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**Research Article**

# Ultrasound Accuracy in the Diagnosis of Anterior Talofibular Ligament Acute Injury: A Single-Center Study

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**Abstract**

***Background***: Ankle sprains are the most common injury in the ankle joint and rank as the second most frequent injury in sports. ***Objectives***: To compare ultrasonography sensitivity in identifying anterior talofibular ligament (ATFL) tears in patients who came within four days of injury vs. those who presented later. ***Methods***: A prospective study was conducted at Al-Kindy Teaching Hospital between October 2022 and April 2023, involving consecutive patients who presented to the orthopedic outpatient clinic unit with an inversion-type ankle injury. All patients underwent a clinical examination by an orthopedic surgeon; then a qualified radiologist performed an ultrasound assessment of the lateral ankle ligaments using a standard protocol and allocated them into two groups based on presentation time. MRI was used as the reference standard for comparison. We conducted an early examination for patients who presented within the first 4 days after the injury and a delayed examination for those who presented later. ***Results***: This study recruited 40 individuals with MRI-confirmed ATFL tears with a mean age of 32.3 years, and 62.5% of them presented within four days of the injury, whereas 15(37.5%) did so later. Ultrasound identified 35 ATFL tears at an overall sensitivity of 87.5%. Early ultrasound showed the tear in 21 with a sensitivity of 84%. In delayed presentation patients, ultrasonography detected the ATFL tear with a sensitivity of 93.3%. ***Conclusions***: Ultrasound is useful in early detection of ATFL tears; however, its efficiency improved even further after 4 days post-injury.

***Keywords***: Acute, ATFL tear, Delayed examination, Early examination, Sensitivity, Ultrasound.

**دقة الموجات فوق الصوتية في تشخيص الإصابة الحادة في الرباط المطفي الأمامي: دراسة أحادية المركز**

**الخلاصة**

**الخلفية**: التواء الكاحل هو أكثر الإصابات شيوعا في مفصل الكاحل ويصنف على أنه ثاني أكثر الإصابات شيوعا في الرياضة. **الأهداف**: مقارنة حساسية التصوير بالموجات فوق الصوتية في تحديد تمزق الرباط الأمامي (ATFL) لدى المرضى الذين جاءوا في غضون أربعة أيام من الإصابة مقابل أولئك الذين قدموا لاحقا. **الطرائق**: أجريت دراسة مستقبلية في مستشفى الكندي التعليمي بين أكتوبر 2022 وأبريل 2023، شملت مرضى متتاليين حضروا إلى وحدة العيادات الخارجية لتقويم العظام مصابين بإصابة في الكاحل من نوع الانعكاس. خضع جميع المرضى لفحص سريري من قبل جراح العظام. ثم أجرى أخصائي أشعة مؤهل تقييما بالموجات فوق الصوتية لأربطة الكاحل الجانبية باستخدام بروتوكول قياسي وخصصها إلى مجموعتين بناء على وقت العرض. تم استخدام التصوير بالرنين المغناطيسي كمعيار مرجعي للمقارنة. أجرينا فحصا مبكرا للمرضى الذين حضروا خلال الأيام الأربعة الأولى بعد الإصابة وفحصا متأخرا لأولئك الذين قدموا لاحقا. **النتائج**: شملت هذه الدراسة 40 فردا مصابين بتمزق ATFL المؤكد بالرنين المغناطيسي بمتوسط عمر 32.3 عاما، و 62.5٪ منهم ظهروا في غضون أربعة أيام من الإصابة، بينما قام 15 (37.5٪) بذلك في وقت لاحق. حددت الموجات فوق الصوتية 35 تمزقا ATFL بحساسية إجمالية تبلغ 87.5٪. أظهرت الموجات فوق الصوتية المبكرة التمزق في 21 بحساسية 84٪. في المرضى الذين تأخروا في العرض ، اكتشف التصوير بالموجات فوق الصوتية تمزق ATFL بحساسية 93.3٪. **الاستنتاجات**: الموجات فوق الصوتية مفيدة في الكشف المبكر عن تمزق ATFL ؛ ومع ذلك ، تحسنت كفاءتها بشكل أكبر بعد 4 أيام بعد الإصابة.

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## INTRODUCTION

Ankle sprains are the most common injury in the ankle joint and rank second in the world of sports. Ligamentous injuries on the lateral aspect of the ankle constitute roughly 85% of the total cases of ankle sprains. There is a greater prevalence of ankle sprains among females and children in comparison to men [1,2]. A violent inversion of the foot in a plantar flexed posture primarily causes lateral ankle sprains. The lateral ligament complex is composed of three discrete ligaments that provide stability to the lateral portion of the ankle: the anterior talofibular ligament (ATFL), the calcaneofibular ligament (CFL), and the posterior talofibular ligament (PTFL) [3,4]. Researchers propose ultrasound as a precise diagnostic tool for lateral ankle injuries that cause minimal patient discomfort. According to a recent meta-analysis, it is more effective in detecting chronic ATFL sprains than MRI. The sensitivity of the US in the diagnosis of acute injuries, however, varied [5, 6]. Van Dijk and colleagues indicated in their study that 160 acute ankle injuries involved ultrasound that could positively predict 85% of ATFL ruptures, while a negative

ultrasound investigation has a predictive value of 77% [7,8]. With a sensitivity of 71%, diagnosing an ATFL injury within 48 hours can sometimes be challenging [9]. While MRI can efficiently confirm the diagnosis [10], it is not readily available in many settings. Therefore, diagnosis through US examination can be a valuable alternative. The aim of this study was to compare how well ultrasound could find ATFL tears compared to MRI, which was used as a standard, in cases where there was clinical suspicion. Specifically, the study also aimed to compare the performance of ultrasound when patients presented within the first four days of the injury to its performance when patients presented at a later stage.

## METHODS

### *Study design and setting*

This is a prospective study conducted at Al Kindy Teaching Hospital between October 2022 and April 2023 on consecutive patients presenting to the orthopedic outpatient clinic with an inversion-type ankle injury after providing informed written consent. All patients underwent a clinical examination by a specialized orthopedic surgeon, including a drawer sign test (an anterior subluxation that is caused by a strain on the ankle joint in the coronal plane while the foot is in 10–20-degree plantar flexion and the knee is in 90-degree flexion; the patient is either in a supine or seated position) [11], to assess their condition. X-rays were performed to rule out any fractures. Subsequently, the patients were scheduled for both MRI and ultrasound examinations on the same day. To ensure an unbiased assessment, two different radiologists who were not aware of the patient's diagnoses performed the imaging evaluations. Patients who did not undergo all the required tests and those with partial tears on MRI were excluded from the study.

### *Intervention and outcome measurements*

The primary outcome measured was determining the overall sensitivity of US in detecting ATFL tears, comparing sensitivity in patients presented within the first four days of the injury to its performance when patients presented at a later stage. The secondary outcome was to investigate whether age and gender are associated with ultrasound outcomes. Based on the timing of the examination, we divided the patients into two groups. Early examination, for those presented within the first 4 days after the injury, and delayed examination, including those who presented later [6]. MRI was used as a standard for diagnosing lateral ankle ligament injuries. 1.5 Tesla Optima tm MR 450w GEM - 70 cm performed the MRI. The ATFL was evaluated in axial, sagittal, and coronal planes using fat-suppressed and non-fat-suppressed sequences according to the sequence specific to our institution. The T2 axial sequence had the following settings: an echo train (ET) of 15, a section thickness of 3 mm, an interslice gap of 10%, a matrix size of 356 x 286, a field of view (FOV) of 18 x 18, and a scan time of 3.25 minutes. An echo time (ET) of 12 seconds, a section thickness of 3 mm, an interslice gap of 10%, a matrix size of 284 × 224, a field of view (FOV) of 18 x 18, and a scan length of 3.04 minutes were the settings for the axial proton density (PD) sequence. We used an echo time (ET) of 12 milliseconds, a section thickness of 3 millimeters, an interslice gap of 10% of the section thickness, a matrix size of 284 × 224, a field of view (FOV) of 18 x 18 centimeters, and a scan duration of 3.40 minutes for the axial proton density fat saturation (PDFS) sequence. The axial short tau inversion recovery (STIR) sequence was used. The echo time (ET) was 10 ms, the section thickness was 3 mm, the interslice gap was 10%, the matrix size was 288 x 256, the field of view (FOV) was 18 × 18, and the scan length was 4.10 minutes. MRI data was transported to dedicated workstations for further analysis. A professional musculoskeletal radiologist assessed all MR images. Radiologists interpreted MRI sequences objectively without knowing the patients' clinical data. They focused on Ligament Disruption Sign (LDS). Torn or missing ligaments were LDS [12]. Axial T2-weighted and PD-weighted sequences revealed the presence of a high signal intensity, either in the form of dot-like or curvilinear patterns, located above the attachment of the ATFL to either the fibula or talus, or both. Some called this appearance a bright rim sign (BRS). The persistence of the bright signal intensity on STIR and PDFS sequences with a lack of cortical disruption allowed BRS to be distinguished from potential bone marrow edema [13] (Figure 1).

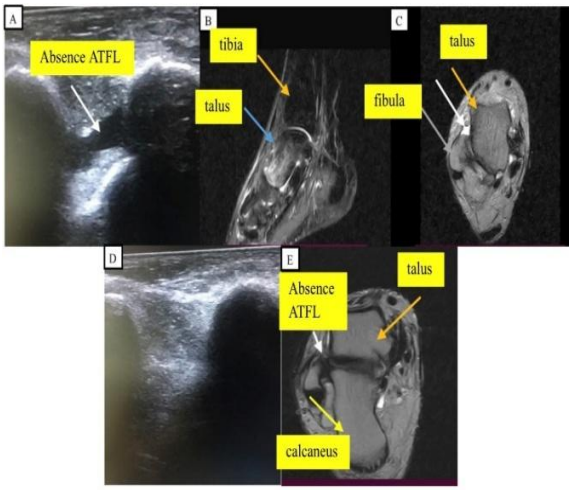


**Figure 1**: ATFL tear imaging. (**A-C**) A 25-year-old male presented 12 days after the initial ankle injury; **A**) grayscale ultrasound shows absent ATFL with fluid collection at its site . **B**) MRI sagittal STIR image shows bone marrow edema involving the talar head **C**) Axial T2WI show absent ATFL with small fluid collection. (**D** and **E**) A 40-year-old women presented 10 hours after ankle trauma; **D**) Ultrasound image shows no obvious ATFL tear (False negative). **E**) Axial T2 MRI image shows absent ATFL.

### *Ultrasound examination*

The GE LOGIC S8 machine was used to conduct hand-held ultrasound using an 8-18 MHz linear array transducer known as the GE L8-18i. The patient's ankle was positioned in a moderately inverted and plantar-flexed posture to ensure comfort (Figure 2).

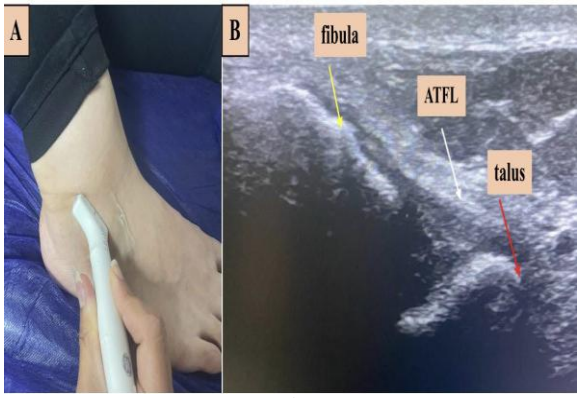


**Figure 2**: **A**) shows the position of the probe during the examination of the ATFL in cases of suspected tear, that is positioned in the transverse plane (parallel to the axis of the ligament ), ventral to the lateral malleolus. **B**) ultrasound appearance of normal (intact) ATFL (white arrow).

This positioning allows for a slight stretching of the ATFL, facilitating clear visualization. In normal cases, the ligaments appear as bright and hyperechoic bundles on the ultrasound images. However, when ligaments are ruptured, the torn ends create a gap in the bundles, indicating discontinuity. Even if the torn ends are not visibly separated, the abnormality of the ligament can still be observed as a hypoechoic area on the ultrasound images.

### *Ethical considerations*

The study protocol was approved by the ethical committee of Al Kindy Teaching Hospital, Baghdad, Iraq (EAC-23012).

### Statistical analysis

Statistical analysis was conducted using the Statistical Package for Social Sciences software for Windows version 25 (IBM Corp., Armonk, N.Y., USA). Sample normality was tested using a Shapiro-Wilk test and visual inspection of their histograms, which showed that all tested variables were not normally distributed. Observational data were represented as frequencies and percentages. The continuous variables were represented by their mean and standard deviation (SD). The Mann-Whitney test was used to compare continuous variables, and Chi-square was used to compare categorical variables. Statistical significance has been defined as a $p$-value < 0.05. The sensitivity measure was computed by dividing the number of true positive outcomes by the total of true positive and false negative results.

## RESULTS

A total of 40 patients with MRI-confirmed ATFL tears were included with a mean age of 32.3±12.5 years. Among them, 22 patients (55%) were females. All patients had a history of an ankle injury that occurred 10 hours to 21 days prior to the clinical examination. Twenty-five patients (62.5%) presented early, within the first four days of the injury, while 15 (37.5%) patients consulted medical advice after that. Weight intolerance, however, was reported by only 5 (12.5%) (Table 1).

**Table 1**: Study cohort characteristics

| Patient Characteristic | Value |
|---|---|
| Age (years) mean±SD | 32.3±12.5 |
| Gender n (%) | |
| Female | 22(55) |
| Male | 18(45) |
| Time of injury(day) mean±SD | 4.85±4.4 |
| Weight intolerance n(%) | 5(12.5) |
| Anterior drawer sign n(%) | |
| Negative | 5(12.5) |
| Positive | 31(77.5) |

The anterior drawer test was positive in 31 patients; 18/31 (58.1%) had the injury recently, within four days of the examination, and 13/31 (41.1%) had delayed examination (Table 2). Ultrasound efficiently detected 35 out of the 40 ATFL tears with an overall sensitivity of 87.5%.

**Table 2**: The sensitivity of the anterior drawer test and US in detecting ATFL tear in early and delayed presentation

| Examination methods | Total | Time of diagnosis (day) | | *p*-value |
|---|---|---|---|---|
| US findings | | First 4 days | After 4 days | |
| Negative | 5(12.5) | 4(16) | 1(6.7) | 0. 633 |
| Positive | 35(87.5) | 21(84) | 14(93.3) | |

Values are expressed as frequency and percentage. US: ultrasound.

Out of the 25 cases that were presented early within the first four days of injury, ultrasound depicted the tears in 21 with a sensitivity of 84%. It missed the diagnosis in only four cases, resulting in 16% false negatives. For patients with delayed presentation, ultrasound successfully identified the ATFL tear in 14 out of 15 cases with a sensitivity of 93.3%. However, it did have one false negative in this group (Table 2 and Figure 3). In addition to ATFL tears, associated calcaneofibular ligament (CFL) tears were identified in 7 (17.5%) cases; among these 7 cases, three patients (7.5%) had additional PTFL tears. There was a significant association between younger patient age, with a mean age of 21 (±9.3) years, and negative ultrasound findings ($p$=0.016) (Figure 3). Female gender 22 (100%) were significantly associated with positive US tests compared to 13 (72.2%) of men ($p$=0.013).

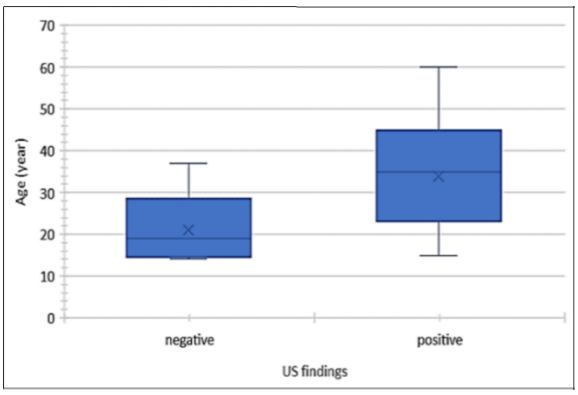


**Figure 3**: The association between ultrasound findings and patients' age.

## DISCUSSION

The significant advancement in the musculoskeletal imaging modalities that occurred in recent years had a profound impact on the diagnosis and management of different conditions affecting bones, ligaments, tendons, and joint diseases across all ages [14,15]. The ATFL most frequently compromises primary ankle stabilization and the ligament during ankle inversion. The importance of evaluating the ATFL's integrity following an acute injury has been repeatedly demonstrated in numerous studies over the past three decades [16]. Patients suspected of having an ATFL injury are frequently evaluated using the anterior drawer test, which is a common clinical examination procedure [16]. Due to its dynamic nature, affordability, and simplicity, this examination is regarded as a crucial criterion for determining the most suitable treatment strategy for each patient [17]. However, subjectivity, lack of repeatability, and difficulty, particularly for less-experienced physicians, are limitations of this method [18-20]. Ultrasound has been suggested as a convenient substitute for MRI in diagnosing lateral ankle injuries [21]. Previous research on ultrasound accuracy in detecting ATFL injuries has predominantly focused on chronic lesions and their relevance for surgical decisions [22-25]. However, in acute cases, the sensitivity of ultrasound varied between 82% and 100% [5,6]. This variability could be attributed to differences in the frequency of the transducer used and operator experience, but the timing between the injury and the ultrasound examination might also play a crucial role. This study is the first to compare the sensitivity of ultrasound in early presentations versus delayed ones. In the current study, the sensitivity of US in patients examined early was 84%. The sensitivity of the US increased to 93.3% in patients who sought help more than 4 days after the injury, with only one false negative case. Early diagnosis can assure the patients and speed up the management plan. Although delayed physical examination is typically associated with accurate diagnosis [8], the US can confirm the diagnosis and exclude associated syndesmosis instability [5]. Campbell *et al*. and Szczepaniak *et al*. evaluated the ATFL tears within the first week of the injury and reported a sensitivity of 82% [26] and 100% [27], respectively, relative to surgical findings as a standard. However, the retrospective study by Szczepaniak *et al*. involved children rather than adults [27]. In our study, younger patients were significantly associated with false negative diagnoses. This is probably because all these patients were presented early, and intolerable pain may impede proper examination. Gün and colleges evaluated US validity relative to MRI as a standard. The sensitivity of the US to detect acute ATFL rupture was 93.8%; however, the time between the injury and examination was not determined [28]. More recent research has indicated that US sensitivity compared to MRI reaches up to 95.4% in the first 48 hours of the injury while the specificity was 75% [29].

### Study limitations

This research includes some limitations, including small sample size and the fact that it is a single-center study. Therefore, we recommend conducting future research that encompasses a larger sample size and involves many centers.

### Conclusion

Ultrasound is useful for early detection of ATFL tears; however, its efficiency improved even further after 4 days post-injury. In cases where ultrasound results are negative, further evaluation through MRI is necessary.

### Conflict of interests

No conflict of interest was declared by the authors.

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The authors did not receive any source of funds.

### Data sharing statement

Supplementary data can be shared with the corresponding author upon reasonable request.

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