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Comparison of Detection Capability of Ligaments in Ankle with Ultrasonography and MRI

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To test the utility of the ultrasound in evaluating collateral ligaments of the ankle, ultrasound images were compared with MR images. Eighteen patients who were taken ankle MR examination, were included in comparison ultrasound study. Ultrasonographic examination was performed on medial and lateral collateral ligaments, and detection rate(DR) and corresponding rate(CR) was calculated. On untrasound examination, DR for ATF was 100%, CR was 83.3%, for the CF, DR 100%, CR 100%, PTF;DR 72.2%, CR44.4%, ATN;DR 94.4%, CR 88.9%, TC;DR 100%, CR 100%, PTT;DR 94.4%, CR 44.4%. There show high DR and CR number in anterior ligamentous groups. Ultrasound examination is appropriate method for detecting collateral ligaments of the ankle, and may play a role as a primary screening tool for ligamentous injury in ankle. (Ajou Med J 1997; 2(2): 112～118)

Key Words: *Ankle, Ligaments, Ultrasonography, Ankle, Anatomy, Ankle, Injuries*

INTRODUCTION

Injuries to the collateral ligaments of the ankle are relatively common types of injury, which require early diagnosis and prompt treatment, for a better prognosis. Physical examination is the most important diagnostic tool, however, in case of acute injury or equivocal instability, imaging diagnostic aids may be needed. MRI is by far most accurate method, and allows as much information on soft tissue status, but is limited due to high cost and long examination time. Recently, with the introduction of high-resolution ultrasonographic equipment, many studies evaluating superficial structure using ultrasonography (US) were presented[1~8]. However, to our knowledge, there are few reports on the evaluation of ligamentous structure of the ankle[9,10]. We believe that US is not inferior to the MRI in detecting and evaluating the ligaments of the ankle. Therefore, we tried to evaluate the capability of US in evaluating the ligaments of the ankle, compared with MRI.

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MATERIALS AND METHODS

Eighteen patients (age 17-64 years old, mean 37.4 years old) whose collateral ligaments of the ankle were identifiable on prior MRI examination were selected. US were performed within 1 week after examination. Routine MR protocol was as follows; spin echo proton and T2WI in oblique axial plane parallel to the dorsum of the foot to observe the anterior talofibular ligament, and fast spin echo fat saturation T2WI in oblique coronal plane perpendicular to the previous section, in order to observe calcaneofibular ligament. (3 mm thickness/ 1 mm gap, FOV 15 cm, 256×256 matrix, 1 acquisition) Orthogonal T1 axial image and sagittal T2WI were also obtained. Ultrasonographic examination was performed with a 10 MHz linear probe, with sonopad or alcohol - contained latex bag to eliminate air between probe and skin. In sitting position, the patient was told to invert or evert his or her ankle in order to stretch the target ligaments. All examination was done by one experienced radiologist.

During the examination, an effort was made to identify the following structures; anterior talofibular ligament (ATF), calcaneofibular ligament (CF), posterior talofibular ligament (PTF), anterior tibionavicular ligament (ATN), tibiocalcaneal ligament (TC), posterior tibiotalar ligament (PTT), anterior tibiotalar ligament (ATT). Thickness of ATF was measured. Grading system was designed for statistical analysisof all ligaments of the ankle; grade 1, integrity of entire ligament is well identifiable, grade 2, integrity of the ligament is identifiable but not in full length, grade 3, ligamentous structure is not identifiable at all, grade 4, torn ligamentous remnant is identifiable. Detection and corresponding rates were calculated as follow;

Detection Rate (DR) = number of grade 1 and 2 of each ligament / total number of patients

Corresponding Rate (CR) = number of same grade in US and MRI / total number of patients

Statistical analysis was performed with SPSS for Windows (release 6.0).

RESULTS

DR of the ATF was 100%(18/18) and CR was 83.3% (15/18), significant statistically ($p<0.05$)(Table 2)(Fig. 1). Three of ATF were underestimated as grade 2, which was grade 1 in MRI. Average thickness of ATF measured 1.38 $\pm$0.44 mm (1.0~2.4 mm) on US, 1.30$\pm$0.49 mm (0.7 ~2.4 mm), not significant statistically. (Table 1) DR and CR for CF was 100%(18/18), 72.2%(13/18) respectively. (Table 3) (Fig. 2) DR for PTF was 72.2%(13/18) CR was 44.4%(8/18). (Table 4)(Fig. 3) DR for ATN was 94.4%(17/18), CR was 88.9%. (Table 5)(Fig. 4) DR for TC was 100%.(Fig. 5) TC was underestimated in five cases. (Table 6) DR for PTF was 94.4%(17/18), CR was 44.4%. (Table 7)(Fig. 6)

DISCUSSION

Ankle sprain, injuries to the collateral ligament of the ankle, is among the most common injuries to the musculoskeletal system. Ankle sprain can be clinically classi-

Table 1. Gradings of the collateral ligaments of the ankle

	Ultrasonography							MRI						
	ATF	TU	CF	PTF	ATN	TC	PTT	ATF	TM	CF	PTF	ATN	TC	PTT
Case 1	1	1.5	2	2	3	1	3	1	1.5	1	1	3	1	3
Case 2	2	2.4	2	3	1	1	2	2	2.2	2	3	1	1	1
Case 3	1	1	1	3	2	1	2	1	0.7	2	3	2	1	1
Case 4	1	2	1	3	1	1	2	1	1	1	2	1	1	1
Case 5	1	1	1	2	2	2	2	1	1.5	1	2	2	1	1
Case 6	2	1	1	2	1	1	2	1	1	1	1	1	1	2
Case 7	1	1.2	1	2	2	1	2	1	1	1	1	1	1	2
Case 8	1	1.5	2	2	1	1	2	1	2	2	1	1	1	2
Case 9	1	1.2	2	3	2	2	2	1	1.5	1	3	2	1	1
Case 10	1	2	2	2	2	1	2	1	1	2	1	1	1	1
Case 11	2	1	2	3	1	1	2	1	1.2	2	2	1	1	2
Case 12	1	1.2	1	2	1	1	2	1	1	1	2	1	1	2
Case 13	1	1.4	2	3	2	2	2	1	1	1	3	2	1	1
Case 14	1	2	1	2	2	2	2	1	1.2	1	2	2	1	1
Case 15	2	1	1	2	1	1	2	1	2.4	1	1	1	1	2
Case 16	1	1	1	2	1	2	2	1	1	1	1	1	1	2
Case 17	1	1.2	2	2	2	1	2	1	1	2	1	2	1	1
Case 18	1	1.2	1	3	2	1	2	1	1.2	2	3	2	1	1

ATF: anterior talofibular ligament, TU:thickness of ATF in Ultrasonography(cm), CF: calcaneofibular ligament, PTF: posterior talofibular ligament, ATN: anterior tibionavicular ligament, TC:tibiocalcaneal ligament PTT: posterior tibiotalar ligament TM: thickness of ATF in MRI(cm)

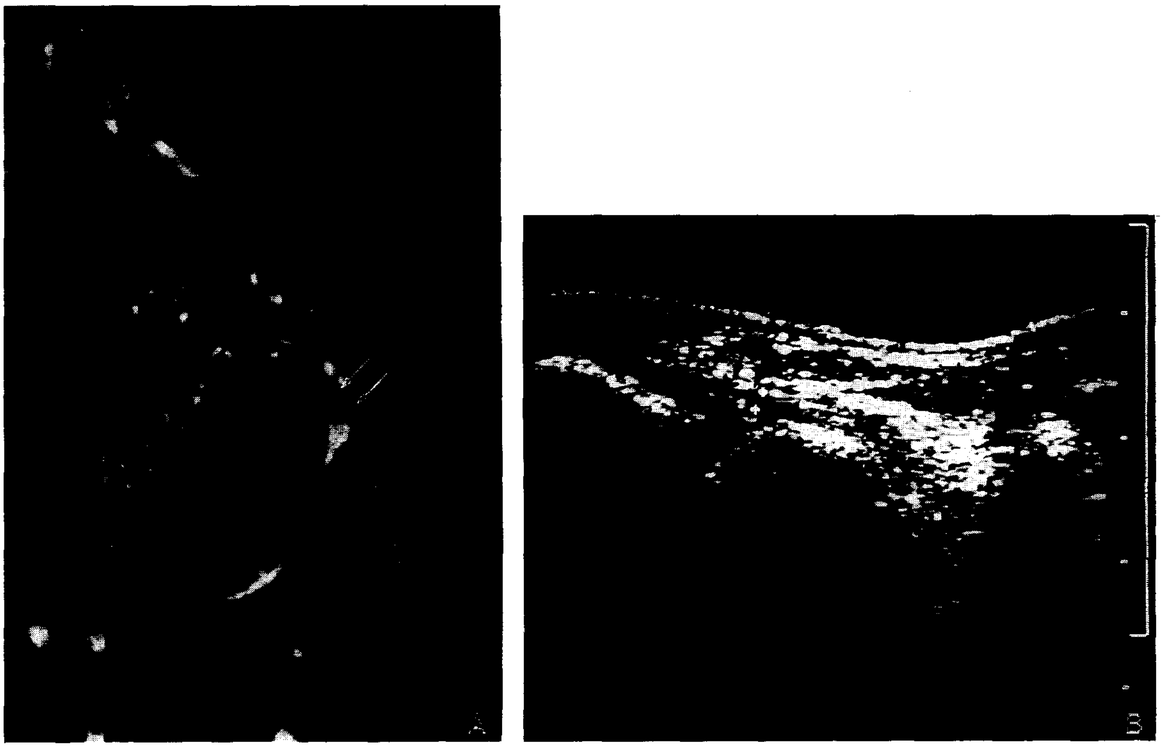

Fig. 1. Anterior Talofibular Ligament: (A) T2WI oblique axial MR image shows anterior talofibular ligament(arrows), form the lateral maleolus to the talar neck and body junction. (B) Ultrasonography obtained with direction parallel to the anterior talofibular ligament, also demonstrates the intact anterior talofibular ligament as a echo poor linear band.(arrows).

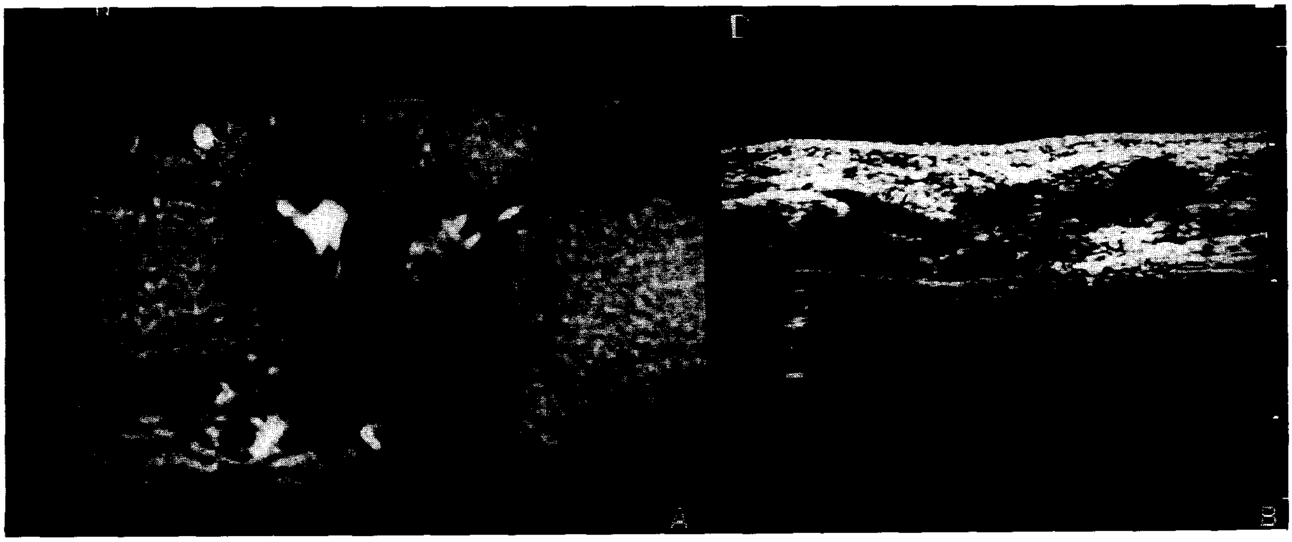

Fig. 2. Calcaneofibular ligament: (A) Oblique coronal proton weighted MR image shows calcaneofibular ligament beneath the peroneal tendon (arrows) (B) Ultrasonography shows calcaneofibular ligament as a lower echoic band.(arrows)

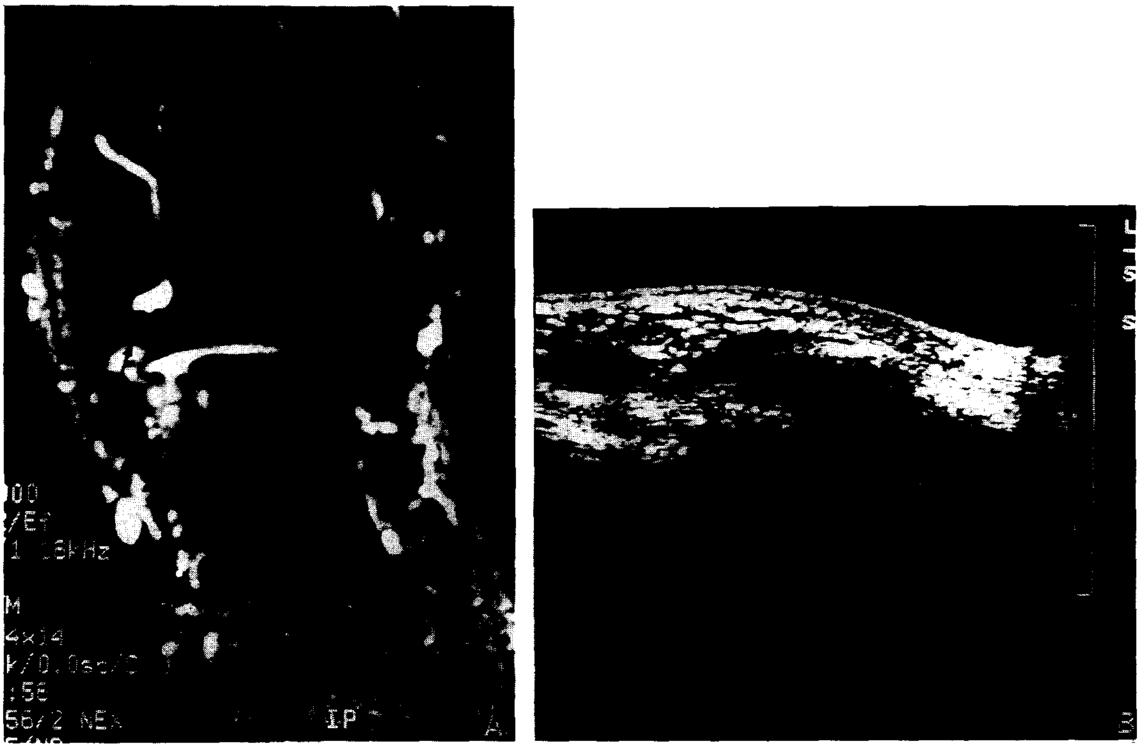

Fig. 3. Posterior talofibular ligament: (A) Oblique coronal fat saturated MR image shows posterior talofibular ligament, which run transversely from lateral maleolus to the talus.(arows) (B) Ultrasonography of same area, hardly visualizes the posterior talofibular ligament, due to overlying cortex of lateral maleolus. (arrows)

Fig. 4. Anterior tibionavicular ligament: (A) Axial T1WI MR image shows anterior tibionavicular ligament clearly.(arrows) (B) Ultrasonography of the same area shows linear dark echoic band structure run from medial maleolus, to the navicula. (arrows)

Table 2. Detection gradings for anterior talofibular ligament

ATF		US		
		Grade 1	Grade 2	Total
MRI	Grade 1	14	3	17
	Grade 2	0	1	1
	total	14	4	18

Table 3. Detection grading for calcaneofibular ligament

CF		US		
		Grade 1	Grade 2	Total
MRI	Grade 1	8	3	11
	Grade 2	2	5	7
	total	10	8	18

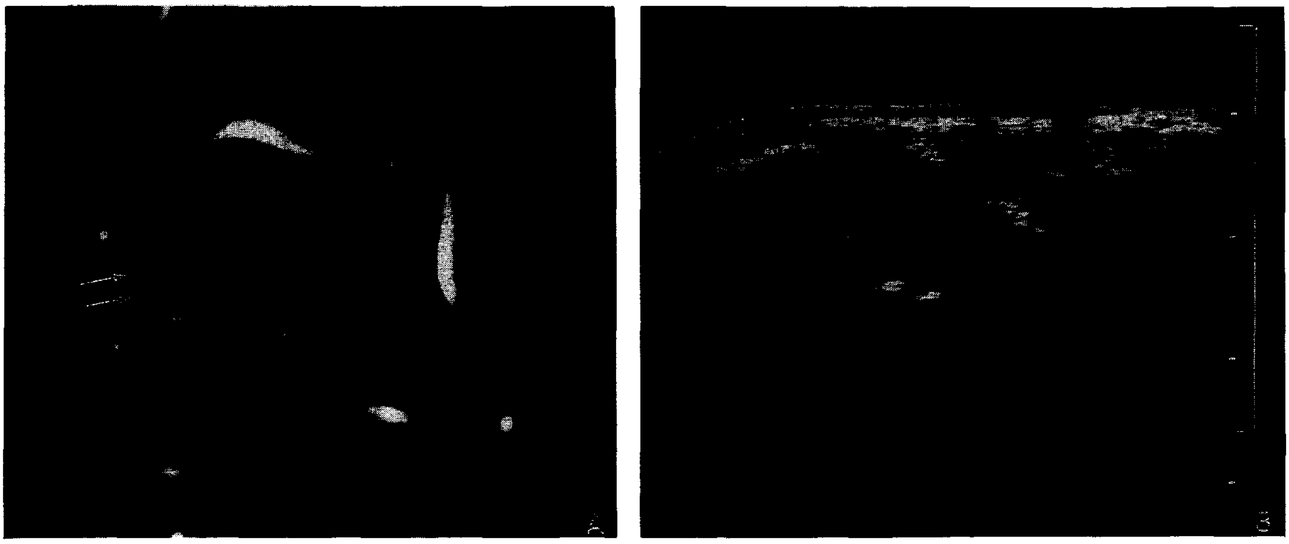

Fig. 5. Tibiocalcaneal ligament: (A) Fat saturated T2WI oblique coronal image shows thick tibiocalcaneal ligament.(arrows) (B) Ultrasonography also demonstrate the tibiocalcaneal ligament clearly.(arrows)

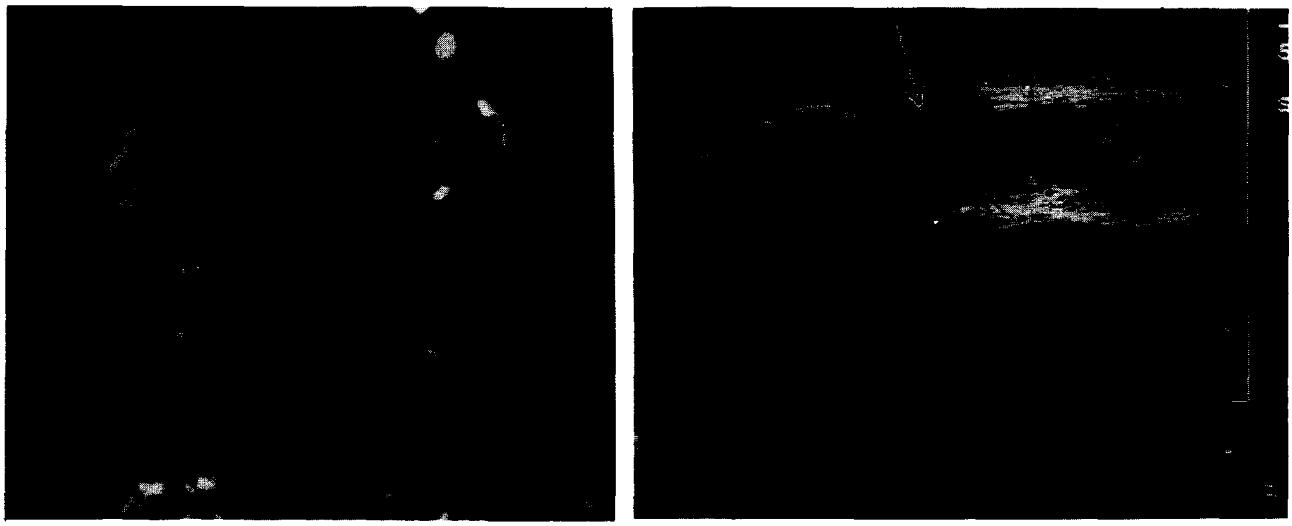

Fig. 6. Posterior tibiotalar ligament: (A) Posterior tibiotalar ligament is well visualized in inferior aspect of medial maleolus, attached to the talus.(arrows) (B) Ultrasonography also clearly demonstrates the posterior tibiotalar ligament.(arrows)

Table 4. Detection grading for posterior talofibular ligament

PTF		US			
		Grade 1	Grade 2	Grade 3	Total
MRI	Grade 1	0	8	0	8
	Grade 2	0	3	2	5
	Grade 3	0	0	5	5
	Total	0	11	7	18

Table 5. Detection grading for anterior tibionavicular ligament

ATN		US			
		Grade 1	Grade 2	Grade 3	Total
MRI	Grade 1	8	2	0	10
	Grade 2	0	7	0	7
	Grade 3	0	0	1	1
	Total	8	9	1	18

fied into the 3 grades based on the severity and extent of the disease[11~13]. Grade 1, mild stretch of the lateral collateral ligamentous complex with no instability, Grade 2, incomplete tear of the complex with only mild instability; Grade 3, complete tear with gross instability. A careful physical examination and plain film radiography are essential for diagnosing ligamentous injuries. Plain radiography is essential in eliminating the possibility of bony fracture, talar dome or epiphyseal injury. Stress radiography may be helpful in chronic ankle instability[14], however, in acute phase of injuries, it may be inaccurate due to edema and muscle spasm. Besides bony fracture, many kinds of soft tissue injuries can mimic ankle sprain, syndesmosis sprain, talo-calcaneal ligament rupture (tarsal sinus syndrome), peroneal tendon rupture, and dislocation of posterior tibialis tendon[15]. Tenography and arthrography had been used in pre-MRI era, however, they are invasive techniques, unless the most reliable methods for confirming communication of joints and tendon sheath[16]. MRI has been introduced as a primary diagnostic tool for soft tissue injury, very sensitive and accurate for evaluation of soft tissue lesions[17]. As for the evaluation of the status of the collateral ligaments of the ankle, MRI provides excellent accuracy[17,18]. However, it is not always convenient due to expensive cost, and long examination

Table 6. Detection grading for tibiocalcaneal ligament

TC		US		
		Grade 1	Grade 2	Total
MRI	Grade 1	13	5	18

Table 7. Detection grading for posterior tibiotalar ligament

PTT		US		
		Grade 2	Grade 3	Total
MRI	Grade 1	10	0	10
	Grade 2	7	0	7
	Grade 3	0	1	1
	Total	17	1	18

time. In addition, it is not so easy to demonstrate the ligamentous structure as a linear continuous band on a single image plane, due to variation of the course of the ligaments. If someone want to do it, he or she must design scan direction repeatedly, until entire length of the ligament becomes visualized. Ultrasonography can be an efficient and economic answer to this question. It has not been long since the application of ultrasound as a diagnostic tool in musculoskeletal disease. The merits of ultrasonography as a diagnostic study are obvious. It is noninvasive and it has no known risk. It can be done quickly, with little discomfort to the patient, and the capacity of bilateral contralateral limb possible, and much less expensive than other diagnostic study. Disadvantages, such as learning curve, ease of interpretation and variable image quality, seem to be diminishing as technology and experience increases. Many authors have told that ultrasonography is effective in diagnosing muscle[1~3] tendon[4], ligamentous abnormalities[5,6], and other soft tissue structures including the synovium[7] and periosteum[8].

There are not so many articles about the normal sonographic appearance of ligamentous structure around the ankle. Friedrich JM et al.[9] had demonstrated the normal ligamentous structures in 3 cadavers and an additional 20 healthy volunteer study, as a thin variable echoic strand, over the joint capsule, which was identified as a echo poor triangular structure, so called, "delta sign". Ligamentous structures can be shown as variable echo due to anisotrophic reflector artifact[10], which is from the direction of the fiber of the ligament against the direction of the ultrasonic beam. But in this study, there were no echogenic ligaments in any cases. We think that the ultrasound evaluation of the integrity of the collateral ligament is reliable enough, because almost hundred percents of the collateral ligaments are detected as least grade 2. Posterior tibiotalar and posterior talofibular ligament are structures beneath the malleoli, which was not a good position for sonic window. The problem from the irregular contour of the lateral surface of the ankle was overcome by alcohol filled rubber bag interface. This bag eliminated the air between the skin and the rigid probe surface. However, the ultrasound device still has some limitations. Ultrasonography will not be able to determine the integrity of the ligament easily, if fibrosis is present around the ligament. Ultrasound cannot penetrate bony structure, therefore, structures behind the malleoli and intraarticular structures will not be evaluated. Holsbeeck MV et al.[10] suggested that ultrasonography can be a screening modality. When presented with a patient with ankle sprain, after excluding bony fracture with plain radiography, ultrasound screening can be done, in order to localize the pathology, whether it is intraarticular or extraarticular, or even superficial soft tissue abnormality. If there are no abnormalities in superficial structures or no joint effusion, just observation and follow-up may be recommended. If the injury is an extraarticular nature, sonographic evaluation only is enough to evaluate and proper management can be started. If joint effusion is present without superficial structural abnormalities, further imaging study such as MRI or CT are recommended.

This study has several limitations, inevitably. The major problem is that the reference for normal was MRI, not cadaveric or operative confirmation. In addition, the second is the small number of cases. An last, this study was proceeded by one examiner.

However, the authors confirmed that the ligamentous structures of the ankle can easily be evaluated with ultrasonography, and therefore it can be a promising tool for evaluation of ligamentous injury of the ankle.

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