it especially valuable for the assessment of a variety of soft-tissue lesions of the ligaments, tendons and other soft-tissue structures. MR imaging is useful in the detection and staging of a number of musculoskeletal infections including cellulitis, soft-tissue abscesses, and osteomyelitis.[3] MR imaging is also excellent for the early diagnosis and assessment of a number of osseous abnormalities. MRI is increasingly being recognized as the modality of choice for assessment of pathologic conditions of the ankle and foot.[4]

In a descriptive study conducted by Mervat Mohamed Ibrahim, et al. concluded that magnetic resonance imaging is modality of choice in evaluating ankle injuries due to its high soft tissue contrast resolution, and multi-planar capabilities. It provides a non-invasive tool for the diagnosis of ankle injuries, which are often difficult to diagnose with alternative modalities. MRI is particularly advantageous for assessing soft tissue structures around the ankle such as tendons, ligaments, nerves, and fascia and for detecting occult bone injuries. 24.3% of them had ligamentous injuries, 22.9% had tendon injuries, 20% had bone injuries and 32.8% had joint effusion.[5]

Kumar, et al. reported the sensitivity and specificity of anterior talofibular ligament and calcaneofibular ligament tears. Kumar, et al. reported the ATFL sensitivity and specificity to be 87% and 60%, respectively, with an accuracy of 71%, whereas the CFL sensitivity and specificity were 47% and 83%, respectively, with an accuracy of 72%.[6]

Magee, et al. reviewed MR images in 30 patients with normal radiographs and persistant ankle pain 6 weeks after injury. They found that limited MR studies are valuable for identifation of talar dome dome injuries.[7]

Yao, et al. evaluated MR images of 13 cases of surgically proven spring ligament insufficiency and in 18 control volunteers. They found increased hetrogenous signal on short TE spin-echo images and increase in thickness of the medial portion of the spring ligament in spring ligament insuffiency.[8]

Bencardino, et al. reviewed the MRI appearance of seven cases of PTT dislocation and subluxation. The tendon was dislocated medial to the medial malleolus in five of the seven patients. The flexor retinaculum was torn from its medial malleolar insertion in five patients and torn in two patients.[9]

Helms, et al. stated that the anterior talofibular ligament is the most commonly torn ligament of the ankle. It is often an isolated tear, but if the traumatic forces are great enough, the other ligaments may tear in a sequential fashion. That is, after the anterior talofibular ligament tears, the calcaneofibular ligament tears, followed, only rarely, by the posterior talofibular ligament.[10]

II. Material And Methods

A prospective study of 50 patients presenting to Department of radiodiagnosis, Bangalore Medical College and Research Institute and its attached hospitals, from November 2018 to May 2020 were subjected to MRI examination of ankle.

Study Design: Cross sectional descriptive study

Study Location: This was a tertiary care teaching hospital based study done in Department of radiodiagnosis, Bangalore Medical College and Research Institute and its attached hospitals, Bengaluru, Karnataka, India.

Study Duration: November 2018 to November 2020.

Sample size: 50 patients.

Sample size calculation: The sample size calculation based on previous study conducted by Mervat Mohamed Ibrahim, et al[1] . which had 66% of abnormal MRI findings as follows-

$n=4pq/d^2$

where, n=sample size, p=proportion

p=66, q=100-p=100-66=34

d=20% of p=13.2

n=4pq/d2

n=4x66x34(13.2)2

=8976/174

n=50

Inclusion criteria:

1. Patients above 18 years of age with ankle pain following traumatic insult
2. Patients willing to give informed consent

Exclusion criteria:

1. Any patient with a history of non-traumatic ankle pain which includes: osteoarthritis and rheumatoid arthritis.
2. Patients who had surgeries to the ankle joint.
3. Patients with metabolic diseases.
4. Patients with ankle joint tumors.

5. Patients having history of claustrophobia.
6. Patients having history of metallic implants insertion, cardiac pacemakers and metallic foreign body in situ.

Procedure methodology

Criteria for patient selection:

The patients selected for the study were patients with history of traumatic ankle insult referred to the Department of radiodiagnosis for imaging evaluation of ankle pain. Patients were interviewed and relevant clinical data was collected. Based on the history and examination, a clinical diagnosis was made. The procedure was explained to the patients and informed written consent was taken from all the patients.

Technique of examination:

All MR imaging examinations were performed on a 1.5-T Siemens AvantoMagnetom MR system.

All patients were screened before entry into the MRI scanning room for ferromagnetic objects, cardiac pacemakers, aneurysm clips etc.

Imaging was done with the foot at right angles to the lower leg with the patient in a supine position. A standard extremity coil generally was employed for the ankle. The imaging planes, sequences, and even the selection of coil varied depending on the clinical circumstances. The lower extremity was externally rotated and the planes of imaging was oriented to the anatomy of the foot, rather than to the magnet. Only the extremity with a suspected abnormality was imaged to employ a small field of view to increase the detail and resolution of the images. Ankle MRI protocol took 45 to 60 minutes. The FOV included the distal tibia and fibula, all of the tarsal bones, and the bases of the metatarsals. Slice thickness ranged from 3-5 mm with gap of 1 mm. Matrix 256/192.

The straight sagittal plane was our survey plane and usually the first plane acquired in all ankle MRI protocols. At least two axial orientations was typically used, straight axial slices and oblique axial slices. At least three ways to orient slices in the coronal plane, least commonly used were the straight coronal plane, oblique coronal slices were used much more often than straight coronal slices and the third one was mortise coronal slices. Lastly, mortise sagittal slices were the survey plane we used for osteochondral lesions of the talus.

Sequences: 1- Fat suppressed fast-pin echo T2-weighted sequence or an inversion recovery sequence (edema-sensitive sequences) in all the planes. 2- T1-weighted images in all imaging planes whenever the tendons were not the primary site of interest. 3- When the tendons are the site of clinical concern, proton-density–weighted images were used, along with T2-weighted sequences, in the straight axial and oblique coronal planes. They were read side-by-side with edema sensitive images to look for abnormal amounts of fluid in the tendon sheaths.

Protocol of MRI ankle: Axial T1W / TSE, Axial T2W / TSE, Axial - STIR / TSE, Sagittal T2W / TSE, Sagittal STIR / TSE, Coronal T1W / TSE, Coronal T2W / TSE, Coronal STIR / TSE.

MRI findings were recorded in all patients as per the proforma.

Statistical analysis[11,12,13,14]

Data was entered into Microsoft excel data sheet and was analyzed using SPSS 22 version software. Categorical data was represented in the form of Frequencies and proportions. Continuous data was represented as mean and standard deviation.

Graphical representation of data: MS Excel and MS word was used to obtain various types of graphs such as bar diagram and pie diagram.

Statistical software: MS Excel**,** SPSS version 22 **(**IBM SPSS Statistics, Somers NY, USA) was used to analyze data.

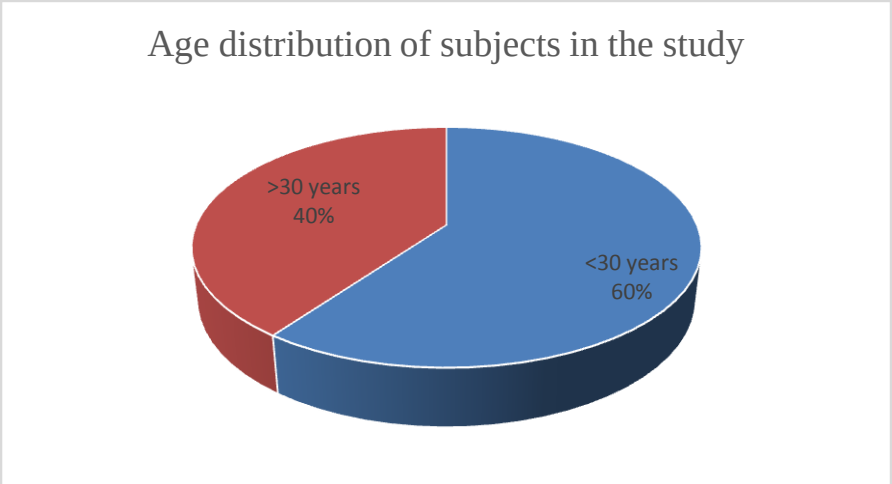
III. Result

The study included 50 patients (35 males and 15 females) ranged in age between 12 and 60 years with mean age 12-60 [Mean± SD: 28.98±12.44], 60% of the patients were < 30 years and 40% of them were > 30 years.

Table no 1: Age distribution of subjects in the study

Age (years)	Number of patients	%
<30	30	60
>30	20	40
Total	50	100
Range (Mean+/-SD)	12-60 (28.98+/-12.44)	

GRAPH 1. Pie chart showing age distribution of subjects in the study.



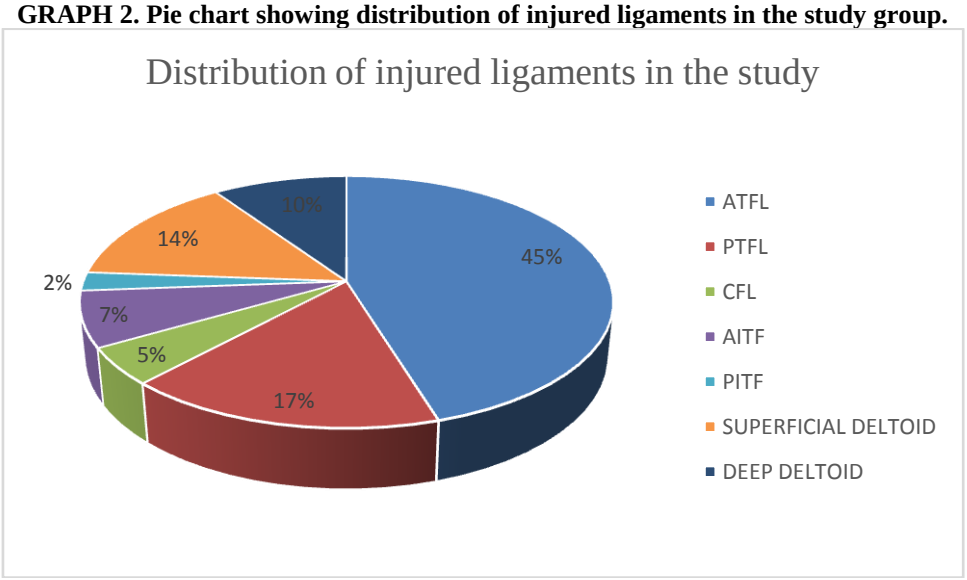
Ligament Injuries

Nineteen out of included 50 patients had ligament injuries. 19 patients had ATFL injuries, 7 patients had PTFL injuries, 2 patients had CFL injuries, 3 patients had AITF injuries, 1 patient had PITF injury, 6 patients had superficial deltoid ligament injuries and 4 patients had deep deltoid ligament injuries.

TABLE 2. Distribution of injured ligaments in the study.

Ligament Injured	Number of Patients
ATFL	19
PTFL	7
CFL	2
AITF	3
PITF	1
SUPERFICIAL DELTOID	6
DEEP DELTOID	4

GRAPH 2. Pie chart showing distribution of injured ligaments in the study group.

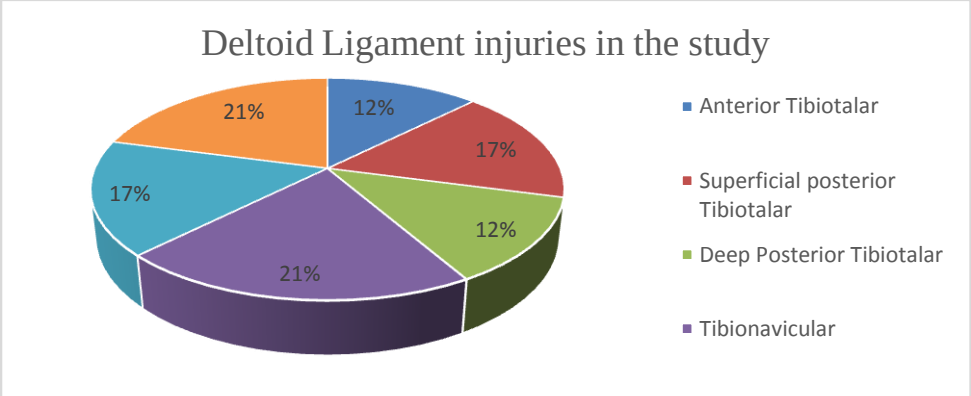


Among the patients with deltoid ligament injuries, 3 patients had anterior tibiotalar ligament injury, 4 patients had anterior tibiotalar ligament injuries, 4 patients had superficial posterior tibiotalar ligament injuries, 3 patients had deep posterior tibiotalar ligament injuries, 5 patients had tibionavicular ligament injuries, 4 patients had tibiospring ligament injuries and 5 patients had tibiocalcaneal ligament injuries.

TABLE 3. Distribution of Deltoid ligament injuries in the study

Ligament Injured	Number of Patients
Anterior Tibiotalar	3
Superficial Posterior Tibiotalar	4
Deep Posterior Tibiotalar	3
Tibionavicular	5
Tibiospring	4
Tibiocalcaneal	5

GRAPH 3. Pie chart showing distribution of Deltoid Ligament injuries in the study group.



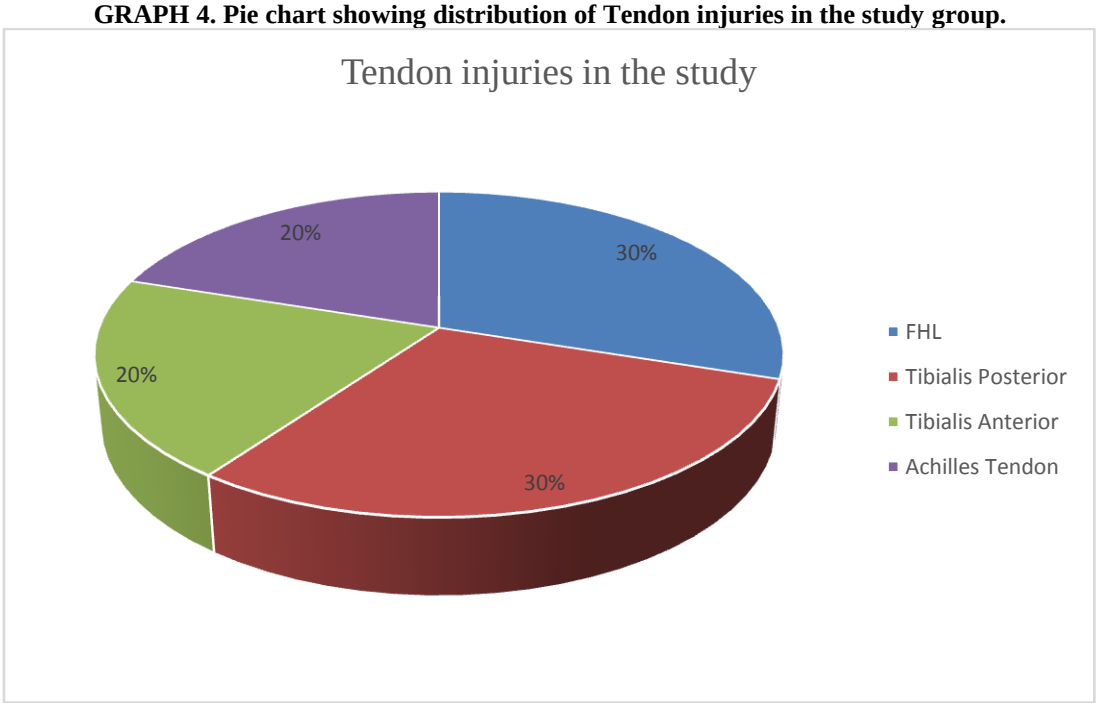
Tendon Injuries

10 out of included 50 patients had tendon injuries. 3 patients had FHL tendon injuries, 3 patients had Tibialis Posterior tendon injuries, 2 patient had Tibialis Anterior tendon injuries and 2 patients had Achilles tendon injuries.

TABLE 4. Distribution of Tendon injuries in the study

Tendon Injured	Number of Patients
FHL	3
Tibialis Posterior	3
Tibialis Anterior	2
Achilles Tendon	2

GRAPH 4. Pie chart showing distribution of Tendon injuries in the study group.

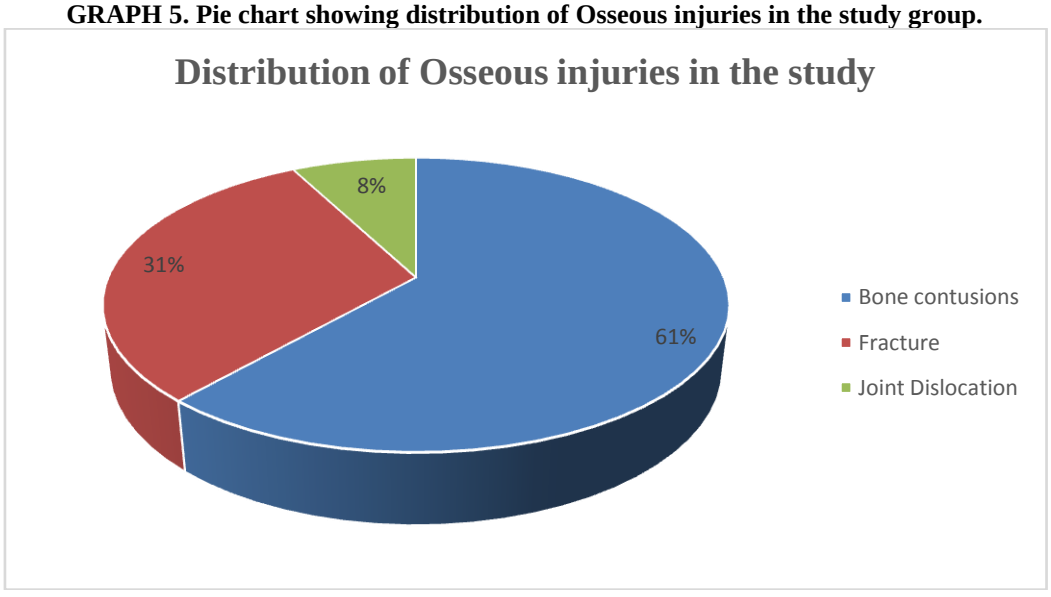


10 out of included 50 patients had osseous injuries. 8 patients had bone contusions, 4 patients had fractures and 1 patient had ankle joint dislocation.

TABLE 5. Distribution of Osseous injuries in the study

Bone Contusions	Fractures	Joint Dislocation
8	4	1

GRAPH 5. Pie chart showing distribution of Osseous injuries in the study group.



IV. Discussion

Nineteen out of included 50 patients had ligament injuries. 45% had ATFL injuries, 17% patients had PTFL injuries, 5% patients had CFL injuries, 7% patients had AITF injuries, 2% patient had PITF injury, 14% patients had superficial deltoid ligament injuries and 10% patients had deep deltoid ligament injuries. Among the 19 patients with ATFL injuries, 53% patients had sprain, 26% patients had partial tear and 21% patients had complete tear. Among the 4 patients with complete ATFL tears, 50% had tears at midsubstance. The talar end and fibular end tears were present in 25% each. Among the 7 patients with PTFL injuries, 43% had sprain, 28% patients had partial tear and 29% patients had complete tear. Among the 2 patients with CFL injuries, sprain and

partial tear were present in 50% each. Among the 3 patients with AITF injuries, 67% had sprain and 33% had partial tear. Partial tear was seen in 1 patient with PITF injury. Among the 6 patients with superficial deltoid ligament injuries, 33% had sprain, 50% had partial tear and 17% had complete tear. Among the 4 patients with deep deltoid ligament injuries, 33% had sprain, 50% had partial tear and 17% had complete tear. Among the patients with deltoid ligament injuries, 12% had anterior tibiotalar ligament injury, 17% had superficial posterior tibiotalar ligament injuries, 12% had deep posterior tibiotalar ligament injuries, 21% had tibionavicular ligament injuries, 17% had tibiospring ligament injuries and 21% had tibiocalcaneal ligament injuries. 10 out of included 50 patients had tendon injuries. 30% had FHL tendon injuries, 30% had Tibialis Posterior tendon injuries, 20% had Tibialis Anterior tendon injuries and 20% had Achilles tendon injuries. Among the 3 patients with FHL tendon injuries, 33% had tendinosis and 67% had partial tear. Among the 3 patients with Tibialis Posterior tendon injuries, 33% had tendinosis and 67% patients had partial tear. Among the 2 patients with Tibialis Anterior tendon injuries, 50% had tendinosis and 50% had partial tear. Among the 2 patients with Achilles tendon injuries, 50% had tendinosis and 50% had partial tear. 10 out of included 50 patients had osseous injuries. 61% had bone contusions, 31% had fractures and 8% had ankle joint dislocation. 60% had ankle joint effusion.

Table no 6 : Comparison between MRI findings in present study and literature

Imaging findings	Our study (n=50)	Mervat Mohamed et al (n=40)
Ligament injuries	38%	42%
Tendon injuries	20%	40%
Osseous injuries	20%	35%
Joint effusion	50%	57%

V. Conclusion

MRI is an excellent modality for detection of pathology and characterisation of the various injuries following ankle trauma. Ankle joint effusion was the most common MRI finding followed by ligament injuries, tendon injuries and osseous injuries. MRI was helpful in describing the features and to diagnose various conditions. ATFL was the most commonly injured ligament. Sprain was the most common type of ATFL injury. Tibionavicular and tibiocalcaneal were the most common ligaments injured in deltoid ligament. FHL and tibilalis posterior were the most common tendons injured. Bone contusion was the most common osseous injury. Knowledge of the MRI findings associated with traumatic ankle injuries is important for early diagnosis and prompt treatment. Good clinical and radiological correlation can help in complete evaluation of these conditions.

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