Coll. Antropol. **36** (2012) 2: 605–610
Original scientific paper

Comparative Assessment of the Acute Ankle Injury by Ultrasound and Magnetic Resonance

Petra Margetić[1] and Roman Pavić[2,3]

[1] University of Zagreb, »Sestre Milosrdnice« University Hospital Center, Clinic of Traumatology, Radiology department, Zagreb,Croatia
[2] University of Zagreb, »Sestre Milosrdnice« University Hospital Center, Clinic of Traumatology, Department of Hand Surgery, Zagreb, Croatia
[3] »J. J. Strossmayer« University, School of Medicine, Osijek, Croatia

A B S T R A C T

We compared ultrasound (US) with magnetic resonance (MR) findings of muscle tendon and ligaments (mt&l) of 17 men and 13 women, 16–66 years old, who suffered from acute ankle injury without bone fracture visible on conventional radiographs. Joint effusion (JE), and injury of the Tibials anterior muscle tendon (TAmt), Calcaneofibular ligament (CFl), Long flexor of the great toe muscle tendon (LFGTmt), Short peroneus muscle tendon (SPmt), Long peroneus muscle tendon (LPmt), and Anterior talofibular ligament (ATFl) were assessed by the US, at seven days, and MR, at seventeenth day. Grading of ligament and muscle tendon injury as stretching (Grade 1), partially ruptured (Grade 2), and complete rupture (Grade 3); no lesion was considered to be Grade 0. Joint effusion and ATFl were the most common lesions whereas the TAmt lesion was the least frequent: JE ~ ATFl > SPmt ~ LPmt > LFGTmt ~ CFl ~ TAmt. Both US and MR were equally sensitive in detecting the presence (or absence) of the mt&l ankle injury, whereas US was less specific than MR in detecting G3 injury.

Key words: *acute ankle injury, ultrasound, magnetic resonance, anterior talofibular ligament*

Introduction

Ankle joint injuries are common trauma particularly associated with the lateral ligament sprain induced by the adverse forces acting upon the collateral ligament complex. The degree of the ankle joint injury vary in intensity of damage such that it may be classified as stretching (Grade 1; G1), partially ruptured (Grade 2; G2), and completely ruptured (Grade 3; G3) muscle tendon and ligament[1]. There is a general consensus that the great majority of G1 and G2 ankle joint injuries heal uneventfully with conservative care. However, the treatment of G3 ankle joint injury is debatable since some practitioners prefer operative repair (especially for the top athletes), whereas others prefer casting and a physical therapy regimen[1].

Diagnosis of ankle joint injury involves the conventional radiograph to eliminate fractures and routine ultrasound to evaluate the size and location of the musculoskeletal system disorders of muscle tendons and ligaments (mt&l) due to their superficial location[2,3]. In cases of doubt, magnetic resonance may be used for the differential diagnosis of either acute or chronic muscle tendon or ligament injury. There have been some studies which compared US and MR findings, but they usually analyzed sindesmosis and lateral ligaments[2,4,5]. The aim of this study is to compare the grading of the ankle joint injuries by ultrasound and magnetic resonance, respectively. Purpose was extended to analyze the grade of ligament disruptions as well as disruption of the tendons.

Materials and Methods

This study was approved by the Ethic Committee of the Clinic of Traumatology, following the principles of the Declaration of Helsinki guiding research on human subjects. Every subject approved their participation in the study with his/her written consent. The study involved 17 male and 13 female patients who suffered from

Received for publication July 23, 2009

acute ankle joint injury without visible bone fractures on conventional radiographs. Coincidentally, 50% of the subjects had right ankle joint injury and the other 50% the left ankle joint injury. We studied the joint effusion (JE), and injury of the Tibial anterior muscle tendon (TAmt), Calcaneofibular ligament (CFl), Long flexor of the great toe muscle tendon (LFGTmt), Short peroneus muscle tendon (SP mt), Long peroneus muscle tendon (LPmt), and Anterior talofibular ligament (ATFl) with the US and MR. The degree of the ankle joint injury varies in intensity of damage such that it may be classified as stretching (Grade 1; G1), partially ruptured (Grade 2; G2), and completely ruptured (Grade 3;G3) muscle tendon and ligament, respectively[1].

One week after injury the US of the injured ankle joint was performed (Shimadzu 2200, Shimadzu Corporation, Kyoto, Japan) with a 7–15 MHz linear probe. If the ligament was edematous and hypo echogenic, surrounded by effusion but without visible break of continuity, the injury was qualified as ligament stretching (G1). If some straight parallel fibers could still be seen, a diagnosis of incomplete rupture was made (G2). A rupture of the ligament was diagnosed when a dehiscence of the ligament ends or interruption of the parallel fibers in combination with a hypo echogenic zone of edema and/or hematoma could be visualized (G3). If only thickening of the muscle tendon was visible accompanied by the hypo echogenic zone with or without respective surrounding

TABLE 1
ANATOMICAL LOCATION AND GRADING OF THE MUSCLE AND LIGAMENT INJURY WITH THE ULTRASOUND (US) AND MAGNETIC RESONANCE (MR)

No. No.	Case Code	Side L/R	CTFl U	CTFl MR	Atmt U	Atmt MR	LFGTmt U	LFGTmt MR	LPmt U	LPmt MR	SPmt U	SPmt MR	ATFl U	ATFl MR	JE U	JE MR
1.	Ko.Mi	L							1	1	1	1	3	3	1	1
2.	Šp.St	R											2	2	1	1
3.	Ko.Ma	R	1	1									1	1		
4.	Pi.Ju	L					1	1			1	1	1	1	1	1
5.	Mi.Lj	R											1	1	1	1
6.	Si.El	R			1	1			1	1			1	1	1	1
7.	Vo.To	L											1	1	1	1
8.	Po.Fr	L							1	1					1	1
9.	Gr.Je	L							1	1	1	1	1	1	1	1
10.	Ga.Kr	L											2	2	1	1
11.	Tk.Da	R													1	1
12.	Hm.Da	R			1	1			1	1	1	1	3	3	1	1
13.	Ča.Sl	L	1	3									2	2	1	1
14.	Bi.Go	R									1	1	2	3	1	1
15.	Žg.Ve	R					1	1			1	1	3	3	1	1
16.	Mo.Di	R					1	1					3	3	1	1
17.	Pu.Sa	L													1	1
18.	Me.Du	R							1	1			1	1	1	1
19.	Te.Sa	L									1	1	1	2	1	1
20.	Ut.In	R					1	1	1	1			3	3	1	1
21.	Mi.Mi	L			1	1	1	1			1		1	3	1	1
22.	Đu.Mu	R											3	3		
23.	Do.Am	R	1	1											1	1
24.	Br.Kr	L									1	1				
25.	Me.Ti	L					1						1	2	1	1
26.	Ćo.Ba	L	1	1												
27.	Bu.Da	R			1								1	3	1	1
28.	Do.Na	L											1	3	1	1
29.	Bu.Ži	R	1	3							1					
30.	Di.Fr	L											1		1	1

1 Grade 1 (G1) injury – sprain, 2 Grade 2 (G2) injury – partial rupture, 3 Grade 3 (G3) – complete rupture, L left, R right, AT·mt Anterior tibial muscle tendon, CF·l Calcaneo fibular ligament, LFGT·mt Long flexor of the great toe muscle tendon, SP·mt Short peroneal muscle tendon, LP·mt Long peroneal muscle tendon, ATF·l Anterior talofibular ligament, JE joint effusion

effusion, it was diagnosed as lesion (G1+G2). A full thickness muscle tendon tear (G3) was diagnosed if there was a gap in the tendon.

Magnetic resonance findings from hypo intense to intermediate signal in T1WI and the hyper intensity signal in T2WI indicated the injured ligaments (G1+G2).

TABLE 2
COMPARISON OF THE ULTRASOUND (US) AND MAGNETIC RESONANCE (MR) FOR THE ASSESSMENT OF THE ACUTE ANKLE INJURY LESION (N=30)

Muscle tendon and ligament	Ultrasound No of cases Grade	Magnetic resonance No of cases Grade
Anterior tibial muscle tendon		
[a]No lesion	26 G0	26 G0
[b]Lesion	4 G1,G3	4 G1,G3
Calcaneofibular ligament		
No lesion	26G0	26G0
Lesion	4 G1	4 G1
Long flexor of the great toe muscle tendon		
No lesion	23G0	23G0
Lesion	7 G1	7 G1
Short peroneus muscle tendon		
No lesion	23G0	23G0
Lesion	7 G1	7 G1
Long peroneus muscle tendon		
No lesion	20G0	20G0
Lesion	10 G1	10 G1
Anterior talofibular ligament		
No lesion	8G0	8G0
Lesion	22 G1,2,3	22 G1,2,3
Joint effusion		
No lesion	4 Absent	4 Absent
Lesion	26 Present	26 Present

[a] No lesion: G0, [b]Lesion: G1 sprain, G2 partial rupture, G3 complete rupture

TABLE 3
GRADING OF THE ANTERIOR TALOFIBULAR LESION WITH THE ULTRASOUND (US) AND MAGNETIC RESONANCE (MR) (N=30)

Grade	Ultrasound	Magnetic resonance
No lesion (G0)	8	8
Sprain (G1)	12[a]	7[b]
Partial rupture (G2)	4	4
Complete rupture (G3)	6[a]	10[b]

Frequencies bearing the different superscript in the same row differ significantly ($p<0.05$)

During US examination patients were laying in the recommended standard position[6].

Ten days after the US evaluation of the acute foot ankle injury, magnetic resonance imaging was performed by fixed extremity coil of a 1.5 Tesla unit (Siemens – Symphony, Siemens AG, Medical Solution, MR Erlangen, Germany) by standard protocol[7]. The ligament injury was defined as acute when there was edema around or in the ligament, or chronic when there was disruption or thickening of the ligament without edema. Ligament rupture (G3) was defined as discontinuity with signal changes. Bone bruises showed an increased, poorly defined bone marrow signal in T2WI.

Statistics

Normality of data distribution was tested with Kolmogorov-Smirnov test[8]. The correlated dichotomous responses were compared with McNamar test[9]. We used SPSS for Window's statistical package version 15.0 (The Predictive Analytical Co., Chicago, IL, USA).

Results

The distribution frequency of muscle tendons and ligaments in acute ankle injury for the joint effusion, and injury of the TAmt, CFl, LFGTmt, SPmt, LPmt and ATFl is shown in Table 1. JE was the most prominent accompanying condition associated with the mt&l acute ankle injury, next followed by the ATFl whereas the TAmt lesion was the least frequent: JE ~ ATFl > SPmt ~ LPmt > LFGTmt ~ CFl ~ TAmt (Table 2).

Muscle tendons and ligaments involved simultaneously at the same time. In five cases mt&l injury was not accompanied with joint effusion although the injury may be G3. In three cases no mt&l was involved and only joint effusion was noted, whereas one, two, three, or four mt&l were involved 10, 9, 6, and 2 times, respectively. Both US and MR were equally sensitive in detecting the presence (or absence) of the mt&l ankle injury. Indeed,

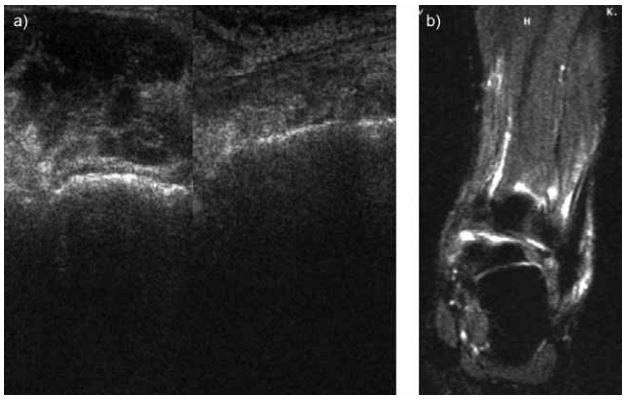

Fig. 1.a) (Ultrasound). Left: Rupture (Lesion G3) of the left Calcaneofibular ligament Right: Normal ligament on the contra lateral side; b) (Magnetic resonance). Rupture (Lesion G3) of the left Calcaneofibular ligament.

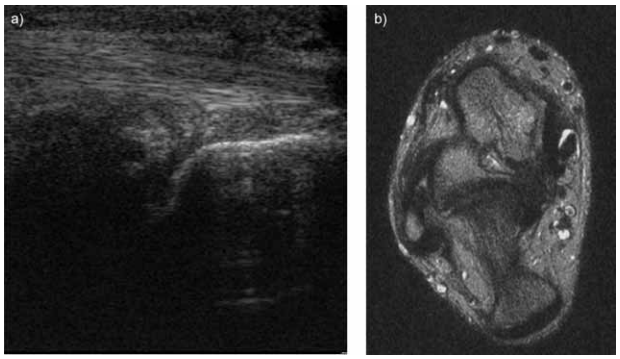

Fig. 2.a) (Ultrasound) Stretching (Lesion G1) of the left Anterior tibial muscle tendon; 2.b) (Magnetic resonance). Stretching (Lesion G1) of the right Anterior tibial muscle tendon.

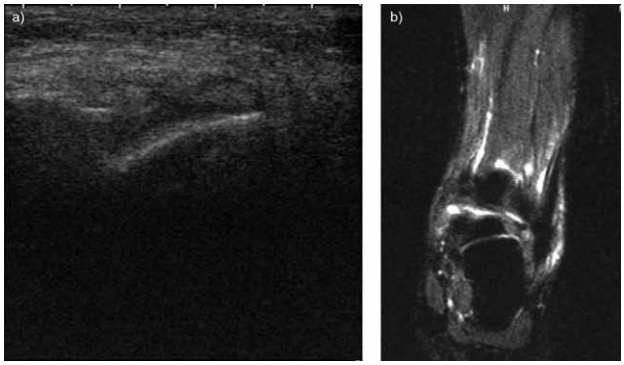

Fig. 3.a) (Ultrasound) Stretching (Lesion G1) of the right Long flexor of the great toe muscle tendon; 3.b) (Magnetic resonance) Stretching (Lesion G1) of the left Long flexor of the great toe muscle tendon.

whenever the injury was diagnosed by US, it was also diagnosed by MR, and whenever there were no injury shown by the US there were no injury on MR. Thus, both imaging techniques gave a concordant paired results, i.e., they were equally sensitive in diagnostic capacity. However, the grade of the injury for the ATFl, i.e., the specificity, varied between the US and MR (Table 3).

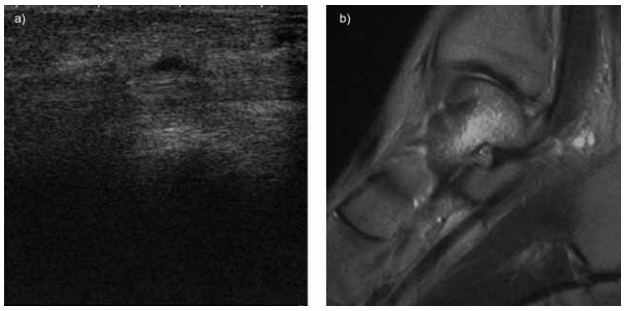

Fig. 4.a) (Ultrasound). Stretching (Lesion G1) of the left Short peroneal muscle tendon; 4.b) (Magnetic resonance). Stretching (Lesion G1) of the right Short peroneal muscle tendon.

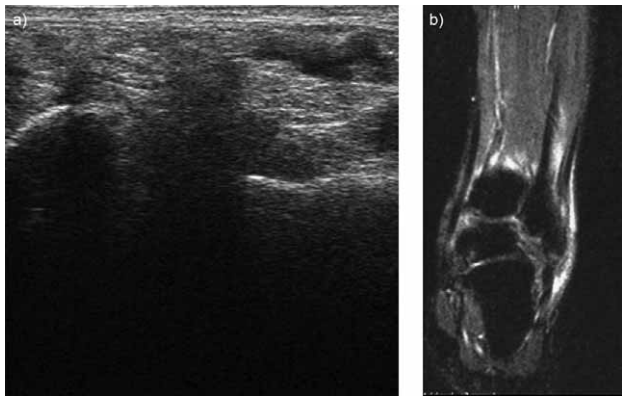

Fig. 5.a) (Ultrasound). Stretching (Lesion G1) of the left Long peroneal muscle tendon; 5.b) (Magnetic resonance). Stretching (Lesion G1) of the left Long peroneal muscle tendon.

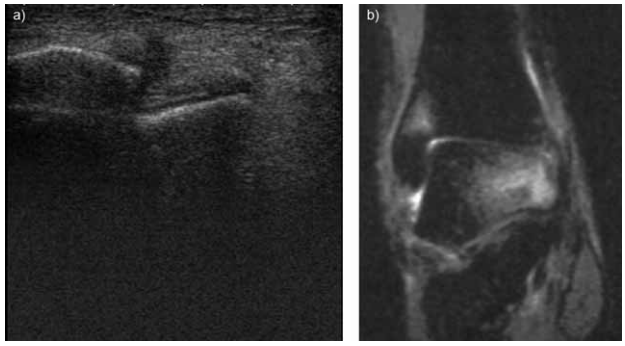

Fig. 6.a) (Ultrasound). Rupture (Lesion G3) of the right Anterior talofibular ligament; 6.b) (Magnetic resonance). Rupture (Lesion G3) of the right Anterior talofibular ligament.

Samples of the US (A figures) and MR (B figures) images of the injured muscle tendon and ligaments are shown for TAmt (Figure 1a and 1b), CFl (Figure 2a and 2b), LFGTmt (Figure 3a and 3b), SPmt (Figure 4a and 4b), LPmt (Figure 5a and 5b), ATFl (Figure 6a and 6b), and JE (Figure 7a and 7b).

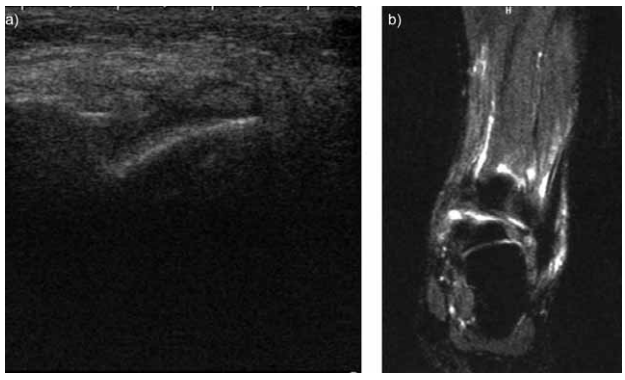

Fig. 7.a) (Ultrasound) Effusion (Lesion G1) in left talocrural joint [Case 30.Di.Fr]; 7.b) (Magnetic resonance) Effusion (Lesion G1) in the left talocrural joint.

We compared the frequency distribution of the ankle injury lesions obtained by the US and MR in Table 2. Thus, every of six tested mt&l without lesion (G0) were contrasted against the injured pair regardless of the grade of the injury (G1+G2+G3). McNamar test of paired comparisons showed no difference between the US and MR in this case, i.e., the total number of lesions for certain mt&l was the same by both US and MR. Again, the sensitivity of diagnosing the ankle injury was equal for US and MR.

The number of the ATl injury allowed for comparative assessment of US *vs*. MR with regard to the grade of the injury (Table 3). Apparently, the US detected the significantly larger number of G1 lesions, whereas the MR detected a greater number of G3 lesions ($p<0.05$ for both comparisons).

Discussion and Conclusion

To generate high quality images of adequate size and proper annotation it is imperative to accurately assess the superficial structure of muscle tendons and ligaments of the foot ankle requires. To achieve that aim, a proper knowledge of anatomy and relevant pathological conditions is required, together with the high level diagnostic equipment, precise positioning of the subject on the examination table and skilful manipulation of the diagnostic probe.

In this study we demonstrated that both US and MR are the equally reliable imaging techniques for diagnosing the presence of the acute ankle injury, they were of equal sensitivity potential to detect if there was or if there was not an acute ankle injury. However, the selective specificity of the two methods to differ the grade of the established acute ankle injury was different for the US *vs*. MR. Indeed, the US helped in diagnosis of considerably more sprain injuries (G1) than MR, whereas the MR helped in diagnosis of considerably more complete ligament ruptures (G3) than the US. Thus, the MR appears to be more crucial in the assessment of the different grade of the foot ankle injury than the US and, therefore, MR should be always consulted if a surgical solution.

Ultrasound is routinely used to assess the disorders of the muscle-skeletal system since the size of the superficially located muscle tendons and ligaments (mt&l) can be easily visualized[2,3,10]. Magnetic resonance has similar quality in clinical assessment of the ankle injury, but is less available. Thus, the Anterior talofibular ligament, the most often involved mt&l structure in this study, can be visualized by the MR imaging in almost 100% of cases. The Calcaneofibular ligament, another mt&l structure that is the least often involved can be seen in approximately 80% of subjects if the coronal plane of imaging is used[11]. Other mt&l structures analyzed in this study are also available for both the US and MR assessment[7].

Partial tears (G2) can be detected without loss of rectilinear appearance during dynamic sonography[12,13]. In the case of a ruptured ligament (G3), the site of the lesion is best visualized with the subject in supine position because the torn ends of the ligament are separated from each other[3,14,15]. When tears occurred at the level of ligament insertion, a cortical avulsion may be demonstrated by the ultrasound1[6,17]. There were few studies which had compared US and MR findings in acute ankle trauma, but they analyzed lateral ligaments and sindesmosis without analyzing medial, deltoid ligaments or tendons and muscles, as we did in this study[2,5,18,19].

It was not possible to confirm the US findings of our subjects surgically[20], since closed treatment of G1-G3 injuries is considered to be appropriate for the most cases of the acute ankle injury in this clinical hospital. Therefore, we relied on MR for the imaging of the mt&l structures after the US assessment. Indeed, only few studies had surgically confirmed US and/or MR findings[4,15,21]. However, the increase of fluid within the ligament is more easily identified by MR than by the US. Therefore, it is reasonable to assume that the minor injuries followed with the post traumatic increase of the fluid in the ligament would change the MR signal whereas the ligament itself may still appear to be normal on US examination[22,23].

Acknowledgements

The authors would like to thank D. Boljkovac, M.D. (surgery), Ph.D., M. Burić, M.D. (orthopaedic surgery), M.Sc., Prof. B. Momčilović, M.D. (internal medicine & occupational health), M.Sc., Ph.D., and Prof. D. Ivanković, (statistics), Ph.D., for their help and support.

REFERENCES

1. MINER HAYOOD T, The Ankle, 336 (1997) 318. — 2. MILZ P, MILZ S, STEINBORN M, MITTLEMEIER T, PUTZ R, REISER M, Acta Orthop Scand, 69 (1998) 51. DOI:[10.3109/17453679809002357]. — 3. MORVAN G, BUSSON J, WYBIER M, MATHIEU P, Eur J Ultrasound, 14 (2001) 73. DOI:[10.1016/S0929-8266(01)00147]. — 4. LAGALLA R, IOVANE A, MIDIRI M, LO CASTO A, DE MARIA M, Radiol Med, 88 (1994) 742. DOI:[10.1016/S0929-8266(01)00147-1] — 5. MILZ P, MILZ S, STEINBORN M, MITTLMEIER T, REISER M, Radiologe, 39 (1999) 34. DOI:[10.1007/s001170050474]. — 6. CHHEM RK, CARDINAL E, Gudelines and Gamuts in Musculoskeletal Ultrasound (Wiley-Liss, New York, 1999). — 7. MORRISON WB, Top Magn Reson Imaging, 14 (2003) 179. — 8. WILCOX R, Kolmogorov-Smirnov test. In: ARMITAGE P, COLTON T (Eds) Encyclopedia of statistical sciences (Wiley, New York, 2005). DOI:[10.1002/0470011815.b2a15064]. — 9. LACHENBRUCH PA, »McNamar« s test. In: ARMITAGE P, COLTON T (Eds) Encyclopedia of statistical sciences (Wiley, New York, 2005). DOI:[10.1002/0470011815.b2a10035]. — 10. RASMUSSEN OS, Scand J Med Sci Sports, 10 (2000) 360. DOI:[10.1034/j.1600-0838.2000.010006360.x]. — 11. BELTRAN KS, MUNCHOW AM, KHABIRI H, MAGEE DG, MCGHEE RB, Radiology, 177 (1990) 455. — 12. PEETRONS PA, SILVESTRE A, COHEN M, CRETEUER V, Can Assoc Radiol J, 53 (2002) 6. — 13. SIMANOWSKI JH, Orthopaedics, 31 (2002) 317. DOI:[10.1007/s00132-001-0262-0]. — 14. RAWOOL NK, NAZARIAN LN, Semin Ultrasound CT, MR, 21 (2000) 275. DOI:[10.1016/S0887-2171(00)90046-5]. — 15. RIJKE AM, GOITZ HT, MCCUE FC 3rd, DEE, PM,

Am J Sports Med, 21 (1993) 528. DOI:[10.1177/036354659302100409]. — 16. BRASSEUR JL, JBR-BTR, 86 (2003) 96. — 17. GEUSENS E, PANS S, VAN BREUSEGHEM I, BRYS P, Emerg Radiol, 9 (2002) 283. DOI:[10.2143/TVG.58.12.1001356]. — 18. MATTER HP, GRUBER G, KONERMANN W, GRUBER GM, LITZLBAUER HD, Ultraschall in Med, 19 (1998) 34. DOI:[10.1055/s-2007-1000456]. — 19. MOELLER TB, RIEF E, MRI Parameters and Positioning (Thieme, Sttutgart-New York, 2003). — 20. ERICSSON E, Knee Surg Sports Traumatol Arthrosc, 10 (2002) 329. — 21. CARDONE BW, ERICKSON SJ, DEN HARTOG BD, CARRERA GF, J Comput Assist Tomo, 17 (1993) 102. DOI:[10.1097/00004728-199301000-00019]. — 22. ASTON DJ, Magn Reson Imaging Clin N Am, 9 (2001) 413. — 23. KERR R, Semin Roentgenol, 35 (2000) 306.

P. Margetić

Clinic of Traumatology Zagreb, Draškovićeva 19, 10 000 Zagreb, Croatia
e-mail: hpetra23@gmail.com

USPOREDBA ULTRAZVUČNE DIJAGNOSTIKE S NALAZOM MAGNETSKE REZONANCIJE KOD AKUTNE TRAUME GLEŽNJA

S A Ž E T A K

Uspoređivali smo nalaz ultrazvuka s nalazom magnetske rezonancije kod ozlijeđenika sa akutnom traumom gležnja. Skupina se sastojala od 17 muškaraca i 13 žena, između 16 i 66 godina starosti koji su imali akutnu traumu gležnja bez vidljive koštane traume na standardnim rendgenogramima. Ultrazvučnom dijagnostikom sedam dana nakon ozljede i magnetskom rezonancijom nakon sljedećih deset dana ustvrdili smo postojanje eventualnog intraartikularnog izljeva, analizirali ozljede tetive prednjeg tibijalnog mišića kalkaneofibularnog ligamenta, tetive dugog fleksora palca, tetive kratkog i dugog peronealnog mišića te prednjeg talofibularnog ligamenta. Ozljede tetiva i ligamenata stupnjevali smo kao leziju (I stupanj), parcijalnu rupturu (II stupanj) i kompletnu rupture (III stupanj). Uredan nalaz je 0 stupanj. Intraartikularni izljev i ozljeda prednjeg talofibularnog ligamenta bile su najčešći nalaz kod obje dijagnostičke metode. U zaključku možemo reći da su obje dijagnostičke metode podjednako osjetljive i specifične u dijagnosticiranju akutne trauma mišića i ligamenata gležnja iako se magnetska rezonancija pokazala više specifična u dijagnosticiranju trećeg stupnja ozljede.