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ROLE OF MAGNETIC RESONANCE IMAGING IN EVALUATION OF TRAUMATIC ANKLE INJURIES

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Abstract:
Objective: This study aimed to comprehensively evaluate traumatic ankle injuries using Magnetic Resonance Imaging (MRI) and provide detailed insights into demographics, injury patterns, and prevalence.
Methods: A total of 55 patients with suspected ankle injuries following trauma were included in this descriptive study. MRI was employed for evaluation, and data were collected over an 18-month period. Demographic details, injury types, and prevalence were systematically analyzed.
Results: The study revealed a higher incidence of traumatic ankle injuries in the 21-30 age group, with a male predominance. Acute onset of symptoms, commonly associated with twisting, was observed. Ligament injuries were predominant (83.6%), with lateral ligaments, especially the Anterior Talofibular Ligament, most frequently affected. Tendon injuries, bone injuries (including contusions, fractures, osteochondral lesions, and osteonecrosis), and joint effusion were also identified.
***Conclusion**:* MRI emerged as a valuable tool for characterizing traumatic ankle injuries. Ligament injuries, particularly grade 1 sprains, predominated, emphasizing the role of lateral ligaments. Notable variations in injury patterns, tendon involvement, and bone injuries were elucidated. The study contributes to clinical understanding and highlights the importance of tailored treatment strategies based on imaging findings.

1. Introduction

Foot and ankle structures bear massive amounts of force during athletic activities and are naturally susceptible to a vast and ever-expanding array of injuries.[1] Traumatic injuries of the ankle are the most common musculoskeletal injuries and account for approximately 10% of all visits to emergency departments.[2] In order to a better understanding of these lesions, a classification based on the anatomic origin are outlined. The spectrum of injuries has been

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classified as: (1) osseous lesions (2) ligamentous injuries (3) tendinous lesions (4) miscellaneous injuries.[3]

It is easier to organize the approach for analysing pathology at the ankle by considering compartmental anatomy. The compartments can simply be divided into the anterior, posterior, lateral, and medial soft tissue compartments. The signal characteristics of the marrow and contour detail of the joints are also described. Last the sinus tarsi, plantar fascia, and subcutaneous soft tissues should be surveyed.[4]

Ankle injuries can happen to anyone at any age. However, men between 15 and 24 years old have higher rates of ankle sprain, compared to women older than age 30 who have higher rates than men. Half of all ankle sprains occur during an athletic activity. The most common ankle injuries are sprains and fractures, which involve ligaments and bones in the ankle but can also tear or strain a tendon.[5]

The most common mechanism of injury is represented by inversion of the foot (less frequently eversion).[6] The lateral ligamentous complex is involved in the majority of ankle sprain injuries, and comprises the anterior talofibular ligament (ATFL), the calcaneofibular ligament (CFL), and the posterior talofibular ligament (PTFL). The ATFL is the weakest ligament of the lateral ligamentous complex followed by the CFL. The ATFL and CFL are commonly injured, whereas the PTFL is rarely torn except in cases of complete dislocation of the ankle.[7]

Clinical diagnosis can at times be challenging, due to the complex anatomy and multiple sites of potential injury. In athletes, there is a reduced threshold for imaging to clarify diagnosis, guide prognosis, and treatment. Diagnostic imaging is also helpful in evaluating ongoing symptoms in the subacute or chronic setting.[8]

Imaging of the foot and ankle can be beneficial to rule in or rule out pathology after trauma to the foot or ankle or when an injury is not progressing with conservative management. For bony pathology, there are three standard views for a radiograph. If instability is suspected a stress image can be taken to determine ligamentous laxity. If soft tissue damage or tissue inflammation is suspected magnetic resonance imaging or diagnostic ultrasound may be indicated.[9]

Magnetic resonance imaging (MRI) is the most accurate diagnostic procedure for the evaluation of traumatic ankle injuries like ligamentous injuries. MRI also allows for characterization of injury based on known biomechanical patterns. MRI is very helpful in local staging and surgical planning because it confirms the diagnosis in cases when radiographs are normal or equivocal, because it is as sensitive but more specific than other radiological modality.[10]

Magnetic resonance (MR) imaging has opened new horizons in the diagnosis and treatment of many musculoskeletal diseases of the ankle. It demonstrates abnormalities in the bones and soft tissues before they become evident at other imaging modalities. The exquisite soft-tissue contrast resolution, quick, non-invasive nature, and multiplanar capabilities of MR imaging make it especially valuable for the detection and assessment of a variety of soft-tissue disorders of the ligaments. MR imaging is particularly advantageous for assessing soft

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tissue structures around the ankle such as tendons, ligaments, nerves, and fascia and for detecting occult bone injuries.[11]

The diagnostic accuracy of MRI, ultrasound, and stress radiograph when compared to "gold standard" arthroscopic surgery, was found to be 97%, 91% and 67%, respectively in determining tears of the ATFL. Accurate localization of tears was achieved in 93% of cases when MRI was used as the diagnostic modality whereas ultrasound could only localize the tears in 63% cases.[12]

2. Materials and Methods

METHODOLOGY

SOURCE OF DATA:

Patients with clinical suspicion of ankle injury following trauma referred to the department of Radio-diagnosis at Krishna Rajendra Hospital attached to Mysore Medical College and Research Institute, Mysore from department of Orthopaedics, MMCRI for diagnosis and evaluation were subjected to MRI.

METHOD OF COLLECTION OF DATA:

STUDY DESIGN: Descriptive study

STUDY PERIOD:

- The study was conducted for a period of 18 months. It was a study done from January 2020 to June 2021.

SAMPLE SIZE:

- Sample size of our study was 55
- Sample size was calculated by the formula,

$$n = z\alpha^2 pq/d^2$$

Where,

P= prevalence of traumatic ankle injuries is 5% according to hospital records.

q= 1-p= 97.88%

d= absolute error (8%)

z α = Standard normal variate for 95% confidence interval is 1.96.

Therefore, the sample size (n) comes out to be 28.5 rounded off to 30. However, the sample size was extended to 55 due to availability of cases.

INCLUSION CRITERIA:

1. Patients presenting with history of ankle pain following trauma.
2. Patients referred with clinical suspicion of ankle injury.
3. Patients willing to give written informed consent for the present study.
4. Patients of all age groups

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EXCLUSION CRITERIA:

1. Patient with history of non-traumatic ankle pain which includes infectious etiology, metabolic disease, ankle joint tumours and who had surgeries to the ankle joint.
2. Patients with ferromagnetic implants, pacemakers and aneurysm clips.
3. Patients with claustrophobia.
4. Patients not willing to give written informed consent

THE METHOD OF STUDY CONSIST OF:

Informed and written consent was taken from all patients. Detailed history was recorded. Patients fulfilling the inclusion and exclusion criteria underwent Magnetic resonance imaging of the ankle joint. MR imaging was performed on a GE OPTIMA MR360 1.5 Tesla MRI system.

Protocol and technique:

Positioning:

- Patient is positioned in supine position with feet pointing towards the magnet.
- Ankle is placed in surface coil and locked (Ankle should be at 90° position)
- Foot is secured tightly using cushions to prevent movement
- Laser beam localiser cantered over the ankle joint

The FOV included the distal tibia and fibula, all of the tarsal bones, and the bases of the metatarsals.

Localiser:

A three plane localiser is taken in the beginning to localize and plan the sequence.

Localisers are T1 weighted low resolution scans usually less than 25sec.

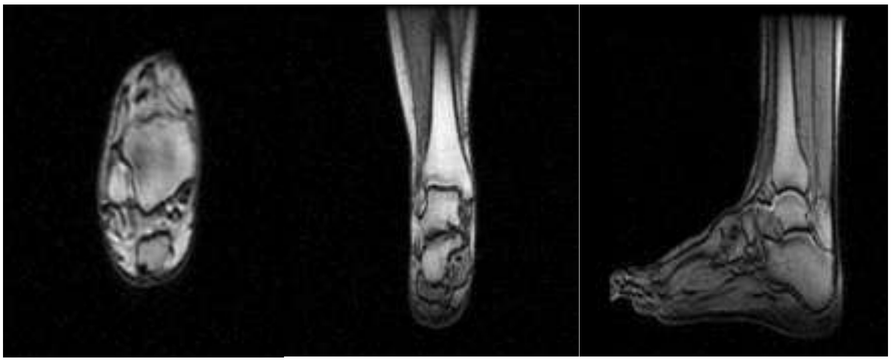

Figure 1: Three plane localiser

Imaging planes:

Standard MRI planes for ankle includes sagittal, coronal, and axial planes.

Axial imaging plane: Planned on a sagittal plane. plane parallel to long axis of calcaneus. Ankle scanned from distal tibia through subcutaneous soft tissues (include plantar fascia). Slices covered from 4 slices above tibio-talar joint down to the plantar aspect of the foot.

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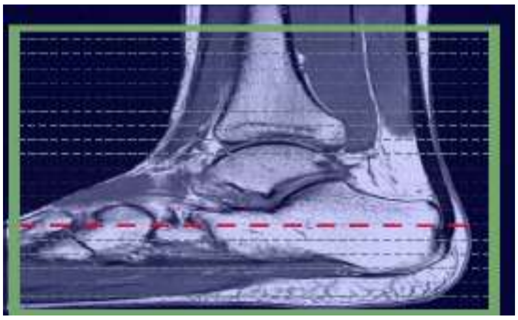

Figure 2 : Axial scan planning

Coronal plane imaging: Planned on the axial plane. Coronal plane (red): plane that bisects the medial malleolus, talar dome, and lateral malleolus. Ankle scanned from calcaneus through metatarsal bases.

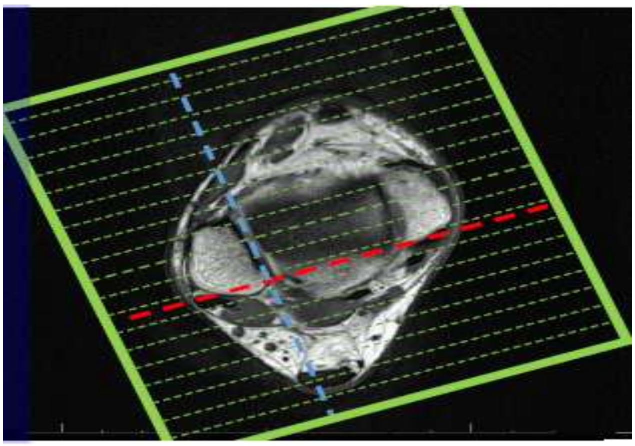

Figure 3: Coronal plane scanning

Sagittal plane imaging: Planned on the axial plane. Sagittal plane (red): plane 90 degrees to the coronal plane (blue). Ankle covered from medial through lateral malleolus

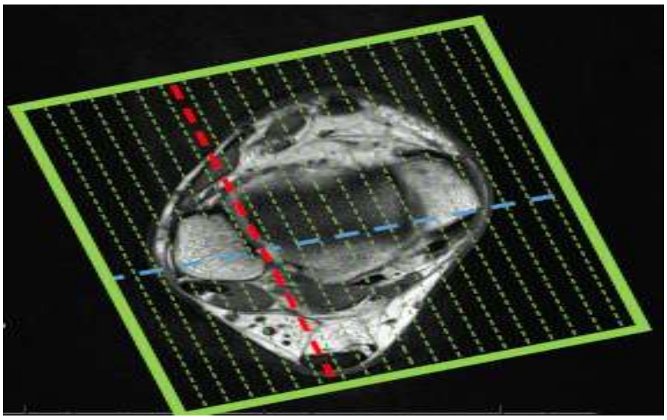

Figure 4 : Sagittal scan planning

Table 1: MRI ankle sequences

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Sequences	Imaging plane
T1	Sagittal
T2	Axial, sagittal, coronal
STIR	Coronal, sagittal
PDFS	Axial, sagittal
3DFSPGR	Sagittal

Table 2: Parameters :

SEQUENCES	TR(msec)	TE(msec)	Thickness (cm)	Gap (cm)	FOV	Matrix
Sagittal T1W	549	14.4	4	0.5	26	320X224
Sagittal PDFS	2165	12.5	4	0.5	25	320X224
Sagittal T2W	3388	103.7	4	0.5	26	320X224
Sagittal STIR	5209	46.8	4	0.5	26	256X192
Coronal T2W	3544	103.1	4	1	20	320X224
Coronal STIR	5771	47.9	4	1	20	256X192
Axial PD fat sat	2748	12.5	4	1	24	320X224
Axial T2	3576	86.6	4	1	25	320X192

Figure 5: MRI SCANNER IN MMC-RI ,GE Optima MR360 1.5 Tesla

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Figure 6: Surface coil used for ankle MRI

Statistical analysis:
Data will be presented in the form of frequency, percentage ,proportions ,graphical methods like pie, bar and other statistical techniques using Microsoft excel sheet

3. Results

Demographic Data: The study included 55 patients with ankle injuries following trauma. The age range was 19 to 76 years, with the most common age group affected being 21-30 years (38.2%). The mean age was 37.2. Males were more commonly affected (67%) than females (32%). Right ankle joint injuries (58.1%) were more prevalent than left ankle joint injuries (41.8%). Traumatic ankle injuries were more common in acute onset (61.8%) compared to chronic onset (38.2%).
Traumatic Ankle Injuries: The study identified various types of traumatic ankle injuries using MRI. Ligament injuries were the most common (83.6%), followed by joint effusion (67.3%), bone injuries (38.1%), and tendon injuries (25.5%).
Ligamentous Injury: Ligament injuries were classified into grade 1 sprain (71.9%), partial tear (22.8%), complete tear (1.8%), and chronic tear (3.5%). Among different ligamentous complexes, lateral ligament injuries were observed in 61%, high ankle ligament injuries in 40%, and medial ligament complex injuries in 36%.
Among lateral ligaments, the Anterior Talofibular Ligament (ATFL) was the most frequently injured (56.4%), followed by the Calcaneofibular Ligament (CFL) (45.5%) and the Posterior Talofibular Ligament (PTFL) (16.4%). Grade 1 sprain was the most common type of injury in ATFL (32.7%) and CFL (38.2%), while partial tear was the most common in PTFL (10.9%).
Among medial ligaments, deep deltoid ligament injuries were observed in 22%, and superficial deltoid ligament injuries in 20%. The Anterior Tibiotalar Ligament (ATTL) and Deep Posterior Tibiotalar Ligament (DPTTL) were the most commonly injured medial ligaments.

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High ankle ligaments, specifically the Anterior Inferior Tibiofibular Ligament (AITFL) and Posterior Inferior Tibiofibular Ligament (PITFL), were injured in 34% and 24% of patients, respectively.

Tendon Injuries: Tendon injuries were classified into tenosynovitis (5.5%), tendinosis (1.8%), partial tear (12.7%), complete tear (5.5%), and chronic tear (1.8%). Posterior group tendon injuries were the most common (18.2%), with the Achilles tendon being the most frequently injured overall (18.2%). The study found a male predominance in Achilles tendon injuries.

Bone Injuries: Different bone injuries included contusions (23%), fractures (12%), osteochondral lesions (3.6%), and osteonecrosis (3.6%). Talus was the most commonly injured bone, with contusions being the most common type of bone injury.

Joint Effusion: Joint effusion was present in 67% of patients.

Table 4 - Showing distribution and classification of different tendinous pathological entities.

		Tenosynovitis		Tendinosis		Partial tear		Complete tear		Chronic tear	
		N	%	N	%	n	%	n	%	n	%
Anterior	TA	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
	EHL	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
	EDL	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
	PTT	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Lateral	PB	3	5.5	0	0.0	0	0.0	0	0.0	0	0.0
	PL	3	5.5	0	0.0	0	0.0	0	0.0	0	0.0
Medial	TP	2	3.6	0	0.0	2	3.6	0	0.0	0	0.0
	FDH	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
	FHL	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Posterior	Achilles	0	0.0	1	1.8	5	9.1	3	5.5	1	1.8
	Plantaris	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0

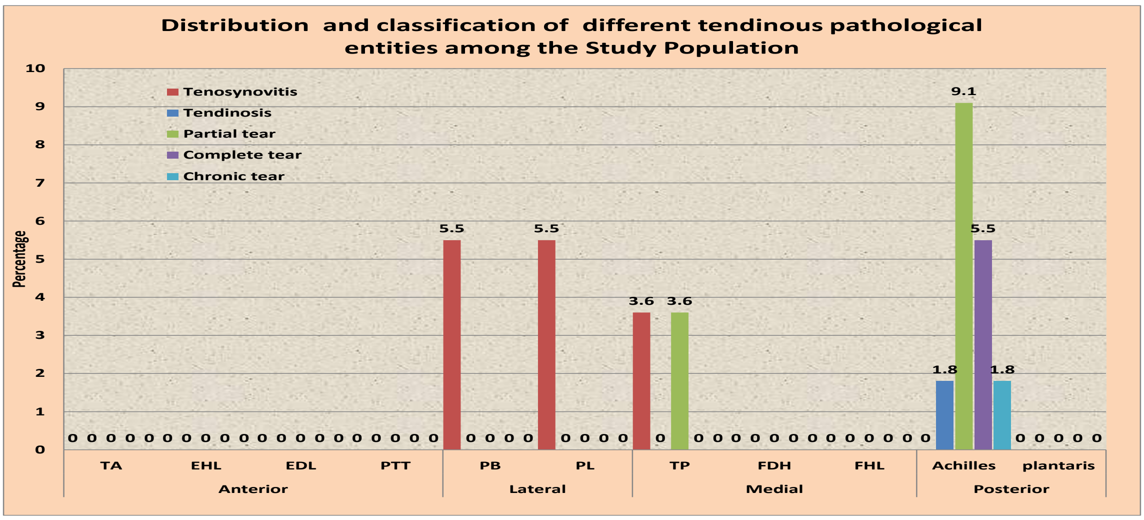

Figure 7: Chart depicting distribution and classification of different tendinous pathological entities.

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In present study, among various types of tendon injuries, partial tear was most common in Achilles(9.1%) followed by complete tear(5.5%). In tibialis posterior there was equal incidence of partial tear and tenosynovitis(3.6%). In peroneus brevis and longus tenosynovitis(5.5%) was most common type of injury

Classification of Achilles tendon injuries based on its anatomical location

Table 6: Showing classification of Achilles tendon injuries based on its anatomical location

	Number of patients	Percentage
Insertional	4	40
Non insertional	6	60
Total	10	100

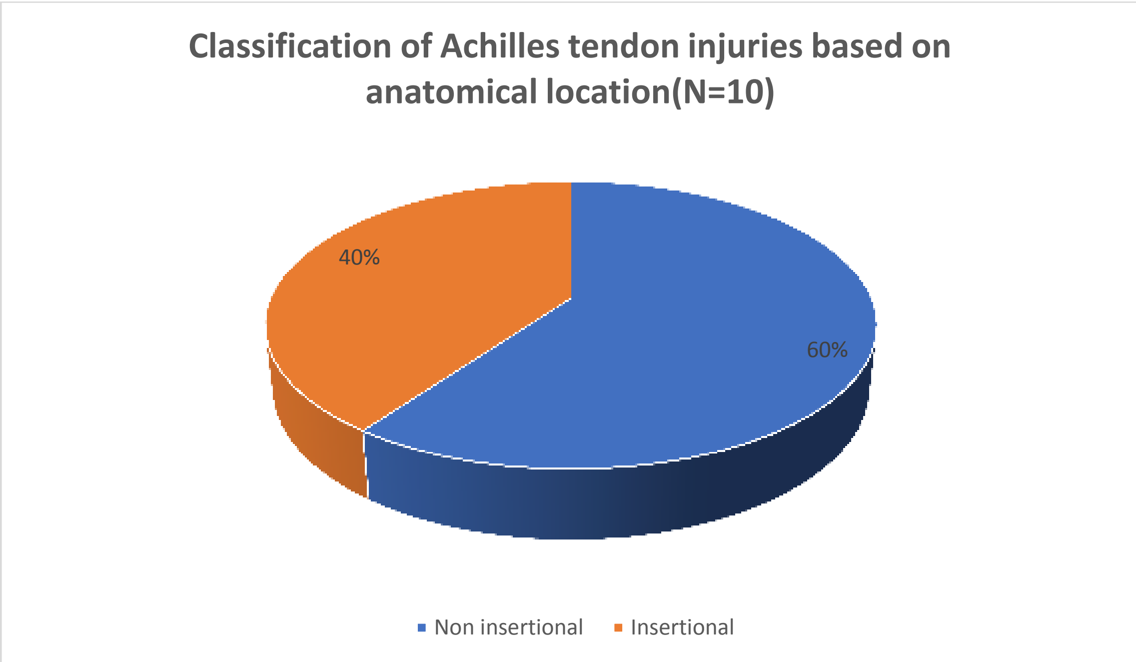

Figure 7: Pie chart depicting classification of Achilles tendon injuries based on its anatomical location

The most common site of Achilles tendon injury in present study was non insertional site(60%)

Distribution of Achilles tendon injury in males and females

Table 8: Showing distribution of Achilles tendon injury in males and females

	Males		Females		total	
	n	%	n	%	n	%
Achilles' injury	7	70	3	30	10	100

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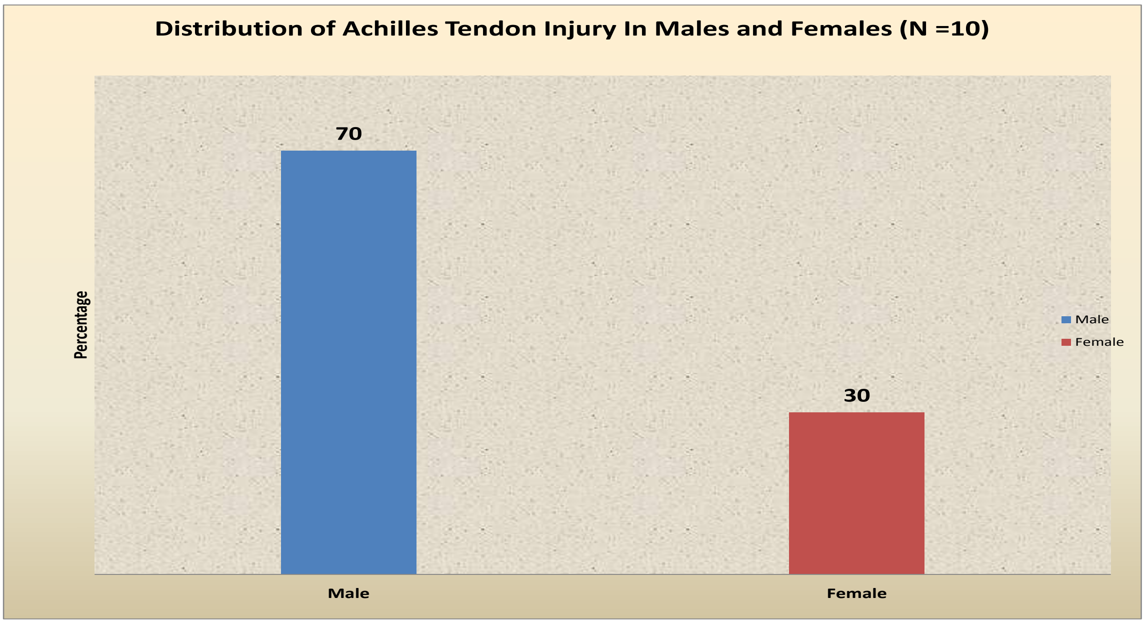

Figure 8: Distribution of Achilles tendon injury in males and females

In present study, among 10 patients with Achilles tendon injury 7 patients(70%) were males, 3 patients(30%) were females. Achilles tendon injury was more common in males.

Table 9 : Showing different Bone injuries diagnosed by MRI.

	Number	percentage
Contusions	13	23.63
Fractures	7	12.7
Osteonecrosis	2	3.6
Osteochondral lesions	2	3.6

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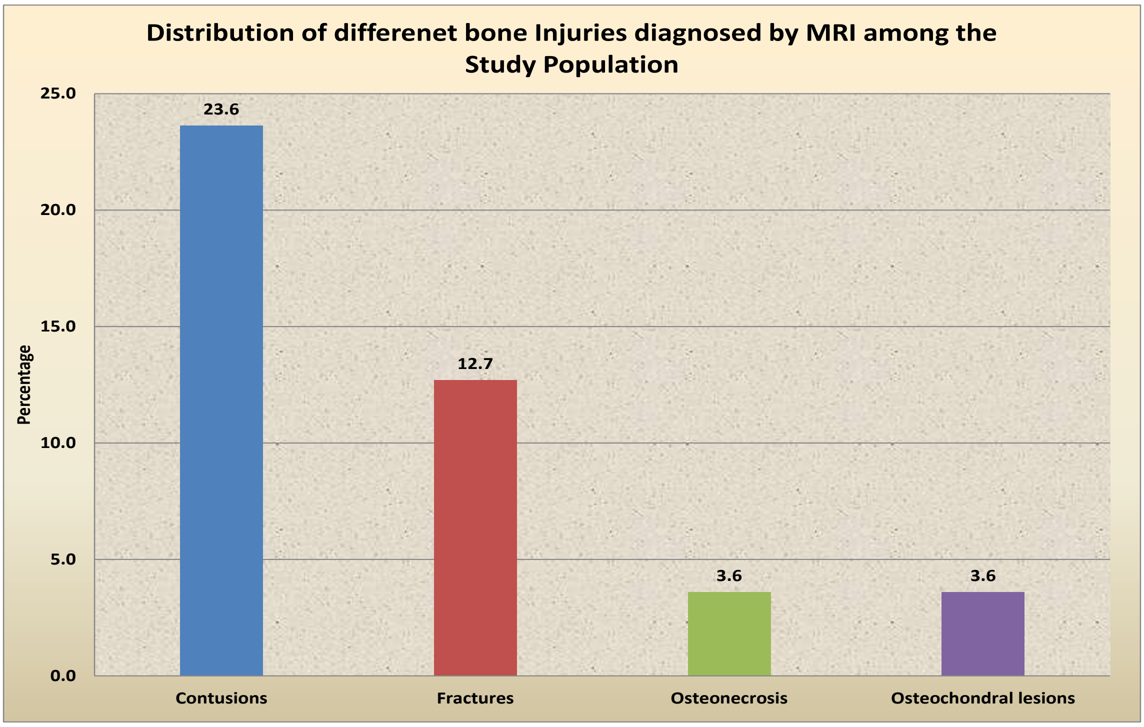

Figure 9: Chart depicting different Bone injuries diagnosed by MRI.

The different bone injuries diagnosed in present study were contusions, fractures, osteonecrosis and osteochondral lesions. Contusions were the most common bone injury(23.6%)

Distribution of different bone injuries

Table 10 : Showing distribution of different bone injuries

Bone	Contusion		Fracture		Osteonecrosis		Osteochondral lesions	
Talus	8	14.5	0	0.0	2	3.6	2	3.6
Calcaneum	5	9.1	1	1.8	0	0.0	0	0.0
Tibia	6	10.9	3	5.5	0	0.0	0	0.0
Fibula	2	3.6	4	7.3	0	0.0	0	0.0

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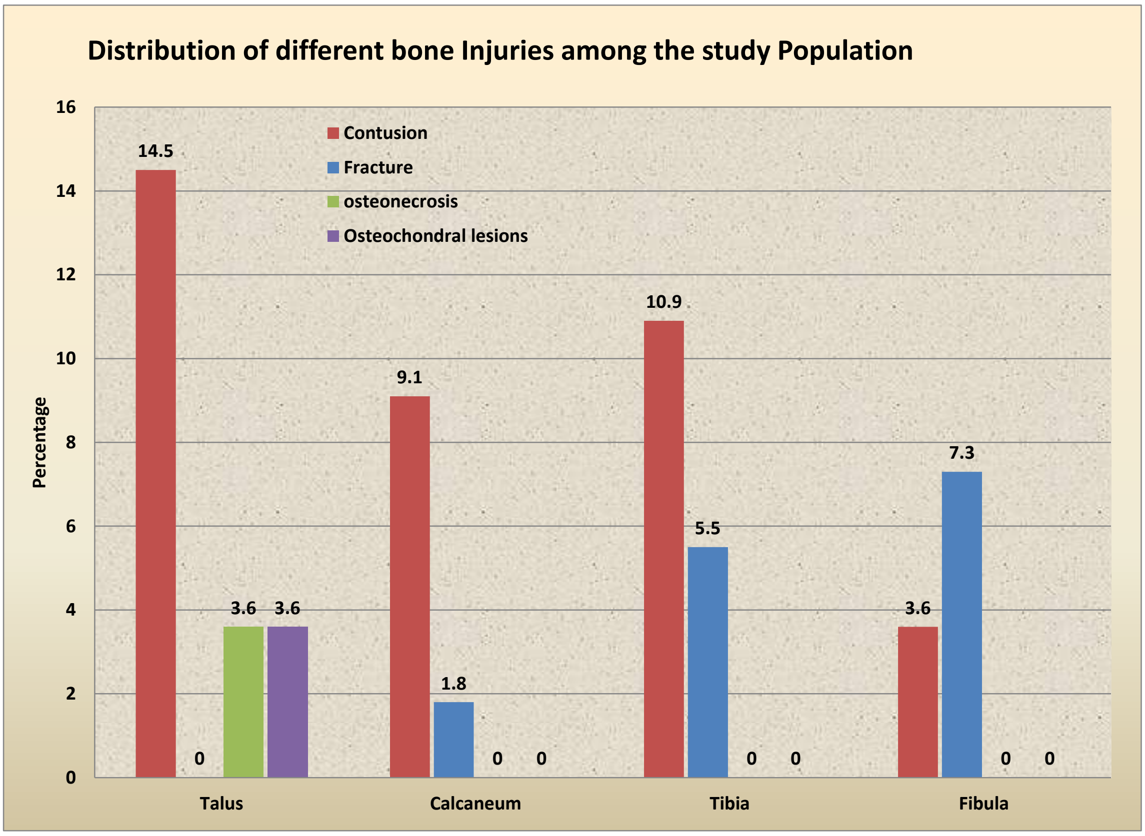

Figure 10: Chart depicting distribution of different bone injuries

In present study among various types of bone injuries, contusions(14.5%) were the most commonest finding in talus, followed by an equal incidence of osteonecrosis and osteochondral lesions(3.6%). The most commonest findings in calcaneum , fibula and tibia were contusions followed by fracture.

Involvement of joint in the study population

Table 11 : Showing involvement of joint in the study population

Joint effusion	Number of patients	Percentage
Present	37	67.3
Absent	18	32.7

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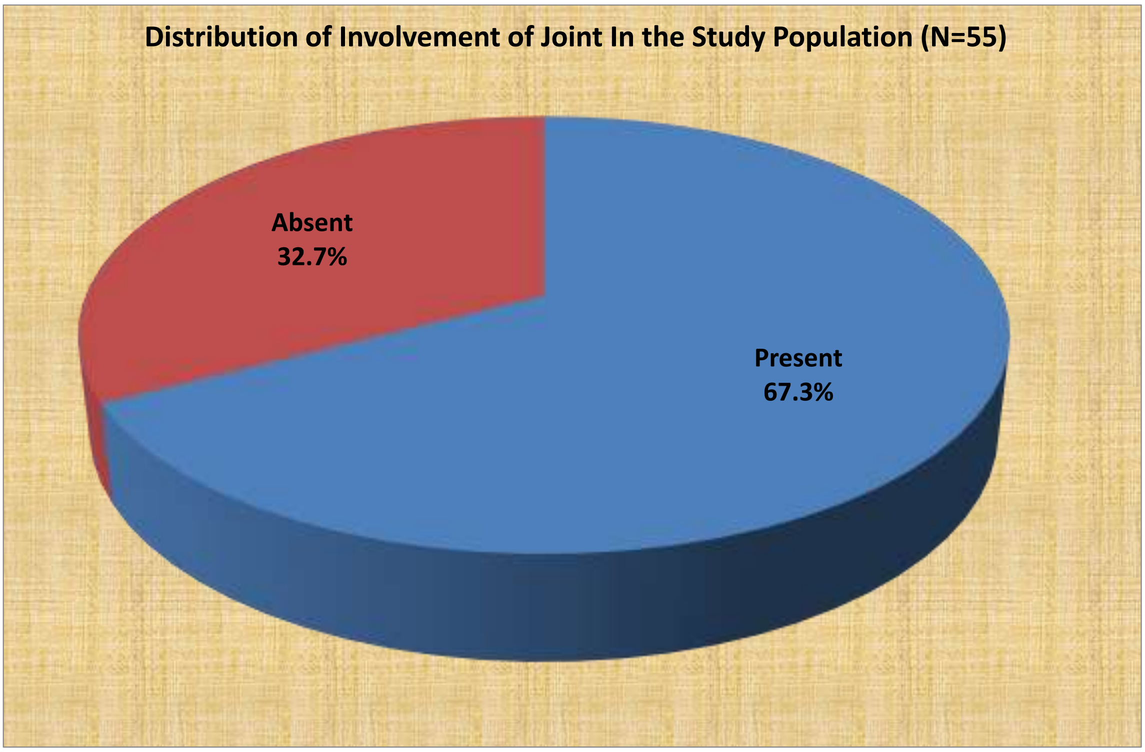

Figure 13: Pie chart depicting involvement of joint in the study population

In present study, among 55 patients joint effusion was present in 37(67%)

4. Discussion

The present study conducted a detailed examination of 55 patients with ankle injuries following trauma, utilizing Magnetic Resonance Imaging (MRI) for evaluation. The findings shed light on the demographics, types of injuries, and their prevalence, offering valuable insights for both clinical understanding and future research.

The demographic profile of the study population revealed a higher incidence of traumatic ankle injuries in the age group of 21-30 years, aligning with existing literature on ankle trauma demographics. The male predominance in traumatic ankle injuries observed in this study is consistent with previous research, emphasizing the gender-based susceptibility to such injuries.

The distribution of injuries between the right and left ankle joints, with a higher prevalence on the right side, adds valuable information to the understanding of injury patterns. The study highlighted acute onset of symptoms, predominantly associated with twisting as the mode of injury, underlining the significance of these mechanisms in the context of ankle trauma.

Comparisons with previous studies revealed some variations in age distribution, with a higher proportion of patients over 30 years in this study. Such differences might be attributed to variations in the study population or regional factors influencing injury patterns.

The predominance of ligament injuries in the studied population (83.6%) underscores the importance of ligamentous involvement in traumatic ankle injuries. Ligament injuries, particularly grade 1 sprains, were the most prevalent, consistent with previous research. The

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lateral ligament complex, especially the Anterior Talofibular Ligament (ATFL), emerged as the most commonly affected, in line with established literature.

In contrast to some studies, the medial ligament complex, particularly the deep deltoid ligament, exhibited a higher incidence in the present study. This discrepancy highlights the diversity in injury patterns and the need for nuanced interpretations of ligamentous involvement in ankle trauma.

Tendon injuries, although less frequent than ligament injuries, displayed distinct patterns. The Achilles tendon stood out as the most commonly injured tendon, predominantly presenting with partial tears. Notably, anterior group tendon injuries were conspicuously rare, suggesting a specific vulnerability or protective mechanism in this subgroup.

Bone injuries, including contusions, fractures, osteochondral lesions, and osteonecrosis, added a layer of complexity to the spectrum of traumatic ankle injuries. The talus emerged as the most commonly injured bone, with contusions being the predominant type of bone injury.

Joint effusion, identified in a significant proportion of patients (67%), reinforced its role as a prominent MRI finding in traumatic ankle injuries. This observation aligns with previous research, emphasizing the clinical relevance of joint effusion as an indicator of intra-articular pathology.

While the study provides valuable insights into the characteristics of traumatic ankle injuries, it is not without limitations. The lack of correlation between MRI findings and surgical outcomes represents a significant constraint, limiting the study's ability to elucidate the direct clinical implications of the identified injuries. Future research endeavors could benefit from bridging this gap, offering a more comprehensive understanding of the correlation between imaging findings and subsequent interventions.

In conclusion, the study enriches our understanding of traumatic ankle injuries by detailing their demographics, injury patterns, and prevalence based on MRI evaluations. The findings contribute to the existing body of knowledge, emphasizing the significance of imaging modalities in characterizing the complexity of ankle trauma. This knowledge has implications for clinical decision-making, prognosis assessment, and the development of tailored treatment strategies for individuals with traumatic ankle injuries.