The Value of Ultrasound in Acute Ankle Injury: Comparison With MR

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Abstract

Objective: To assess the value of the ultrasound (US) in different grades of acute trauma by comparing with MR.

Methods: We analyzed 30 patients, of average age 33, with acute ankle trauma, without fracture on standard radiograms. One week after injury all patients were sent for US. We used linear probe 8–15 MHz. Ten days later, the patients were examined on MR.

Results: Anterior talofibular ligament was normal in 20.6% by US and in 20.3% by MR. Ligament lesion were found by ultrasound in 40%, proven in only 20.6% by MR. Ultrasound diagnosed 33,3% ruptured ligament, MR found 50% rupture of anterior talofibular ligament. In 80.3% cases the calcaneofibular ligament appeared to be intact with both methods. Ultrasound found stretch ligament in 10.6% cases and MR proved that in 10% cases. In other 6.6% cases, MR found complete rupture. Intraarticular effusion was found in 80.3% patients by US and in 86.6% by MR. Lesion of tendon of long peroneal muscle was found in 40.6% patients by both methods. Lesion of tendon of short peroneal muscle was found in 33.3% lesions and proved by MR in only 20.3% cases. In other patients findings were normal. US found 10% lesions of the tendon of anterior tibial muscle and MR found 10.3% lesions. US found 10.6% lesions of tendon of long halucis flexor and MR found 20%. Our results were statistically analyzed by cross-tabs, the Stuart-Maxwell test, Npar tests and the McNemar test.

Conclusion: US proved to be a good and reliable method for diagnosing Grade I and II of ankle sprain, but for proper evaluation of Grade III, MR is recommended.

Key Words

Lower limb injuries · Orthopedic trauma

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Introduction

Ankle joint injuries are common and are usually related to lateral ligament sprain. Approximately 85% of them are due to inversion forces and, therefore, involve the lateral collateral ligamentous complex. A Grade I sprain is a mild injury limited to microtears and stretching of the ligaments. Grade II sprains are partial macroscopic tears and in Grade III sprains the ligament has ruptured completely. There is general agreement that the overwhelming majority of Grade I and II sprains heal uneventfully with conservative care. Treatment of Grade III sprains is more controversial: some practitioners prefer operative repair, at least for high performance athletes and others prefer a regimen of casting and physical therapy [1], which is the case in our institution.

The proper role of imaging in diagnosis of ankle sprains includes first of all conventional radiographs to ensure a fracture is not overlooked. Ultrasound is now routinely used to evaluate disorders of the musculoskeletal system, and because of their size and superficial location the ankle tendons can be well evaluated [2]. Some studies described visualization of lateral ankle ligaments and tibiofibular syndesmosis [3].

Magnetic resonance imaging can be useful in the setting of either acute or chronic ligamentous injury. The anterior talofibular ligament can be identified by MR imaging in virtually 100% of patients in whom it is present. The calcaneofibular ligament can be seen in approximately 80% of people using the coronal plane of imaging [4]. The anterior and posterior tibial tendon, peroneal tendons, flexor hallucis longus tendon and Achilles tendon can be easily examined by MR as well as stress fracture and bone bruises [5].

In this study we tested the ability of 7–15 MHz high-frequency ultrasound to distinguish between intact and ruptured ankle ligaments and to diagnose lesions of ankle tendons. This was achieved by comparing the findings of ultrasonography with MR findings.

Patients and Methods

High-frequency (7–15 MHz) ultrasound and MRI were performed in 30 patients with acute ankle injury. All ultrasound examinations were always done by only one radiologist We analyzed 17 male and 13 female patients, with the average age of 33 years (16–66) without visible bone fracture on standard radiograms at initial examination. A week after, we performed ultrasound investigation on a SHIMADZU 2200 using a 7–15 MHz linear probe. A stand-off pad was not necessary because the variable focus-depth was easily adapted to the thickness of the soft tissue overlying the bone.

During the sonographic examination of anterior ankle the patients were in supine position with the knee in flexion and the plantar surface of the foot in full contact with the examination table. For better evaluation of ligaments and tendons we changed the degree of plantar flexion using dynamic ultrasound. The anterior tibial tendon (ATT), extensor hallucis longus tendon (EHL), extensor digitorum longus tendon (EDL) were scanned initially in the sagittal plane from medial to lateral, from the musculotendinous junction down to their insertion site and then in the transverse plane. The anterior recess was also assessed for fluid or loose bodies. The transducer was rotated 90° for examination of the tendons in the transverse orientation. The anterior tibiofibular ligament was studied in the transverse plane.

For the examination of the peroneal tendon, the anterior tibiofibular ligament, anterior talofibular ligament and calcaneofibular ligament, the patient was in the supine position and the plantar foot surface in full contact with the examination table and slightly inverted.

For the examination of the posterior tibial tendon (PTT), flexor digitorum longus tendon (FDL), flexor hallucis longus tendon (FHL) and deltoid ligament (anterior and posterior tibiotalar ligament, tibiocalcanear and tibionavicular ligament) the patient was in the supine position with the plantar surface of the foot on the examination table or in a frog-leg position.

A rupture of the ligaments was diagnosed sonographically if a dehiscence of the ligamentous ends or interruption of the parallel fibers in combination with a hypoechogenic zone (edema, hematoma) could be visualized. If some straight, parallel fibers could still be seen, a diagnosis of incomplete rupture was made. If the ligament was edematous and hypoechoic, surrounded by effusion but without visible break of continuity, then this was qualified as ligament stretching.

A full thickness tendon tear was diagnosed by a gap in the tendon. This might be filled with hematoma in the acute setting or with scar/granulation tissue in long-standing cases. If only thickening of tendon and changes in the echostructure (hypoechoic zone) with or without surrounding effusion were visible, it was diagnosed as a lesion.

MR imaging was performed 10 days after ultrasound examination with a 1.5 T unit (SIEMENS). The MR protocol included T1WI, T2WI, PDWI, FS PD FSE, STIR without contrast in standard axial sagittal and coronal planes. A fixed extremity coil was employed.

Results were analyzed by cross-tabs, Stuart-Maxwell test, Npar tests and the McNemar test.

Our institutional ethics committee approved this study, and a written informed consent was obtained from all patients.

Results

In our study, MR findings of injured ligaments included changes from hypointense to intermediate signal intensity in T1WI and to hyperintense signal intensity on T2WI; interruption of a segment or entire ligament on T1WI, extension of hyperintense fluid in the soft tissue on T2WI and hyperintense soft tissue edema on T2WI. We defined ligament injury as acute (edema around or in the ligament) or chronic (disruption or thickening of the ligament without edema).

Bone bruises had an ill-defined increased marrow signal intensity on T2WI images.

The visualization of the anterior talofibular ligament is explained in both table 1 and figure 1. In five cases we found a complete tear only after dynamic US examination.

Table 1. Comparison of US and MR findings.

	US (%)	MR (%)	p Value
Anterior talofibular ligament			
Normal findings	20.6 (8/30)	20.3 (7/30)	< 0.05
Lesion	40 (12/30)	20.6 (8/30)	
Rupture	33.3 (10/30)	50 (15/30)	
Calcaneofibular ligament			
Normal findings	80.3 (25/30)	80.3 (25/30)	> 0.05
Lesion	10.6 (5/30)	10 (3/30)	
Rupture	0	6.6. (2/30)	
M. peroneus brevis			
Normal findings	66.6 (20/30)	70.6 (23/30)	> 0.05
Lesion	33.3 (10/30)	20.3 (7/30)	
M. tibialis anterior			
Normal findings	90 (27/30)	86.6 (26/30)	> 0.05
Lesion	10 (3/30)	10.3 (4/30)	
M. flexor hallucis longus			
Normal findings	80.3 (25/30)	80 (24/30)	> 0.05
Lesion	10.6 (5/30)	20.3 (6/30)	

Figure 1. Rupture of anterior talofibular ligament, US and MR, GRE.

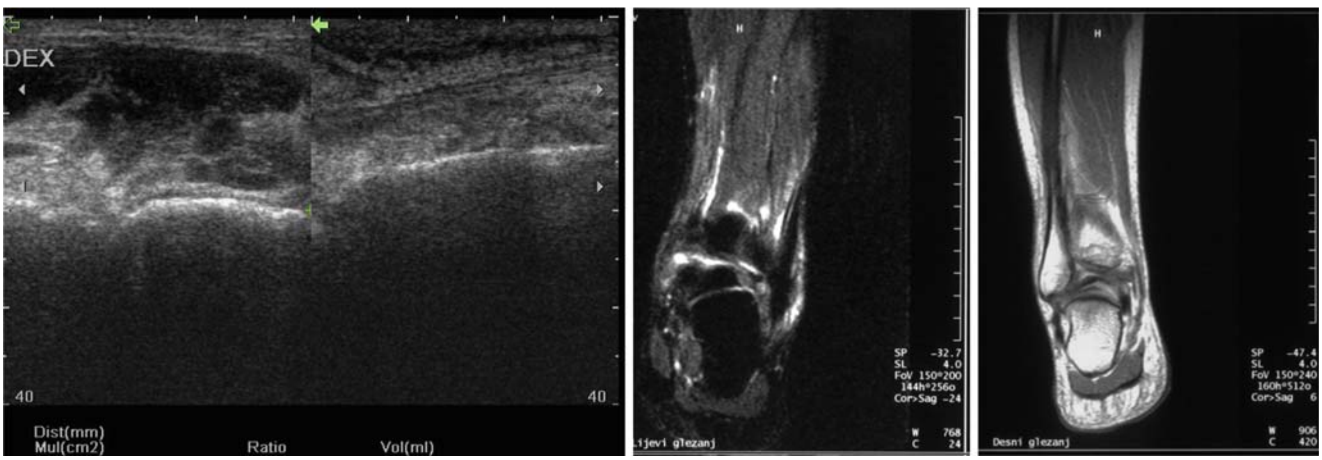


Figure 2. Lesion of calcaneofibular ligament, US – comparison with contralateral side, MR – STIR and T1.

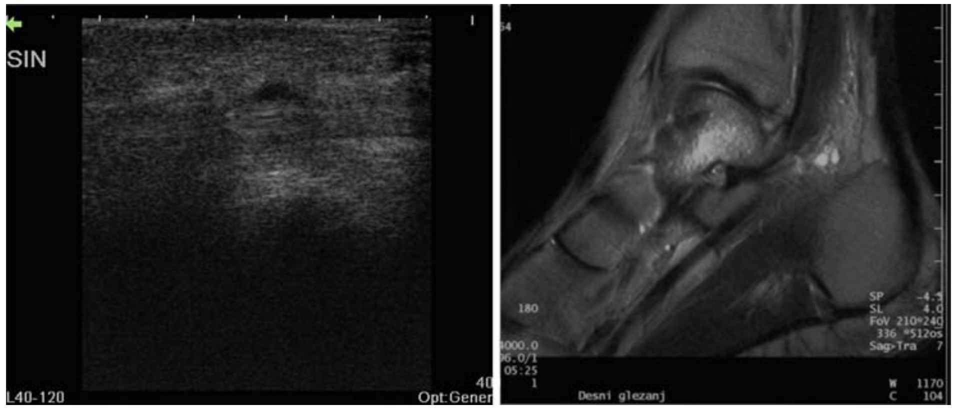
The calcaneofibular ligament is shown in table 1 and figure 2.

The long peroneal muscle tendon appeared normal in 16 cases (50.3%) by both methods. In 14 patients (40.6%) effusion in the surrounding tissue was found by ultrasound and was confirmed by MR (Figure 3).

Results of imaging of the short peroneal muscle tendon are presented in table 1 and figure 4, of the

Figure 3. Lesion of long peroneal muscle tendon, MR – T2, STIR, GRE.

Figure 4. Lesion of short peroneal muscle tendon, US, MR, T2.



anterior tibial muscle tendon in table 1 and figure 5 and of the flexor hallucis longus in table 1 and figure 6.

In all 30 patients, initial radiograms were normal without any fracture. In case no. 2, a high signal intensity was found by MRI in T2WI and STIR sequences, which indicated bone bruises. Intrarticular effusions were found in 25 cases (80.3%) by ultrasound and in 26 patients (86.6%) by MR imaging (Figure 7).

Posterior fibulotalar ligament is also very important for ankle stability. However, it is rather difficult to be visualized on MR in standard positions using standard sequence. We found two lesions and two rupture of posterior fibulotalar ligament on MR. In other 28

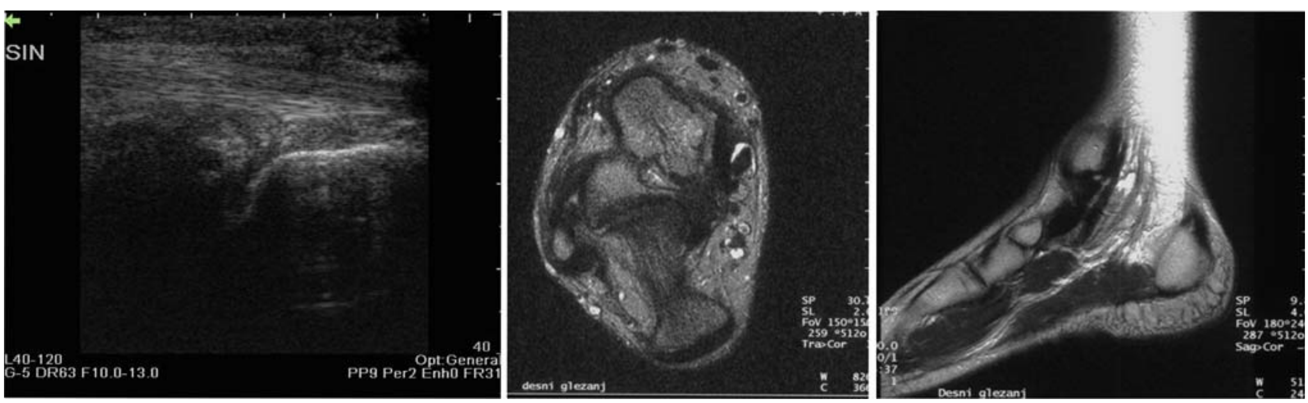


Figure 5. Lesion of anterior tibial muscle tendon, US, MR – STIR, T2.

Figure 6. Lesion of flexor hallucis longus muscle.

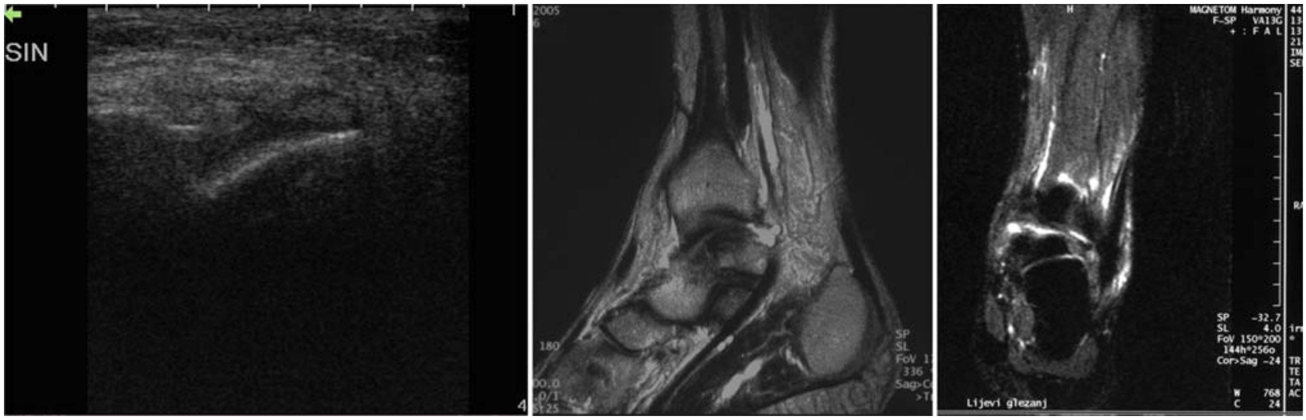


Figure 7. Intraarticular effusion, US, MR – STIR.

cases we could not confirm normal findings. Posterior fibulotalar ligament seemed normal on ultrasound in all cases.

In one case we found ganglion cyst in posterior recessus of talocrural joint by both methods. One patient had effusion in talonavicular joint, proved by ultrasound and MR.

In all our patients, syndesmotic ligament was intact by both methods.

Using cross-tabs and the Stuart-Maxwell test we found a statistically significant difference between US and MR findings only in imaging of the anterior talofibular ligament. In imaging of other structures we found no statistically significant difference.

We also used Npar tests and the McNemar test, which showed no statistically significant differences between these two imaging methods.

Discussion

Because of their size and superficial location, the ankle tendons and ligaments can be well evaluated with ultrasound [6]. We performed US in all cases of ankle sprain in order to evaluate the position of the ligament and to analyze the echostructure and shape of ligaments and tendons. Accurate assessment of the superficial structures of the ankle, such as tendons and ligaments, requires a good knowledge of the normal anatomy, pathological condition and the use of high-level equipment. Moreover, high-quality images of adequate size, with annotations are necessary to convey an accurate diagnosis to the clinician. Ultrasound shows normal ligaments as thin, regular, hyperechoic bands with well-defined sharp borders. Pathological ligaments appear hypoechoic and thickened. Depending on the severity of the ligament damage, different ultrasound patterns can be recognized.

In the supine position, intact ligaments are more easily depicted as full-length, parallel-layered echogenic structure (longitudinal scans in the direction of each ligament), with the bony insertions as reference structures. In the case of a ruptured ligament, the site of lesion is seen more clearly in this position because the torn ends are separated from each other [7–9]. We examined our patients who were in the supine position with the plantar surface of the foot in full contact with the examination table where ligaments are slightly stretched, and easier for US examination. In that position, we can easily evaluate the size and shape of ligaments and tendons, their echogenicity as well as the surrounding soft tissue and the intra-articular space.

In benign sprains the ligament appears intact and straight, but presents a focal or diffuse hypoechogenicity. We defined this type of sprain as a lesion. Additionally, partial tears can be detected without loss of the normal rectilinear appearance during dynamic sonography [10, 11]. But we were not able to find any case of a partial rupture either by US or by MR imaging.

In more severe sprains, a complete tear of the ligament may be detected either at the central portion or at the osseous insertions. Dynamic ultrasound shows a lack of the normal tightening of the ligament during stress maneuvers. We always changed the position of the ankle (prone–supine and internal–external rotation) for better evaluation of the shape and size of the ligament. In five cases we found a complete tear of the anterior talofibular ligament only after dynamic US examination. In the neutral position the ligament seemed to be normal. An effusion usually surrounds the ligament and facilitates the detection of tears. We found effusion surrounding the ligament in all cases of ruptures. Because of the close relation of the ligament with the fibular tendons, an effusion is detected inside the tendon sheath in calcaneofibular ligament tears. In tears at the level of ligament insertion, a cortical avulsion may be demonstrated by ultrasound [12, 13]. We could not find tears of the calcaneofibular ligament by US examination. In five cases, even dynamic US showed only thickening and hypoechogenicity of the ligament with an effusion surrounding the sheath and without any exact tear or effusion inside the sheath. In two of them, MRI found a complete tear in the middle portion of the ligament.

Syndesmosis sprain usually occurred in combination with bone fracture, lateral fibular subluxation or luxation in talocrural joint. That is probably why we did not find any syndesmosis sprain in our patients [14–16].

Closed treatment is appropriate for most acute ankle injuries, so we could not confirm the sonographic findings surgically according to Ericsson [17]. We, therefore, had to rely on MRI as regards the status of the ligaments, tendons and talocrural joint as well. Only a few studies have surgically confirmed US or MR findings [18–20].

It should be remembered that an increase in fluid within the ligament itself is more easily identified by MR than by ultrasound. It is, therefore, quite likely that minor injuries with a posttraumatic increase in the fluid inside the ligament will alter the MR signal characteristics although the ligament may still appear normal on sonographic examination [21, 22]

That could be the reason for a statistically significant difference between US and MR findings in imaging of the anterior talofibular ligament.

In conclusion, ultrasound proved to be a valuable imaging method in diagnosing acute ankle trauma. Normal findings and stretched ligaments – lesions, were confirmed in 100% cases by MR. However, ultrasound was statistically less reliable in distinguishing between a complete and partial ligament rupture and in distinguishing between a rupture and ligament stretching. Some of lesions found by ultrasound proved to be a rupture on MR imaging. Therefore, ultrasound has a great value in routine diagnostics of acute trauma. For Grade III ankle sprains, MR can be a valuable method to distinguish lesions from ruptured ligaments.

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