Original Research Article

MRI Evaluation of Ankle and Foot Pathologies: A Cross-Sectional study in RRMCH, Bengaluru

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Abstract

Background and purpose: Ankle joint is one of the most commonly injured joints in sedentary individuals as well as in athletes. Ankle ligaments are frequently injured in twisting injuries. The other pathologies in the ankle and foot are tendon pathologies, neuromas, ganglion cysts and plantar fasciitis. **Aim**: The purpose of this study was to describe the demographic profile of patients presenting with ankle and foot pathologies, to identify and describe the MRI features of various ankle and foot pathologies, to assess and grade the severity of various ligament and tendon pathologies. **Methods:** This study was a cross-sectional study of patients who underwent MRI evaluation of the ankle or foot in the Department of Radiodiagnosis, Rajarajeswari Medical College & Hospital, Bengaluru from January 2014 to December 2020. The study population consisted of 64 cases. All the MRI scans of the ankle and foot were performed using 1.5 Tesla Siemens Magnetom Avanto (Tim 76x18) MR machine using a flex coil. **Results:** The study population consisted of 64 patients comprising of 39 males and 25 females. The age of the patients ranged from 9 to 75 years. Majority of the patients belonged to the age group of 21 – 30 years constituting about 34% of the total study population.Bones were the commonest site of pathology followed by joints, soft tissues, tendons and ligaments. The commonest type of tendon pathology was acute tenosynovitis. Anterior talofibular ligament was the most frequently injured ligament. Fractures, joint effusion and abscess were the commonest types of bone, joint and soft tissue pathologies respectively. **Conclusion:** Young adults and males are the most commonly affected population. Bones are the commonest site of pathology followed by joints, soft tissues, tendons and ligaments. MRI can identify, assess and grade the severity of tendon and ligament injuries which can help in treatment planning and rehabilitation.

Keywords: Haglund's syndrome, Impingement syndrome, Madura foot, Morton's neuroma, Plantar fasciitis, Sinus tarsi syndrome, Tears, Tendinosis, Tenosynovitis

Abbreviations

ATFL - Anterior talofibular ligament; AVN – Avascular necrosis; CFL – Calcaneofibular ligament; DJD – Degenerative joint disease; FS – Fat Suppressed; FSE – Fast Spin Echo; MRI – Magnetic Resonance Imaging; PTFL - Posterior talofibular ligament; PD – Proton Density; STIR – Short Tau Inversion Recovery.

Introduction

Ankle joint is one of the most commonly injured joints in sedentary individuals as well as in athletes. Ankle ligaments are frequently injured in twisting injuries. The other pathologies in the ankle and foot are tendon pathologies (tenosynovitis, tendinosis, paratenonitis and tears), neuromas, ganglion cysts and plantar fasciitis.

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MRI is very sensitive in identifying marrow edema which is useful in early detection of contusions, stress fractures, osteomyelitis, cellulitis and soft tissue abscesses. MRI can assess hyaline articular cartilage which is very helpful in evaluation of arthritis and osteochondral lesions, and in identifying intra-articular loose bodies [1,2,3].

MRI of the ankle and foot provides very good soft tissue contrast and spatial resolution and therefore better assessment of complex soft-tissue anatomy (e.g., muscles, ligaments, tendons, and fibrous coalitions) than other modalities [1,2,3].

Aims & Objectives

1. To describe the demographic profile of patients presenting with ankle and foot pathologies.
2. To identify and describe the MRI features of various ankle and foot pathologies.
3. To assess and grade the severity of various ligament and tendon pathologies.

Methods

Source of Data

This study was a cross-sectional study of patients who underwent MRI evaluation of the ankle or foot in the Department of Radiodiagnosis, Rajarajeswari Medical College & Hospital, Bengaluru from January 2014 to December 2020.

The sample size was estimated using the formula:

$n = Z^2P(1-P)/d^2$

Where n is the sample size, Z is the level of confidence (95 %), d is precision, and P is the expected prevalence [4].

The preliminary or initial study population consisted of 77 patients. 13 patients with negative MRI, incomplete or suboptimal scan images were excluded. So, the final study population consisted of 64 cases. The requirement for informed consent from the study subjects was waived by the institutional ethics committee because this study was a retrospective review of the cases. Institutional ethics committee clearance was obtained. The institutional ethics committee approval number for this study is RRMCH-IEC/14/2021.

Inclusion and Exclusion Criteria

All patients referred to the department of Radiodiagnosis for MRI ankle or foot were included in the study. The exclusion criteria were patients with negative MRI, postoperative cases and other general contraindications to MR imaging.

Equipment and Technique

All the MRI scans of the ankle and foot in this study were performed using 1.5 Tesla Siemens Magnetom Avanto (Tim 76x18) MR machine using a flex coil. The patient was placed supine with the foot in partial (about 20°) plantar flexion. Ankle MR imaging was performed in the axial (perpendicular to the tibia), coronal (aligned along the intermalleolar axis), and sagittal (perpendicular to the intermalleolar axis) planes. The foot was imaged in the oblique axial plane (i.e., parallel to the long axis of the metatarsal bones), oblique coronal plane (i.e., perpendicular to the long axis of the metatarsals), and oblique sagittal plane.

The sequences used in performing the MR scans were T1 sagittal; T2 coronal; PD FS axial, coronal and sagittal; and PD axial. The slice thickness was 3 mm. Intravenous contrast agent was given only in few necessary cases.

Methods

MR images were read in consensus by the first (7 years of post MD Radiodiagnosis reporting experience), second (5 years of post MD Radiodiagnosis reporting experience), third (22 years of post MD Radiodiagnosis reporting experience) and fourth (1 year of post MD Radiodiagnosis reporting experience) authors at a Siemens syngo.via MR workstation.

Evaluation of ankle tendons

The ankle tendons were primarily assessed using the PD and PD FS sequences in axial and sagittal planes. The ankle tendons were considered normal when they demonstrated low signal intensity on PD, FS PD, T2 and T1 FSE sequences without any discontinuity of the fibres.

The ankle tendon pathologies were classified into tenosynovitis or paratenonitis, tendinosis, partial tears and complete tears [1].

Acute tenosynovitis was diagnosed when there was fluid within the tendon sheath. Flexor hallucis longus tenosynovitis was diagnosed when there was disproportionate amount of fluid in the sheath in comparison to tibiotalar joint fluid [1].

Paratenonitis was diagnosed when there was high signal intensity around the tendon in fluid-sensitive sequences [1].

Tendinosis was diagnosed when the tendon demonstrated focal areas of thickening and high signal intensity (but less than fluid signal intensity) on PD, FS PD, T2 and T1 FSE sequences without any discontinuity of the fibres [1].

Tears were diagnosed when the tendon demonstrated fluid signal intensity on PD, FS PD, T2 and T1 FSE sequences with disruption of the fibres. Tears were further classified into partial tears and complete tears or ruptures [1]. Peroneal tendon longitudinal split tears were classified into partial-thickness and full-thickness split tears [5].

Evaluation of ankle and foot ligaments

The ligaments were primarily assessed using the PD and PD FS sequences in all three orthogonal planes. The ligaments were considered normal when they demonstrated low signal intensity on PD, FS PD, T2 and T1 FSE sequences without any discontinuity of the fibres. Mixed or striated signal intensity is normally seen in posterior talofibular, posterior inferior tibiofibular, deep deltoid and interosseous talocalcaneal ligaments.

The ligament pathologies were classified into sprains, partial tears and complete tears. Ligament sprain was diagnosed when the ligament appeared hyperintense without any disruption of fibres. Ligament tears were diagnosed when there was disruption of fibres or non-visualisation of the ligament [1].

Statistical Analysis

All the data were expressed in numbers and percentages.

Results

Demographics of Ankle and Foot Pathologies

The study population consisted of 64 patients comprising of 39 males (60.93 %) and 25 females (39.06 %). The age of the patients ranged from 9 to 75 years. Majority of the patients belonged to the age group of 21 – 30 years constituting about 34 % of the total study population. The right ankle or foot was affected in 38 patients (59.375 %) and the left ankle or foot in 26 patients (40.625 %).

Distribution of Pathology

Bones (30 cases – 46.87 %) were the commonest site of pathology followed by joints (28 cases – 43.75 %), soft tissues (24 cases – 37.5 %), tendons (20 cases – 31.25 %) and ligaments (7 cases – 10.93 %)

Types of Tendon Pathology

The commonest type of tendon pathology was acute tenosynovitis followed by partial tears, tendinosis and complete tears. Peroneus brevis (acute tenosynovitis – 8 cases, tendinosis – 1 case, partial tears – 3 cases) was the most commonly affected tendon followed by peroneus longus tendon (acute tenosynovitis – 8 cases, tendinosis – 1 case), tibialis posterior (acute tenosynovitis – 7 cases), flexor digitorum longus (acute tenosynovitis – 4 cases) and flexor hallucis longus (acute tenosynovitis – 2 cases). Achilles tendon was affected by tendinosis (1 case), paratendinitis (2 cases), Haglund's syndrome (1 case), xanthoma (1 case) and complete tear (2 cases). Plantaris tendon and anterior compartment tendons were normal in all cases.

Location and Grading of the Ligament Injuries

Anterior talofibular ligament (sprain – 2 cases, partial tear – 1 case and complete tears – 4 cases) was the most frequently injured ligament followed by PTFL (2 cases of sprain), CFL (sprain – 1 case and complete tear – 1 case) and deltoid ligament (1 case of complete tear). Complete tear (5 cases) was the commonest type of injury followed by sprain (5 cases) and partial tear (1 case). Syndesmotic ligaments and spring ligament complex were normal in all cases.

Table 1:Types of Bone, Joint and Soft Tissue Pathology and Type of Normal Anatomic Variant

Type of bone pathology	N	%	Type of joint pathology	N	%
Acute osteomyelitis	11	17.18	Septic arthritis	2	3.125
Chronic osteomyelitis	1	1.56	Ankylosis – bony	2	3.125
Fractures	16	25	Dislocations	2	3.125
Contusions	5	7.81	DJD	9	14.06
Avascular necrosis	2	3.12	Hallux valgus deformity	1	1.56
Osteochondroma	1	1.56	Joint effusion	28	43.75
Madura foot or pedal mycetoma*	1	1.56	Anterior impingement syndrome	1	1.56

Multiloculated bone cyst	1	1.56			
Type of soft tissue pathology	**N**	**%**	**Type of normal anatomic variant**		
Abscess#	6	9.375	Accessory soleus	1	1.56
Ganglion cyst	2	3.125	Accessory navicular	7	10.93
Bursitis	4	6.25	a) Type I	5	7.81
Morton's neuroma	1	1.56	b) Type II	2	3.12
Plantar fasciitis	1	1.56	c) Type III	0	-
Low-flow venous malformation	4	6.25	Os peroneum	1	1.56
Madura foot*	1	1.56	Variations of posterolateral talus+	4	6.25
Sinus tarsi syndrome	2	3.125	a) Type II	2	3.12
Lipoma	1	1.56	b) Type III	1	1.56
Muscle strain	2	3.125	c) Type IV	1	1.56
Muscle contusion	1	1.56			

Note: *There was only one case of Madura foot where both soft tissues and bone were involved.
4 cases of abscesses were secondary to acute osteomyelitis.
+ Type I variant of the posterolateral talus is normal lateral tubercle.

Figure 1. (A, B, C and D): Haglund's Syndrome in a 36-Year-Old Male Patient: Sagittal (A) and Axial (B and C) FS PD and Sagittal (D) T1 FSE Images Demonstrate Insertional Achilles Tendinitis with Partial Tear (Arrow), Reactive Calcaneal Marrow Edema, Thickened Tendon (Bent Arrow) and a Calcaneal Bony Prominence (Curved Arrow)

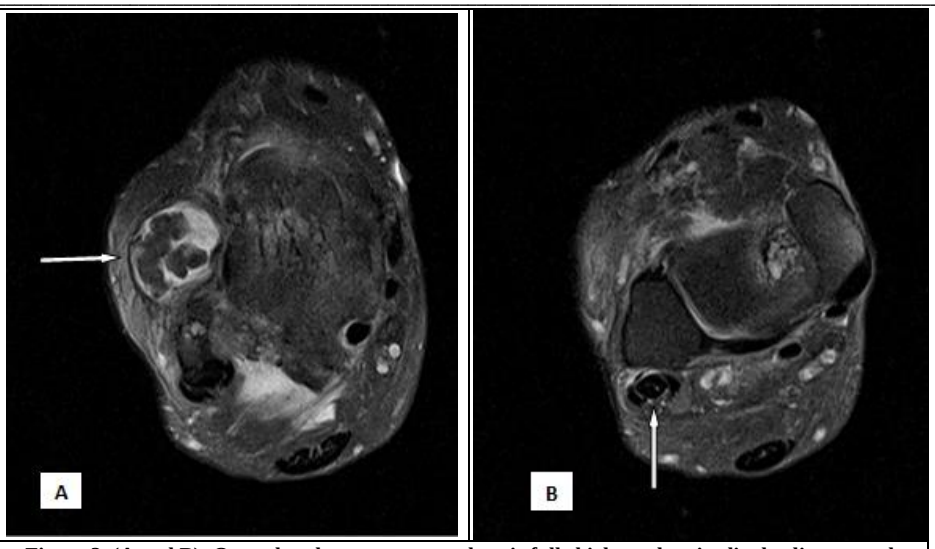


Figure 2. (A and B): Osteochondroma, peroneus brevis full-thickness longitudinal split tear and peroneus longus tendinosis in a 60-year-old female patient: (A) Axial FS PD FSE image demonstrates an osteochondroma (arrow) arising from the lateral aspect of calcaneal body with a cartilage cap thickness of 3.9mm and (B) Axial FS PD FSE image demonstrates peroneus brevis full-thickness longitudinal split tear and peroneus longus tendinosis (arrow).

Figure 3. (A, B, C and D): Anterior impingement syndrome in a 52-year-old female patient: Sagittal T1 (A) and Sagittal FS PD (B, C and D) FSE images demonstrate grade 3 tibial exostosis (arrow) with secondary spur formation (double arrow) on the dorsum of the talus, tram track lesion (bent arrow) in the talus, tibiotalar degenerative joint disease, mild tibiotalar joint effusion and a loose body (chevron)

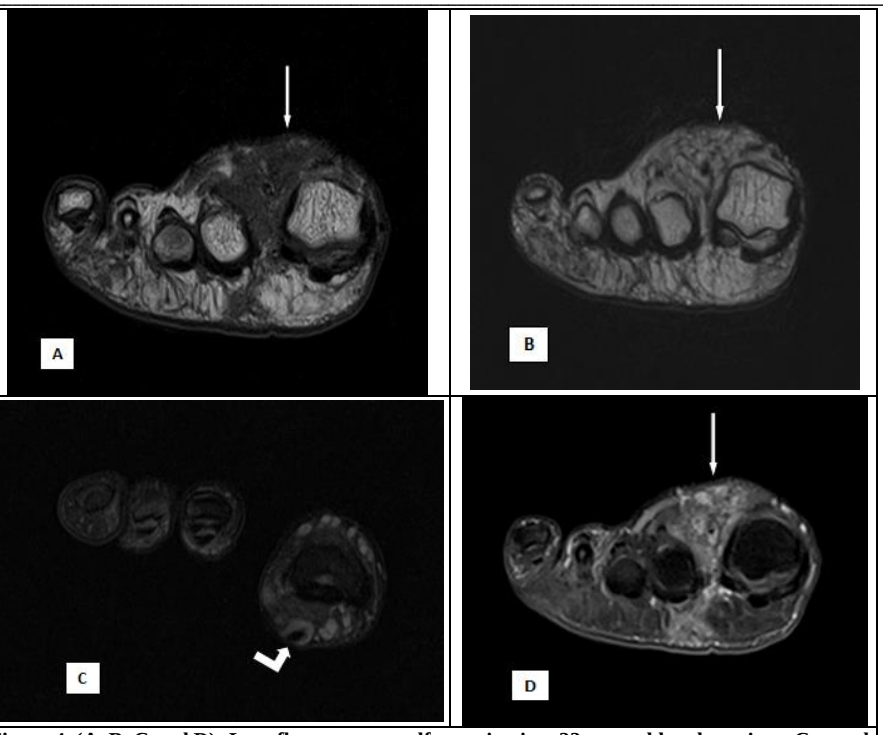


Figure 4. (A, B, C and D): Low-flow venous malformation in a 22-year-old male patient: Coronal T1 (A), Coronal T2 (B) and Coronal FS PD (C) FSE images demonstrate a T1 isointense, T2 and FS PD hyperintense lesion (arrow) involving the dorsum of the forefoot, first intermetatarsal space, dorsal and plantar aspects of the great toe. C: Coronal FS PD FSE image demonstrates few phleboliths (bent arrow) within the lesion in the plantar aspect of the great toe. D: Coronal FS T1 post contrast image demonstrates enhancement of the lesion (arrow)

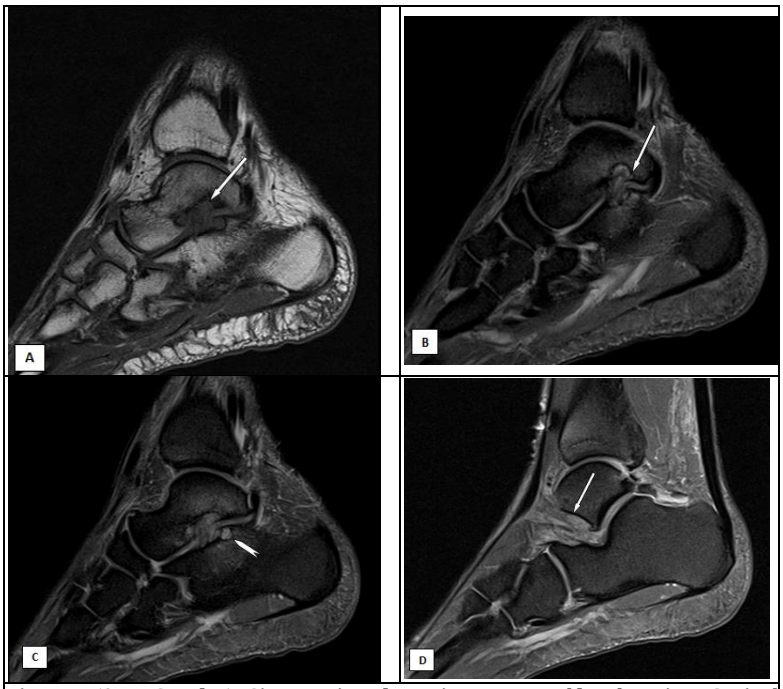


Figure 5. (A, B, C and D): Sinus tarsi syndrome in a 37-year-old male patient: Sagittal T1 (A) and Sagittal FS PD (B and C) FSE images demonstrate poorly defined margins of interosseous and cervical ligaments (arrow), secondary sclerosis and subchondral cystic change in roof of sinus tarsi and calcaneus (chevron). D: Sagittal FS PD FSE image demonstrates increased signal in the inferior extensor retinaculum (arrow)

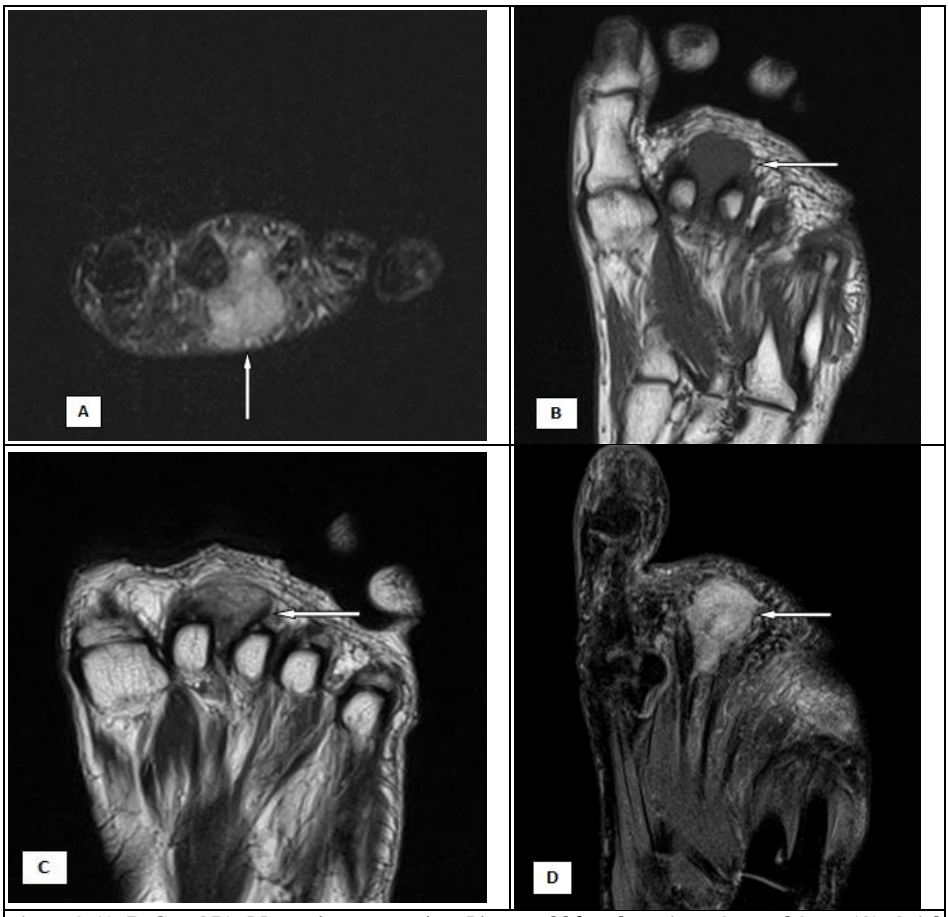
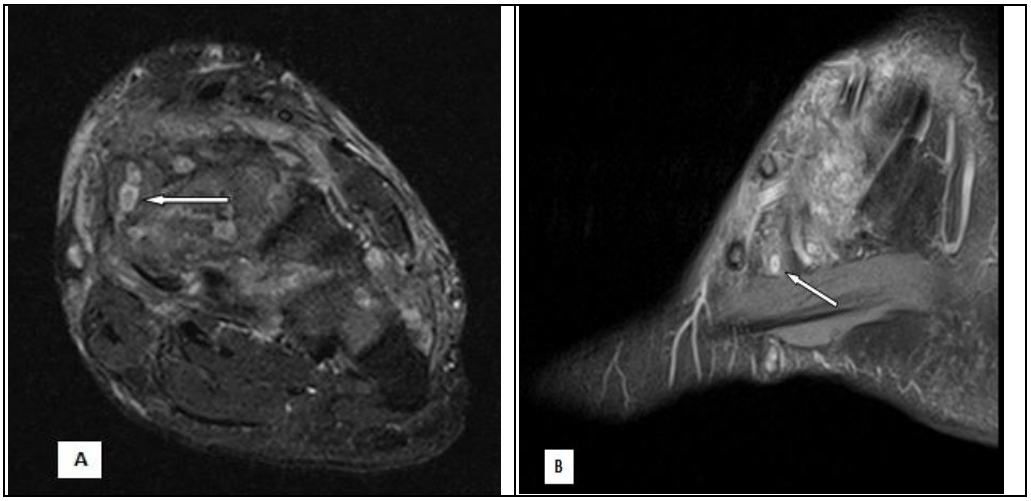


Figure 6. (A, B, C and D): Morton's neuroma in a 54-year-old female patient: Coronal STIR (A), Axial T1 (B), Axial T2 (C) and Axial FS PD (D) FSE images demonstrate a well-defined, T1 isointense, T2, FS PD and STIR hyperintense, fusiform teardrop-shaped lesion (arrow) with bulbous plantar extension between the 2nd and 3rd metatarsal heads.



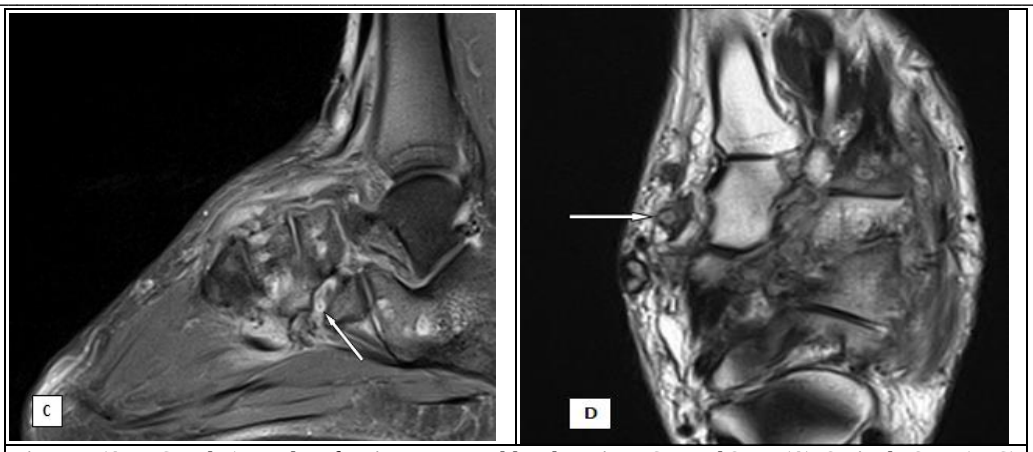


Figure 7. (A, B, C and D): Madura foot in a 44-year-old male patient: Coronal STIR (A), Sagittal FS PD (B, C) and Axial T2 (D) FSE images demonstrate "dot-in-circle" sign within the bones and soft tissues of the ankle and foot

Discussion

The ankle joint is a hinge joint. The key articulations in the ankle are the tibiotalar joint, subtalar joint and other tarsal joints. The ankle is supported by various ligaments surrounding the joint. The ankle tendons are grouped into medial, lateral, anterior and posterior compartment tendons. The medial group consists of posterior tibialis tendon, flexor digitorum longus tendon and flexor hallucis longus tendon. The posterior tibial artery, veins, and tibial nerve run between the flexor digitorum longus and flexor hallucis longus tendons. The lateral group consists of peroneus brevis and longus tendons. The anterior group (from medial to lateral) consists of tibialis anterior, extensor hallucis longus, extensor digitorum longus and peroneus tertius tendons. The posterior group consists of Achilles and plantaris tendons [1].The ankle ligaments consist of lateral complex ligaments (anterior talofibular ligament, posterior talofibular ligament, and calcaneofibular ligament), medial complex ligaments (deltoid ligament -tibionavicular ligament, tibiospring ligament, tibiocalcaneal ligament, anterior tibiotalar ligament, posterior tibiotalar ligament), syndesmotic ligaments (anterior inferior tibiofibular ligament, posterior inferior tibiofibular ligament, inferior transverse ligament and distal interosseous ligament or membrane) and spring ligament complex (calcaneonavicular ligament – Superomedial calcaneonavicular ligament, medioplantar oblique calcaneonavicular ligament, inferoplantar longitudinal calcaneonavicular ligament) [1].

Demographics of Ankle and Foot Pathologies

In the current study of 64 patients, majority was males and the commonest age group was 21-30 years. The current study findings correlated with the study of Sharma UK et al. [6] on 100 patients with musculoskeletal diseases of ankle and foot. In that study, fifty two patients were male and 48 patients were female with age ranging from 6 months to 70 years.

Distribution of Pathology

In the current study, bones were the commonest site of pathology followed by joints, soft tissues, tendons and ligaments. The current study findings partially correlated with the study of Bhudiya J et al. [7] on 47 patients. In that study, they found joints were most commonly involved followed by bones, ligaments, tendons and soft tissues.

Tendon Pathologies

In this study, the commonest type of tendon pathology was acute tenosynovitis followed by partial tears, tendinosis and complete tears. Acute tenosynovitis was seen most commonly involving the common peroneal tendon sheath, followed by tibialis posterior, flexor digitorum longus and flexor hallucis longus tendons. There were no cases of chronic or stenosing tenosynovitis. Complete tears were only seen in the Achilles tendon. There was a case of Haglund's syndrome (Fig. 1) in a 36-year-old male patient. Partial tears were seen only in peroneus brevis tendon. There were 3 cases of partial tear involving the peroneus brevis tendon, two of them were longitudinal split tears and one was an interstitial tear. In one of these cases (a 60-year-old female) (Fig. 2), there was an osteochondroma (cartilage cap thickness of 3.9mm) arising from the lateral aspect of the body of calcaneum, longitudinal split tear of peroneus brevis, peroneus longus tendinosis and partial tear of anterior talofibular ligament. There were 3 cases of tendinosis, one each in Achilles, peroneus brevis and longus tendons.The current study findings are similar to the findings reported by Mulcahey MK et al. [8] in their study of 2285 National football league players, 85 players (37.3 % of players with MRI) with tendon injuries were identified: 26 Achilles, 55 peroneal, 3 flexor hallucis longus, and 19 posterior tibial.

The current study findings of complete tendon tear correlate with the studies of Bhudiya J et al. [7]. Bhudiya J et al. [7] reported complete tears only in the Achilles tendon similar to the current study findings.

Ligament Injuries

In this study, lateral complex ligaments were most commonly injured. Anterior talofibular ligament was the most commonly injured ligament followed by calcaneofibular ligament and posterior talofibular ligament. One case of complete tear of ATFL in a 27-year-old male patient had associated comminuted fracture of the medial malleolus at the deltoid ligament attachment, acute tenosynovitis of FDL and common peroneal tendons.

The current study findings correlated with the study of Mulcahey MK et al. [8]. In their study, the most common ligament injuries were to the anterior talofibular ligament (n = 158, 12.7 % of sprains) and syndesmosis (n = 137, 11.0 %). van Putte-Katier N et al. [9] also reported that ATFL was the most commonly injured ligament after lateral ankle trauma. Bhudiya J et al. [7] also reported that lateral complex ligaments were most commonly injured (83.33 %). Rosenberg ZS et al. [3] also reported that lateral ankle sprains represent 16 %-21 % of all sports-related traumatic lesions with ATFL being the most frequently injured ligament.

Bone Pathologies

In this study, the commonest bone pathology was fractures followed by acute osteomyelitis and bone contusions. There were 16 cases of fracture, out of which 3 were pathological fractures. There was a 49-year-old male patient with bony ankylosis of calcaneocuboid joint associated with acute osteomyelitis, pathological fracture and subcutaneous abscess. There were 2 cases of AVN.

The current study findings correlated with the study of Bhudiya J et al. [7]. They reported 26 cases (55.31 %) of bone pathologies in their study of 47 patients with ankle complaints.

Joint Pathologies

In this study, the commonest joint pathology was joint effusion followed by degenerative joint disease. Joint effusion was most commonly seen involving the ankle joint followed by subtalar joint whereas in degenerative joint disease, subtalar joint was most commonly involved followed by ankle joint. There was a case of anterior impingement syndrome (Fig. 3) in a 52-year-old female patient and hallux valgus deformity in a 33-year-old female patient. The current study findings correlated with the study of Bhudiya J et al. [7]. They reported 28 cases (59.57 %) of joint pathologies in their study of 47 patients with ankle complaints.

Soft Tissue Pathologies

In this study, abscess was the commonest soft tissue pathology followed by bursitis and low-flow vascular malformation (Fig. 4). There were two cases each of ganglion cyst and sinus tarsi syndrome (Fig. 5), one case each of Morton's neuroma and plantar fasciitis. The first case of ganglion cyst was seen arising from the FHL tendon sheath in a 48-year-old female patient. The second case of ganglion cyst was in a 50-year-old female patient – there were two cysts abutting each other and with a suspicious communication with the 5th tarsometatarsal joint. There was a 54-year-old female patient with a Morton neuroma (Fig. 6) in the 2-3 web space. According to Linklater JM [10], Morton neuroma most commonly occurs in the 3–4 web space and, to a lesser extent, the 2–3 web space. It virtually never occurs in the 1–2 or 4–5 web space.

There was a case of Madura foot (Fig. 7) in a 44-year-old male patient with involvement of both soft tissue and bone and demonstrating "dot-in-circle" sign. In 2003, Sarris I et al. [11] described the "dot-in-circle" sign in two cases of foot mycetoma and proposed the sign to be highly specific for mycetoma. The inflammatory granulomata appear hyperintense, the peripheral fibrous matrix appears hypointense and the small central hypointense foci within the granulomata represent the fungal balls or grains.

Normal Anatomic Variants

In this study, there were anatomic variants like accessory soleus, accessory navicular, os peroneum and variants of posterolateral talus – type II (Steida's process), type III (Os trigonum), type IV (Os trigonum fused via synchondrosis or syndesmosis). Bencardino JT et al. [12] reported 2 % to 20 % incidence of accessory ossicles. Stoller DW et al. [1] reported that os trigonum was found in 10 % of individuals.

Limitations

Most of the patients in this study were managed conservatively. Few patients underwent surgery or arthroscopy but MRI findings could not be correlated with arthroscopic or surgical findings or histopathology.

Conclusion

Young adults and males are the most commonly affected population by ankle and foot pathologies. Bones are the commonest site of pathology followed by joints, soft tissues, tendons and ligaments. The commonest type of tendon pathology is acute tenosynovitis followed by partial tears. Anterior talofibular ligament is the most frequently injured ligament and complete tear is the commonest type of injury.

MRI is a non invasive, non-ionising diagnostic modality which gives adequate information about the ankle and foot pathologies.

MRI can identify, assess and grade the severity of tendon and ligament injuries which can help in treatment planning and rehabilitation.

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