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Prevalence of associated ligamentous ankle injuries with an isolated lateral malleolus fracture

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Abstract
Background: Magnetic resonance image (MRI) was used with plain radiographic views for evaluation of bone and ligamentous injuries to detect any missing osteo-ligamentous injuries using single imaging modality. The purpose of this study was to ascertain the prevalence of associated ligamentous ankle injuries with an apparently isolated lateral malleolus fracture using MRI.
Methods: This cross-sectional study was carried on 100 eligible patients with an acute isolated lateral malleolus closed fracture. Every patient underwent a history taking and clinical assessment (general and local assessment including inspection, palpation and neurovascular assessment of the affected lower limb) and full investigations. Imaging was done using Plain X-rays (anteroposterior, lateral, mortise and stress views) and MRI.
Results: There was a significant relationship between the tenderness on medial side and Weber classification, Lauga Hansen classification and deltoid ligament injury (posterior tibiotalar ligament (PTTL), anterior tibiotalar ligament (ATTL) and tibiocalcaneal ligament (TCL)) (P value <0.001). There was an insignificant relation between radiographic anterior-posterior (AP) medial clear space (MCS) and (PTTL and ATTL), syndesmotic and Lateral collateral ligament injuries. There was a significant relationship between missed deltoid injuries with weber and Lauge. Hansen classification (P =0.005).
Conclusions: MRI is valuable in the assessment of radiologically isolated lateral malleolus fracture cases. MCS in AP and stress views was insignificantly correlated to deltoid ligament injury, syndesmotic ligaments injury and lateral collateral ligaments injuries however, there was a strong link between syndesmotic ligaments injuries and both tibiofibular overlap (TFO) and tibiofibular clear space (TFCS) in AP and stress views.

Keywords: Lateral malleolus fracture, ligamentous, ankle injuries, prevalence

Introduction

Ankle fractures, which make up around 46.7 % of tibial/fibula fractures and 7.6 % of all fractures, are the most frequent injury treated in emergency and orthopaedic departments. According to epidemiologic data, lateral malleolus fractures are the most frequent type of ankle fracture (56 % to 65 % of all ankle fractures) [1].

The medial and lateral malleoli, talus, and tibial plafond make up the complicated joint of the ankle. The lateral ligaments, the deltoid ligament on the medial side, and the ligaments of the tibiofibular syndesmosis all work together to give ankle static stability in addition to the osseous architecture of the ankle mortise [2, 3].

The primary ankle stabilizer is thought to be the deep deltoid ligament. Identification of this ligament's injury and the resulting ankle instability affects care in the context of a single lateral malleolus fracture [4].

Ankle fractures can be categorized using the Danis-Weber, AO-Müller, and Lauge-Hansen fracture categories, which are all extensively used. According to Weber and AO-Müller, the degree of the fibular fracture in respect to the syndesmotic ligaments determines how a fracture is diagnosed. Based on the location of the foot at the time of damage and the movement of the talus inside the ankle mortise, Lauge-Hansen summarizes the trauma mechanism of ankle fractures [5, 6].

Tibiofibular overlap (TFO), tibiofibular clear space (TFCS), medial clear space (MCS), and tibial clear space are a few of the radiographic measures that have been used to assess the integrity of the syndesmotic and deltoid ligaments (TCS). In addition to the conventional plain radiograph, diagnostic imaging modalities such as computed tomography (CT), ultrasonography, and magnetic resonance imaging can be employed to assess the related ankle ligamentous lesions (MRI) [1].

In spite of plain radiography is the first imaging method used in ankle ligamentous injuries to detect fractures and bone gaps, but many ankles ligamentous injuries could be undiagnosed by plain radiography. Some types of lateral malleolus fractures which initially seem simple and need only casting, may be more complex than one can expect. Missed and neglected ankle ligamentous injuries can cause deep chronic ankle pain, limited range of motion, swelling, and can lead to chronic ankle instability, therefore, we need further and accurate evaluation to diagnose soft tissue injuries as well as bone injuries [6, 7].

In this study, MRI was used with plain radiographic views in order to obtain a global evaluation of bone and ligamentous injuries which the authors deemed crucial to detect any missing osteo-ligamentous injuries using single imaging modality [8].

The primary goal of this study was to determine the prevalence of associated ligamentous ankle injuries with an apparently isolated lateral malleolus fracture using MRI.

Materials and Methods

This cross-sectional study was performed on 100 eligible patients aged from 18-50 years with an acute isolated lateral malleolus closed fracture from those exhibited to the emergency department of Tanta University Hospital from October 2021 to October 2022.

The study was done after being approved by the ethical committee institute of Faculty of Medicine, Tanta University. Signed consent was obtained from all cases.

Exclusion criteria were age either younger than 18 or older than 50, open and old fractures, osteoporotic patient, previous symptomatic ankle joint injuries, past history of ankle joint infection and peripheral neuropathy, any contraindication to MRI examination, fractures associated with neurological or vascular injuries and any other ankle fractures associated with the lateral malleolus fracture.

Each patient underwent a clinical examination and history taking (general and local assessment including inspection, palpation and neurovascular assessment of the affected lower limb) and full investigations.

Imaging using Plain X-rays (anteroposterior, lateral, mortise and stress views): According to the Weber, AO-Müller, and Lauge-Hansen fracture classification systems, the fractures on the radiographs were categorized. In addition to determining the type of fracture, probable ligamentous injury was determined using measures of the TFCS, TFO, MCS, and superior clear space (SCS). The posterolateral, anterolateral, or incisura fibularis of the tibia and the medial border of the fibula are the three points along which the TFCS is measured. The TFO, which was measured at a height of 1 cm above and on a line with the tibial plafond, is the horizontal distance between the medial and lateral borders of the anterior tubercle. A line drawn parallel to the superior talar joint surface and 0.5 cm below the talar dome was used to measure the MCS, which was the largest distance between the medial and lateral borders of the medial malleolus. The SCS was defined as the vertical distance between the talar dome and the tibial plafond. A TFCS greater than 6 mm, the lack of tibiofibular overlap (TFO < 0 mm), an aberrant MCS/SCS ratio greater than 1, or an MCS greater than 4 mm were all deemed abnormal.

MRI imaging according to the following pulse sequences: For the purpose of locating the following slices, a scout set of three T_1 weighted images (T1WI) were obtained. pictures that are axially weighted at T_1 and T_2, either with or without fat suppression. Gradient weighted pictures, T_1, T_2, and TIR in sagittal plane. pictures with coronal T_1 and T_2 weighting. The 256 x 256 matrix size, 2 to 4 mm slice thickness, and a 0.2 to 0.5 mm inter-slice gap were used for the MRI examination. The field of view (FOV) ranged from 8 to 16 cm. To identify ligamentous ankle injuries, the MRI was evaluated. The ligamentous structures were classified as 1 = normal ligament, 2 = partial injury, and 3 = total injury.

Statistical analysis: SPSS v26 was used to conduct the statistical analysis (IBM Inc., Armonk, NY, USA). To determine normality of the data distribution, Shapiro-Wilks test and histograms were employed. The mean and standard deviation were employed to depict quantitative parametric data. Interquartile range (IQR) and median were employed to depict non-parametric quantitative data. Using a non-parametric test called Spearman correlation, one may determine how strongly two variables are related. Frequency and percentages were employed to depict the qualitative factors.

Results

Demographic data, patient classification and radiographic measurements on Antero-Posterior (AP) and stress view were presented in Table 1.

Table 1: Patients characteristics, classification, and radiographic measurements of studied patients

		n = 100
Age (years) (Mean ±SD)		33.04±9.75
Sex n (%)	Male	52 (52%)
	Female	48 (48%)
Side n (%)	Right	48 (48%)
	Left	52 (52%)
Tenderness on medial side n (%)	No	50 (50%)
	Yes	50 (50%)
AO classification	A	28 (28%)
	B	52 (52%)
	C	20 (20%)
Weber	A	28 (28%)
	B	52 (52%)
	C	20 (20%)
Mechanism of injury	twisting injury	100 (100%)
Lauge Hansen classification	PER3	4 (4%)

	PER4	2 (2%)
	SAD1	28 (28%)
	SER2	42 (42%)
	SER3	20 (20%)
	SER4	4 (4%)
Radiographic measurement Median (IQR)		
AP view	MCS	3.4(2.98 - 4)
	SCS	3.5(3 - 4.03)
	TFO	4.85(3.2 - 6.63)
	TFCS	4.55(4 - 5.53)
Stress view	MCS	4.4(3.9 - 4.7)
	SCS	3.5(3 - 4.13)
	TFO	5.6(4 - 7)
	TFCS	4.4(3.58 - 6.05)

Data are displayed in Mean±SD, frequency (percentage) and median (IRQ). IQR: Inter quartile range. PER: pronation external rotation, SAD: supination adduction, SER: supination external rotation, MCS: medial clear space, SCS: superior clear space, TFO: tibiofibular overlap, TFCS: tibiofibular clear space.

The deltoid ligament injury was classified into 3 categories: PTTL, ATTL and TCL. The syndesmotic ligaments injury was categorized into: AITFL, PITFL and IOL. The lateral collateral ligaments injury was categorized into: ATAF, CF and PTAF and other findings as presented in Table 2

Table 2: Distribution of the studied cases according to deltoid, syndesmotic, lateral collateral ligament injury and other findings (n = 100)

	No. (%)
Deltoid ligament injury	
PTTL	
Normal	58 (58.0%)
Partial injury	36 (36.0%)
Complete injury	6 (6.0%)
ATTL	
Normal	82 (82.0%)
Partial injury	18 (18.0%)
Complete injury	0 (0.0%)
TCL	
Normal	88 (88.0%)
Partial injury	12 (12.0%)
Complete injury	0 (0.0%)
Syndesmotic ligaments injury	
AITFL	
Normal	16 (16%)
Partial injury	28 (28%)
Complete injury	56 (%))
PITFL	
Normal	47 (47%)
Partial injury	24 (%))
Complete injury	2 (%))
IOL	
Normal	72 (72%)
Partial injury	22 (22%)
Complete injury	6 (6%)
Lateral collateral ligament	
ATAF	
Normal	60 (60%)
Partial injury	40 (40%)
Complete injury	0 (0%)
CF	
Normal	60 (60%)
Partial injury	36 (36%)
Complete injury	4 (4%)
PTAF	
Normal	80 (80%)
Partial injury	18 (18%)
Complete injury	2 (2%)
Other finding	
Non	78 (78%)
Posterior malleolus avulsion	10 (10%)
Non-displaced medial malleolus, posterior malleolus avulsion, OCD, Volkmann fracture	1 (1%)

OCD	11 (11%)

Data are shown as frequency (percentage). PTTL: posterior tibiotalar ligament, ATTL: anterior tibiotalar ligament, TCL: tibiocalcaneal ligament, AITFL: anterior inferior tibiofibular ligament, PITFL: posterior inferior tibiofibular ligament, IOL: interosseous ligament, ATAF: anterior talofibular ligament, CF: calcaneofibular ligament, PTAF: posterior talofibular ligament, OCD: Osteochondral Defects.

There was a significant relationship between the tenderness on medial side and Weber classification, Lauga Hansen classification and deltoid ligament injury (PTTL, ATTL and TCL) (P value <0.001) and there were other findings in the studied patients as posterior malleolus avulsion which occurred in 10 (10%) patients, non-displaced medial malleolus, posterior malleolus avulsion, OCD, Volkmann fracture occurred in 1 (2%) patient and OCD occurred in 11 (11%) patients and did not occur in 78 (78%) patients. Table 3

Table 3: Relation between tenderness on medial side with Weber, Lauge Hansen classification and deltoid ligament injury.

	Tenderness on medial side		**P**
	No (n= 50)	**Yes (n= 50)**	
	N (%)	**N (%)**	
Weber			
A	20 (40.0%)	8 (16.0%)	0.002*
B	26 (52.0%)	26 (52.0%)	
C	4 (8.0%)	16 (32.0%)	
Lauge Hansen classification			
PER3	0 (0.0%)	4 (8.0%)	<0.001*
PER4	0 (0.0%)	2 (4.0%)	
SAD1	20 (40.0%)	8 (16.0%)	
SER2	28 (56.0%)	14 (28.0%)	
SER3	2 (4.0%)	18 936.0%)	
SER4	0 (0.0%)	4 (8.0%)	
Deltoid ligament injury			
PTTL			
Normal	46 (92.0%)	12 (24.0%)	<0.001*
Partial injury	4 (8.0%)	32 (64.0%)	
Complete injury	0 (0.0%)	6 (12.0%)	
ATTL			
Normal	50 (100.0%)	32 (64.0%)	<0.001*
Partial injury	0 (0.0%)	18 (36.0%)	
Complete injury	0 (0.0%)	0 (0.0%)	
TCL			
Normal	50 (100.0%)	38 (76.0%)	<0.001*
Partial injury	0 (0.0%)	12 (24.0%)	
Complete injury	0 (0.0%)	0 (0.0%)	

Data are shown as frequency (percentage). AP: Antero-Posterior, PER: pronation external rotation, SAD: supination adduction, SER: supination external rotation, PTTL: posterior tibiotalar ligament, ATTL: anterior tibiotalar ligament, TCL: tibiocalcaneal ligament *: Statistically significant at p ≤ 0.05.

There was an insignificant relation between radiographic AP MCS and (PTTL and ATTL) (Figure 2, 3) and syndesmotic ligaments injury (AITFL, PITFL and IOL). AP.MCS was significantly greater in Partial than normal (P value=0.025). There was an insignificant relation between radiographic AP MCS and Lateral collateral ligament (ATAF, CF and PTAF). Table 4

Table 4: Relation between AP. MCS and deltoid, Syndesmotic and Lateral collateral ligament injuries

	AP.MCS	**P value**
Deltoid ligament injury	**Mean ±SD**	
PTTL		
Normal	3.36±0.7	0.088
Partial	3.66±0.89	
Complete	3.97±1.35	
ATTL		
Normal	3.46±0.78	0.213
Partial	3.73±1.01	
TCL		
Normal	3.44±0.77	0.025*
Partial	4.01±1.09	
Syndesmotic ligaments injury	**Mean ±SD**	
AITFL		
Normal	3.29±0.94	0.886
Partial	3.6±0.77	
Complete	3.52±0.83	
PITFL		

Normal	3.46±0.74	0.174
Partial	3.53±0.98	
Complete	4.8±1.41	
IOL		
Normal	3.43±0.78	0.362
Partial	3.61±0.96	
Complete	4.03±0.73	
Lateral collateral ligament	**Mean ±SD**	
ATAF		
Normal	3.48±0.79	0.638
Partial	3.56±0.88	
CF		
Normal	3.39±0.84	0.146
Partial	3.63±0.77	
Complete	4.08±1.03	
PTAF		
Normal	3.43±0.73	0.172
Partial	3.76±1.09	
Complete	4.15±1.63	

Data was presented in Mean ±SD. MCS: medial clear space, PTTL: posterior tibiotalar ligament, ATTL: anterior tibiotalar ligament, TCL: tibiocalcaneal ligament. AITFL: anterior inferior tibiofibular ligament, PITFL: posterior inferior tibiofibular ligament, IOL: interosseous ligament. ATAF: anterior talofibular ligament, CF: calcaneofibular ligament, PTAF: posterior talofibular ligament. *: statistically significant as P-value< 0.05.

There was an insignificant relation between radiographic S MCS and deltoid ligament injury (PTTL, ATTL, TCL), Syndesmotic ligaments injury (AITFL, PITFL, IOL) and Lateral collateral ligament (ATAF, CF, PTAF). Table 5

Table 5: Relation between S. MCS and deltoid, syndesmotic and lateral collateral ligament injuries (n=100)

	S.MCS	**P value**
Deltoid ligament injury	**Mean ±SD**	
PTTL		
Normal	4.19±0.61	0.053
Partial	4.46±0.5	
Complete	4.65±1.15	
ATTL		
Normal	4.28±0.59	0.187
Partial	4.49±0.74	
TCL		
Normal	4.29±0.59	0.223
Partial	4.53±0.83	
Syndesmotic ligaments injury	**Mean ±SD**	
AITFL		
Normal	4.11±0.54	0.336
Partial	4.35±0.69	
Complete	4.36±0.61	
PITFL		
Normal	4.26±0.59	0.306
Partial	4.48±0.74	
Complete	4.5±0.42	
IOL		
Normal	4.28±0.56	0.522
Partial	4.41±0.79	
Complete	4.5±0.8	
Lateral collateral ligament	**Mean ±SD**	
ATAF		
Normal	4.27±0.61	0.317
Partial	4.4±0.65	
CF		
Normal	4.3±0.65	0.604
Partial	4.32±0.59	
Complete	4.63±0.53	
PTAF		
Normal	4.31±0.56	0.356
Partial	4.3±0.86	
Complete	4.95±0.49	

Data was presented in Mean ±SD. MCS: medial clear space, PTTL: posterior tibiotalar ligament, ATTL: anterior tibiotalar ligament, TCL: tibiocalcaneal ligament. AITFL: anterior inferior tibiofibular ligament, PITFL: posterior inferior tibiofibular ligament, IOL: interosseous ligament. ATAF: anterior talofibular ligament, CF: calcaneofibular ligament, PTAF: posterior talofibular ligament. *: statistically significant as P-value< 0.05.

There was a significant relation between AP TFO and (AITFL and PITFL) (P value=0.005) and insignificantly relation between AP TFO and IOL. There was a significant relation between AP TFCS and (PITFL and IOL) and insignificantly relation between AP TFO and AITFL. There was a significant relation between STFO and Syndesmotic ligaments injury (AITFL, PITFL and IOL). There was a significant relation between STFCS and PITFL and insignificantly relation between STFCS and (AITFL and IOL). Table 6

Table 6: Relation between AP TFO, AP TFCS, STFO, S TFCS and syndesmotic ligaments injury in MRI (n= 100)

Syndesmotic ligaments injury	Mean ±SD	P value
AP TFO `		
AITFL		
Normal	5.61±1.57	0.005* P1= 0.801 P2= 0.149 P3= 0.006
Partial	6.13±3.1	
Complete	4.23±2.54	
PITFL		
Normal	5.38±2.42	0.019* P1=0.017 P2=0.901 P3=0.389
Partial	3.65±3.23	
Complete	6.2±0.14	
IOL		
Normal	4.43±1.74	0.281
Partial	4.63±1.88	
Complete	3.53±1.18	
AP TFCS		
AITFL		
Normal	4.83±0.99	0.185
Partial	4.7±1.74	
Complete	5.41±1.98	
PITFL		
Normal	4.85±1.73	0.041* P1=0.034* P2=0.825 P3=0.970
Partial	5.9±1.93	
Complete	5.6±0.14	
IOL		
Normal	4.93±1.76	0.02* P1=0.036* P2=0.565 P3= 0.065
Partial	6±1.94	
Complete	4.17±0.38	
STFO		
AITFL		
Normal	5.96±1.3	0.002* P1=0.419 P2=0.265 P3=0.001*
Partial	7.02±2.81	
Complete	4.78±2.87	
PITFL		
Normal	6.24±2.41	<0.001* P1= 0.000 P2= 0.932 P3= 0.179
Partial	3.5±3.12	
Complete	6.9±0.14	
IOL		
Normal	6.05±2.33	0.029* P1= 0.083 P2= 0.038* P3= 0.803
Partial	4.6±4.01	
Complete	3.8±1.38	
STFCS		
AITFL		
Normal	4.48±1.34	0.210
Partial	7.59±12.34	
Complete	5.11±2.16	
PITFL		
Normal	4.22±1.4	<0.001* P1<0.001* P2=0.988 P3=0.471
Partial	10.35±12.7	
Complete	4.9±0.14	
IOL		
Normal	5.62±7.83	0.798
Partial	6.35±2.67	
Complete	4.33±1.39	

Data are presented as mean ±SD. AITFL: anterior inferior tibiofibular ligament, PITFL: posterior inferior tibiofibular ligament, IOL: interosseous ligament, P1:P value between normal and partial, P2:P value between normal and complete, P3: P value between partial and complete, *: Statistically significant at p ≤ 0.05

There was a significant relationship between missed deltoid injuries with weber and Lauge. Hansen classification (P value=0.005). Table 7

Table 7: Relation between missed deltoid injuries with Weber classification and Lauge. Hansen. Classification

Missed deltoid injuries detected by MRI				P value
Weber classification	Normal	Partial injury	Complete injury	
	N (%)	**N (%)**	**N (%)**	
A	21 (37.5%)	7 (17.5%)	0 (0%)	**0.005***
B	32 (57.14%)	17 (42.5%)	3 (75%)	
C	3 (5.36%)	16 (40%)	1 (25%)	
Lauge. Hansen. Classification				
PER	3 (50%)	2 (33.33%)	1 (16.67%)	**0.026**
SAD1	21 (75%)	7 (25%)	0 (0%)	
SER	32 (48.48%)	31 (46.97%)	3 (4.55%)	

Data are presented as frequency (percentage). MRI: magnetic resonance image, PER: pronation external rotation, SAD: supination adduction, SER: supination external rotation. *: Statistically significant at $p \leq 0.05$.

Discussion

The main finding in our study showed that according to the AO classification, 28 (28%) patients had type A, 52 (52%) patients had type B, and 20 (20%) patients had type C. Regarding the Weber classification, the present study showed that 28 (28%) patients had type A, 52 (52%) patients had type B and 20 (20%) patients had type C (Table 1). Weber B was the most common type associated with missed deltoid ligament injuries in initial X-ray evaluation (Table 7).

In consistent with this study, Rasmus *et al.* [9] revealed that fracture distribution depending on OTA classification is described as 24.1% of Type A, 65.8% of Type B and 10.1% of Type C. Ntalos *et al* [10]. found that according to weber classification the majority of patients were type B, as their study comprised 73 % weber type B and 27% weber type C fractures, but they excluded Weber type A.

Within the range with this study, Jensen *et al.* [11] found that 24 Weber type A, 139 were type B, and 29 were type C. This technique was unable to radiographically classify 20 fractures because they only impacted the medial malleolus. However, most of their cases are caused by sport injuries and motor vehicle accidents unlike simple twisting injuries during walking or running which is the main mode of trauma in our study.

In this study, depending on Lauge Hansen classification, pronation external rotation (PER3) occurred in 4 (4%) patients, PER4 occurred in 2 (2%) patients, SAD1 occurred in 28 (28%) patients, SER2 occurred in 42 (42%) patients, SER3 occurred in 20 (20%) patients and SER3 occurred in 4 (4%) patients (Table 1), SER type was the most common type associated with missed deltoid ligament injuries (Table 7).

In Hermans *et al.* [12] depending on Lauge-Hansen classification, 28 (54.8%) fractures were categorized as supination external rotation (SE), 4 (7.8%) as PER, 11 (21.6%) as supination adduction (SA), 3 (5.9%) as pronation abduction (PA), and 1 (2.0%) as pronation dorsiflexion (PD).

This study shows that there is an insignificant relationship between the age and both Weber classification and Lauge-Hansen classification, different results were displayed by Jensen *et al.* [11], who reported significant associations between the age of the patient and the Lauge-Hansen staging, as 30% of fractures in the age group below 50 were pronation fractures but only 10% in older patient. The difference from the current study may be because they included a larger number of cases and there was no age limit as they included all the patients presented to their hospital over 1-year period.

In the current study, regarding the radiographic measurement on Antero-Posterior (AP), the mean values of the AP MCS were 3.6±1.5 mm, the AP SCS was 3.54±0.84 mm, the AP TFO was 4.98±2.71mm and the AP TFCS was 5.12±1.81mm. Regarding the radiographic measurements on stress views, the mean values of the S MCS was 4.82±2.02, the S SCS was 3.58±0.83, the S TFO was 5.59±2.82 and the S TFCS was 5.71±6.77 (Table 1).

Similar results were detected by Schoennagel *et al* [7], found that the mean TFCS was 5.8±1.1 mm in patient with syndesmotic injury, 4.5±1.1 mm in patient without syndesmotic injury, TFO was 4.4±2.1 mm in patients with syndesmotic injury and 4.7±2.3 mm in patients without syndesmotic injury and MCS was 3±0.7 mm in patients with syndesmotic injury and 2.6±0.7 mm in patients without syndesmotic injury.

In the current study, the deltoid ligament injury was categorized as usually classified in the literature into: PTTL, ATTL and TCL. The most injured deltoid ligament was PTTL (42%) with 36 (36 %) patients who had partial injury, while 6 (6%) patients had complete injury (Table 2). According to Weber classification 8 cases had missed partial deltoid ligament injuries associated with Weber A and 15 cases with Weber B, Weber C was associated with 9 cases with missed partial deltoid ligament injuries and one case with missed complete deltoid injury. According to Lauge-Hansen classification two cases had missed partial deltoid injuries associated with PER type and one case had complete injury, there were eight cases with partial injuries associated with SAD type and 22 cases with SER type (Table 7).

The missed injuries of the deltoid ligament were statistically significant with both Weber and Lauge-Hansen classifications and most of the injuries were recorded with Weber B and SER types.

According to this research, Cheung *et al.* [13], retrospectively studied 19 patients with isolated lateral malleolus fracture to detect which ligament are interrupted using MRI, The posterior tibiotalar ligament of the deltoid group, which is important for stability, was frequently torn (18/19), with partial rips accounting for 83 % (15/18) of the cases.

In line with the current study, Hermans *et al.* [12] who discovered that the avulsion fracture occurred in 18 patients, but only in the tibia, the posterior malleolus fracture was not visible on the radiographs in 6/18 patients, despite including a significant posteromedial fragment in 3 cases. (Table 2). Only in conjunction with anterior syndesmosis injury did the posterior syndesmosis suffer damage. The IOL was injured in 7 patients. In 33 patients with normal measurements on radiographs, MRI showed that anterior syndesmotic injury was present in nine cases, and both anterior and posterior syndesmotic injury in 11 patients. The different proportions may be due to the different sample size.

In accordance with the present results, Cheung *et al.* [13] reported that ATFL was the most commonly injuried ligament (9 out of 19 cases, with 6 partial and 3 complete injury), CF only one case and PTFL 6 cases with partial injury (Table 2).

The current study showed a significant relationship between the tenderness on medial side with deltoid ligament injury (PTTL, ATTL and TCL) (P value <0.001) (Table 3). In contrary, DeAngelis *et al.* [14] observed no statistical significance association of medial tenderness with deep deltoid ligament incompetence. The difference with the current study is probably because they included only SER (supination external rotation), Weber type B lateral ankle fracture with a normal clear space on standard plain radiographs.

In line with the current study, Chiang *et al.* [15] documented by arthroscopic quantitative analysis of medial clean space for deltoid damage of the ankle revealed that medial discomfort was related to DL injury and ankle instability.

In this study, there was an insignificant correlation between MCS and deltoid ligament injury (PTTL, ATTL, TCL), syndesmotic ligaments injury (AITFL, PITFL, IOL), and lateral collateral ligament (Table 4) (Table 5).

Harmonious to the current study, Schottel *et al.* [16] demonstrated that non-stress and stress MCS measurements alone were insufficient to diagnose a deep deltoid tear and advocated for additional diagnostic testing in individuals with MCS measurements between 4 and 5.5 mm on stress radiography. This point of view was supported in the present study as stress views were unable to detect all associated injuries.

Warner *et al.* [17] determined using intra-operative direct observation as the gold standard, the accuracy of MCS measurements on stress and damage radiographs, as well as MRI analysis, to identify a deltoid rupture. According to the findings, MCS readings on injury radiographs are most reliable when they are greater than 5 mm. However, MRI is a more effective diagnostic tool than manual stress examination when the MCS values are less than 5 mm.

Koval *et al.* 2007 [18], employed MRI to assess ankle stability and the requirement for surgery after a positive manual stress test for isolated lateral malleolus fractures. There were no statistically significant connections between the medial clear space measurements and MRI verification of total deltoid ligament rupture.

Bäcker *et al.* [19], determined deltoid ligament integrity on MRI and compared it to the results of weightbearing and gravity stress tests, concluding that neither of these radiographic procedures correlate with the integrity of the deltoid ligament or the syndesmosis as shown on MRI.

The current study demonstrated a significant negative association between AITFL, PITFL, and IOL with (AP TFO and S TFO) but there was a significant positive association between PITFL with (AP TFCS and S TFCS) and between IOL with S TFCS (Table 6). Different results were presented by Nielson *et al.* [62], who came to the conclusion that, with the exception of the tibiofibular overlap measurement on the mortise view with the interosseous membrane, radiographic measurements for syndesmosis injury did not correspond to MRI findings. The difference with the current study may be attributed to the fact that they included all closed ankle fractures not restricted to radiologically isolated lateral malleolus fractures and they only included ankle fractures which indicated for surgery.

In Hermans *et al.* [12], their result was that TFCS and TFO did not correlate with syndesmotic injury.

Similar to the current study, a systematic review for acute ankle diastasis imaging modalities was done by Nico et. al 2022 [20] who found that although MRI does not expose patients to radiation and has a good sensitivity and specificity for detecting acute diastasis injuries, it does have some limitations, including a longer waiting period, contraindications for some patients, such as those who have metallic implants, and a high price tag.

Due to the fact that it was a single centre study with a limited sample size, the study had some limitations. Due to convenience, expense, and the lack of direct surgical or arthroscopic validation of MRI interpretations, MRI is only partially viable.

Male patient 21 years old presented to the ER with acute twisting injury to the left ankle. By examination there were oedema and tenderness on lateral malleolus, medial side tenderness and oedema, limited ROM due to the pain and with no other obvious associated injuries. X-rays: (Figure 1) (AP, lateral and stress view) showed isolated lateral malleolus fracture. Radiographic measurements were taken on AP and stress views showing widened MCS 4.8 mm, TFCS 10mm and TFO 0.9mm in AP view and MCS 5.0 mm, TFCS 5.6mm and TFO 5.4mm in stress view (Figure 2). MRI examination revealed the following: partial tear in TCL of superficial deltoid, partial tear in PTTL of deep deltoid, partial tear in talo-fibular ligament and all the syndesmotic ligaments are torn (AITFL – PITFL- IOL) (Figure 3). Classification: (PER4, Weber type c and AO type 44c)

Fig 1: Radiographs of the left ankle joint (a) AP view, (b) external rotation stress view and (c) lateral view showing isolated lateral malleolus fracture supra-syndesmotic Weber type c and PER4 by Lauge- Hansen classification

Fig 2: Showing radiographic measurements (a) AP view, MCS 4.8mm (line 2), TFCS 5mm (line 4), TFO 0.8 mm (line 5) and (b) stress view, MCS 5.0mm(line 2), TFCS 4.8mm (line 4), TFO 4.8mm (line 5).

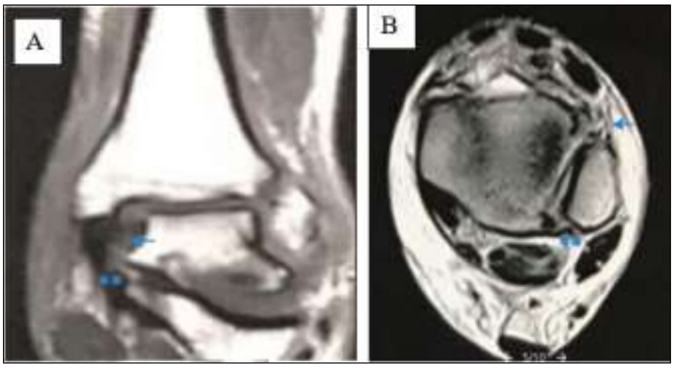

Fig 3: MRI of the left ankle showing partial injury in tibiocalcaneal ligament (asterisk**) and PTTL (arrow) (a) and complete injury in all the syndesmotic ligaments (AITFL (arrow) – PITFL (asterisk**) – IOL) (b).

Conclusions

MRI is valuable in the assessment of radiologically isolated lateral malleolus fracture cases. MCS in AP and stress views was insignificantly correlated to deltoid ligament injury, syndesmotic ligaments injury and lateral collateral ligaments injuries but there was a significant association between syndesmotic ligaments injuries and both TFO and TFCS in AP and stress views. So, the standard and stress plain radiographs are not reliable in predicting all ligamentous ankle injuries in the setting of ankle fractures.

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