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ANKLE

Isolated syndesmotic injuries in acute ankle sprains: diagnostic significance of clinical examination and MRI

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Abstract

Purpose Acute ankle sprains are frequently accompanied by syndesmotic injuries. These injuries are often overlooked in clinical examinations. The aim of this study was (1) to evaluate the incidence of syndesmotic injuries in acute ankle sprains using MRI, (2) to determine the accuracy of common clinical diagnostic tests, (3) to analyse their inter-rater reliability, and (4) to evaluate the role of clinical symptoms in the diagnosis of syndesmotic injuries.

Methods A total of 100 patients with acute ankle sprain injury without associated fractures in plane radiographs were enrolled. The clinical assessment was performed by two independent examiners. Local findings, ankle ligament palpation, squeeze test, external rotation test, Drawer test, Cotton test, and the crossed-leg test (two examiners) were compared with MRI results (read by two blinded radiologists) as a reference standard.

Results Ninety-six participants (57 % male) met the inclusion criteria. MRI detected a ruptured anterior inferior tibiofibular ligament (AITFL) in 14 patients (15 %); 9 partial tears and 5 complete tears were evident. Evidence of pain at rest was found to predict syndesmotic injuries most accurately ($p = 0.039$). The palpation test over the proximal fibula produced the highest inter-rater correlation ($\kappa = 0.65$), but the lowest sensitivity for syndesmotic injuries of 8 %. All other clinical tests demonstrated moderate to fair inter-rater reliabilities ($\kappa = 0.37$–0.52). Low sensitivity values were found with all clinical tests (13.9–55.6 %).

Conclusion In this study, clinical examination was insufficient to detect syndesmotic injuries in acute ankle sprains. MRI scanning revealed a syndesmotic lesion in 15 % of patients. MRI scanning should be recommended in patients with ongoing pain at rest following ankle sprains.

Level of evidence I.

Keywords Ankle · Ankle ligaments · General sports trauma · Magnetic resonance imaging

Introduction

Acute ankle sprains are the most frequent injury treated in orthopaedic practice [23, 36]. The majority of injuries are focused on the lateral ligaments [16]. Injuries to the distal tibiofibular syndesmosis are encountered far less often. The stability of the distal tibiofibular syndesmosis is mainly based on the ligamentous apparatus between tibia and fibula, which consists of three relevant ligaments: the anterior inferior tibiofibular ligament (AITFL), the posterior inferior tibiofibular ligament (PITFL), and the interosseous tibiofibular ligament (ITFL).

A wide variation of incidences of syndesmotic injuries in patients has been reported. This varies between 1 and 20 % for patients with ankle sprains. Athletes reportedly have far higher incidences, of more than 70 % [12, 13, 25].

There are reports that the recovery times after syndesmotic injuries may be as much as fourfold greater than with lateral ankle sprains. Moreover, it has been shown that failure to diagnose syndesmotic lesions may lead to

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poor clinical outcomes [9, 12, 13, 20]. Furthermore, syndesmotic injuries are frequently accompanied by osteochondral lesions and other concomitant ankle injuries [4]. Despite these serious consequences, there is still an incomplete understanding of syndesmotic injuries.

High-quality evidence is still lacking on the appropriate diagnosis and treatment of these high ankle sprains [33, 37]. Likewise, the sensitivity and specificity of the common clinical tests remain to be determined [31]. In plane radiographs, the tibiofibular clear space (TFCS), the tibiofibular overlap (TFO), and the medial clear space (MCS) are parameters for the evaluation of the integrity of the distal tibiofibular syndesmotic apparatus. However, the reliability of plane radiographs for the detection of ankle syndesmosis injury is known to be limited [24, 28, 35]. MRI on the other hand is a reliable diagnostic tool to diagnose syndesmotic lesions [26]. It has reportedly specificity and sensitivity values that are comparable with those of ankle arthroscopy [5, 10, 34]. Both clinicians and patients would benefit from an accurate and reliable diagnostic management of ankle syndesmosis injuries to avoid inappropriate treatment.

The aim of this study was (1) to evaluate the incidence of syndesmotic injuries in acute ankle sprains using MRI and to evaluate the hypothesis that MRI is useful in detecting these injuries, (2) to determine the accuracy of common clinical diagnostic tests, (3) to analyse their inter-rater reliability, and (4) to evaluate the role of clinical symptoms in the diagnosis of syndesmotic injuries.

Materials and methods

One hundred consecutive patients with an acute ankle sprain were included. All patients were examined within 24 h after injury. Exclusion criteria were lower limb fractures or bony avulsions in the plane radiographs and patients with former surgical intervention of the affected side. Inability to obtain an MRI within 24 h of injury was also a reason for exclusion. For the latter reason, four patients were excluded. Forty-one women (43 %) and 55 (57 %) men were included. The mean age of the patients was 32.6 years ± 10.2 (range 18–59). No bilateral ankle sprains were encountered.

Clinical examination

All patients were asked to describe their mechanism of injury and were examined independently by a senior consultant and a resident doctor specialising in orthopaedic trauma surgery. The ability to walk was documented, as was the active range of motion of the ankle joint. Swelling was objectified by circumference measurement and compared to the uninjured contralateral side. Pain levels were recorded using the visual analogue scale (VAS) [6]. The two examiners independently verified the following tests within the first 24 h post-injury: tenderness on palpation over the anterior inferior tibiofibular ligament (AITFL), the proximal fibula (PF), the deltoid ligament (DL), the anterior talo-fibular (ATFL), as well as the calcaneo-fibular ligament (CFL). A simple scale was used ranging from painless (0) to painful (1). The syndesmosis squeeze test was performed, as well as the external rotation test, the Drawer test, the Cotton test, and the crossed-leg test [1, 2, 15]. At the end of the clinical evaluation, the two examiners had to give their frank assessment of syndesmotic integrity. Frequencies of positive and negative agreements and disagreements between the examiners are depicted in Table 3.

For the crossed-leg test, the patient sits and crosses the affected leg over the opposite knee. Pressure is then applied to the proximal fibula of the affected leg. A positive test is pain in the distal ankle.

Information on the sensitivity and specificity of these tests is summarised in Table 4.

Radiographic examination

All patients received standard anteroposterior and lateral radiographs to exclude associated ankle fractures or bony avulsions. Such signs can indicate syndesmotic injuries, and this study was carried out to determine the frequency of isolated syndesmotic injuries in ankle sprains without fractures signs in plane radiographs. An MRI scan was performed in all patients within 24 h of injury, read by two blinded radiologists.

MRI of the ankle was performed using a 3 T scanner (Intera, Philips Healthcare, Best, The Netherlands) with a Flex-M coil (Philips Healthcare, Best, The Netherlands). All patients were placed in supine position, and the examined lower extremity was fixed to avoid motion artefacts. Initially, a 2D short tau inversion recovery (STIR) sequence was applied (TE = 55 ms, TR = 3496 ms, T_I = 180 ms, TSE factor = 13, FoV = 200 mm, slice thickness = 3 mm). A 3D volumetric isotropic T_2-weighted acquisition (VISTA) sequence was performed (TE = 38 ms, TR = 1300 ms, spectral attenuated inversion recovery (SPAIR) TR = 1300 ms, flip angle = 90°, voxel size 0.6 × 0.7 × 0.4 mm, oversample factor = 1.4, FoV = 140 mm, slice count = 225) for the reconstruction of axial, sagittal, and coronal multiplanar-reformatted (MPR) images with a slice thickness of 1 mm. The MR images obtained were evaluated for the presence of SI and osseous or chondral ankle injuries.

MRI was considered the gold standard to evaluate the syndesmotic ligaments. According to Oae, syndesmotic injury was defined as grade 2 or 3 injury reflecting partial or complete tear of the anterior or posterior syndesmotic

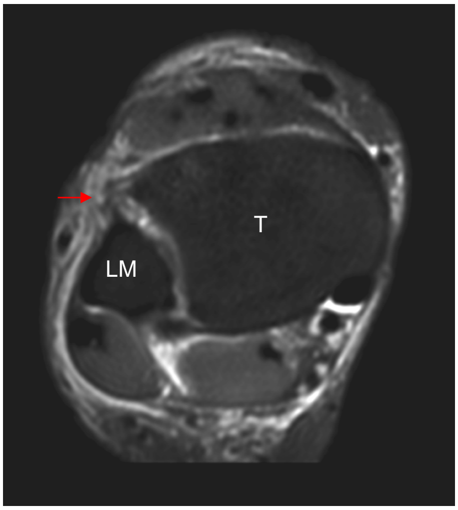

Fig. 1 MRI. Axial MRI image showing a complete tear of the anterior tibiofibular ligament (*red arrow*). *LM* lateral malleolus, *T* tibia

ligament (Fig. 1) [26]. MR images were evaluated in consensus by two radiologists with 5- and 10-years experience in musculoskeletal MRI. No further information about the clinical picture of the patients was provided to the two radiologists.

This study was approved by the local review board (Hamburg University Ethics Committee, reference number: PV3703). All patients signed an informed consent prior to inclusion.

Statistical analysis

A statistical analysis was performed using IBM SPSS Statistics 19. The distribution of data was summarised by descriptive statistics. Results are reported as mean ± standard deviation (SD) for continuous variables and proportions for categorical items. To quantify the accuracy of clinical tests to detect a syndesmotic injury in acute ankle sprains, the area under the curve (AUC) of the receiver operating characteristic (ROC) curve was determined. A power analysis was performed to determine the number of patients to be included in this study. With an expected accuracy of 85 % and a power of 80 % to detect a difference of 0.2215 between the area under the ROC curve under the null hypothesis of 0.5000 and an AUC under the alternative hypothesis of 0.7215 using a two-sided z test at a significance level of 0.0500, a sample size of 96 patients was determined [11, 27]. A weighted kappa analysis was used to calculate the reliability of independent inter-observer agreement (between senior consultant and resident) for each individual test [17]. A stepwise backward logistic regression analysis was retrospectively performed to identify variables best predicting diagnostic accuracy of syndesmosis rupture, adjusted for the above-mentioned sample size. Tenderness on palpation over the anterior inferior tibiofibular ligament (AITFL) and the calcaneo-fibular ligament (CFL), the external rotation test, and pain score at rest (VAS score) were included. A p value of 0.05 or less was considered statistically significant. The reliability of the kappa value was interpreted according to Landis and Koch (Fig. 2) [17].

Results

The most often reported mechanism of injury was hyperdorsiflexion of the foot (81 %); further information on the mechanism of injury was not available. The pain level at rest was a mean of 3.0 ± 2.0 (range 0–8), compared to a mean pain level of 6.4 ± 2.2 (range 1–10) during weight bearing. The mean circumference of injured ankles was 27.5 ± 2.5 cm. There was no significant increase compared to the uninjured side (mean 26.0 ± 2.6 cm) (n.s.) (Table 1).

MRI findings

AITFL lesions (9 partial tears, 5 complete tears) accounted for 15 % of injuries (14 patients). PITFL was partially ruptured in one case—with complete rupture of the AITFL at the same time. PITFL oedema was observed in 27 cases. No complete tear or isolated injury of the PITFL was found (Table 2).

MRI revealed three osteochondral lesions and five fractures (two of the medial malleolus, one of the posterior aspect of the distal tibia, and two bony avulsions) that had not been detected in the plane radiographs; the surrounding bone marrow oedema indicated that these lesions were acute. Two of these occult fractures were associated with a complete tear and one with a partial tear of the AITFL. An increase in concomitant ankle injuries was documented in patients with syndesmotic lesions (21.4 % in patients with SI vs. 6.1 % in patients without SI, n.s.).

Clinical examination

A syndesmotic injury was diagnosed in seven patients by both examiners. However, this clinical diagnosis was supported in only two cases by MRI. Another SI was correctly predicted by only one examiner. Twelve partial or complete tears of the AITFL were not detected by clinical examination alone. For the palpation tests, the best agreement between the examiners was calculated for direct palpation over the proximal fibula (PF), with a kappa of 0.652, the worst with a kappa of 0.391 for palpation over the anterior talo-fibular ligament (ATFL). All clinical tests claimed to

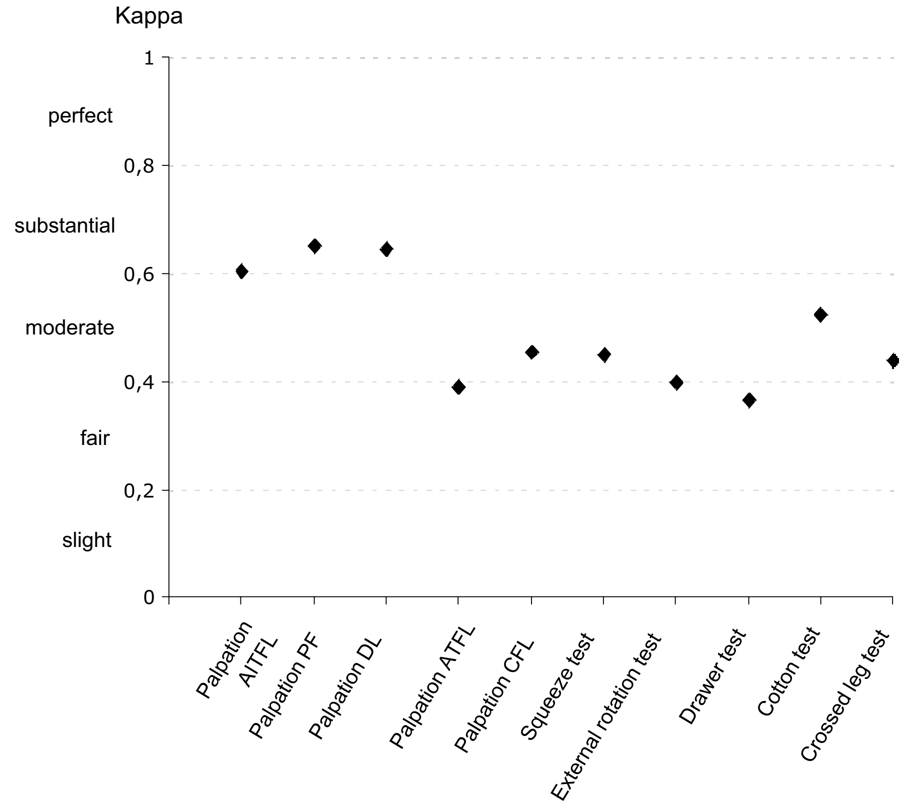

Fig. 2 Kappa coefficients for inter-rater reliability. Evaluations for level of kappa as given by Landis and Koch are included in the figure. *AITFL* anterior inferior tibiofibular ligament, *PF* proximal fibula, *DL* deltoid ligament, *ATFL* anterior talo-fibular ligament, *CFL* calcaneo-fibular ligament

Table 1 Patients data

	$n = 96$
Age	32.6 ± 10.2 years
Gender	
Female	41 (43 %)
Male	55 (57 %)
Circumference	
Affected ankle	27.5 ± 2.5 cm
Unconcerned ankle	26.0 ± 2.6 cm
Pain	
At rest (VAS 0–10)	3.0 ± 2.0
Under weight-bearing (VAS 0–10)	6.4 ± 2.2
Walking ability	79 %

ROM range of motion, *VAS* visual analogue scale

Table 2 MRI findings

	AITFL	PITFL
Intact	35	68
Oedema	47	27
Partial tear	9	1
Complete tear	5	0

AITFL anterior inferior tibiofibular ligament, *PITFL* posterior inferior tibiofibular ligament

detect syndesmotic injuries showed poor inter-rater agreements (Table 3).

There were no significant differences between patients with and without SI in ability to walk, active range of motion, ankle dorsiflexion, ankle flexion (pronation and supination), or circumference (injured minus uninjured ankle). However, mean pain levels at rest were significantly greater in patients with (3.9 ± 2.5 [VAS]) than without SI (2.8 ± 1.8; $p = 0.039$).

Sensitivity, specificity, and predictive value

The highest sensitivity to diagnose an injured AITFL was found for straight palpation over the anterior fibulotalar ligament (0.778), but the specificity was low (0.271), as this test examines a different ligament. Of the tests that had previously been described as being capable of detecting syndesmotic injuries, the external rotation test had the highest sensitivity (0.556) (Table 4). Presence of pain at rest was found to be the most accurate predictor of SI ($p = 0.039$).

Discussion

The most important finding of the present study was that MRI revealed not only many syndesmotic injuries but also

Table 3 Physical examination

	n	Agree		Disagree		κ
		+/+	−/−	±	∓	
Palpation						
AITFL	96	37	40	7	12	0.605
PF	96	3	90	3	0	0.652
DL	96	24	57	7	8	0.646
ATFL	96	63	12	9	12	0.391
CFL	96	39	31	14	12	0.455
Squeeze test	96	29	41	14	12	0.450
External rotation test	96	33	33	19	11	0.399
Drawer test	96	24	43	13	16	0.366
Cotton test	96	21	55	10	10	0.524
Crossed-leg test	96	7	74	10	5	0.440
Rating	96	7	81	4	4	0.626

AITFL anterior inferior tibiofibular ligament, *PF* proximal fibula, *DL* deltoid ligament, *ATFL* anterior talo-fibular ligament, *CFL* calcaneo-fibular ligament

Table 4 Sensitivity and specificity

	Sensitivity	Specificity	PPV	NPV
Palpation				
AITFL	0.417	0.525	0.341	0.596
PF	0.077	0.939	0.167	0.867
DL	0.333	0.695	0.387	0.631
ATFL	0.778	0.271	0.389	0.667
CFL	0.611	0.475	0.415	0.674
Squeeze test	0.444	0.559	0.372	0.623
External rotation test	0.556	0.475	0.385	0.636
Drawer test	0.444	0.678	0.444	0.667
Cotton test	0.306	0.678	0.355	0.615
Crossed-leg test	0.139	0.831	0.333	0.613

PPV positive predictive value, *NPV* negative predictive value, *AITFL* anterior inferior tibiofibular ligament, *PF* proximal fibula, *DL* deltoid ligament, *ATFL* anterior talo-fibular ligament, *CFL* calcaneo-fibular ligament

concomitant lesions to the bony structures directly after a simple ankle sprain.

Our findings suggest that common clinical tests exhibit insufficient diagnostic accuracy. Neither a single test nor (as suggested by Sman et al. [31]) a combination of two different tests reached sufficient sensitivity or specificity to diagnose a syndesmotic injury.

In the current study, 3 T MRI was by far more reliable in the diagnosis of SI than clinical examination or plane radiographs. A major advantage is its non-invasiveness, particularly when compared with ankle arthroscopy.

The inter-rater reliability for all clinical tests was found to be moderate and for the palpation tests even substantial. According to Alonso and Beumer, good inter-rater reliability was only found with the external rotation stress test, whereas the squeeze or the Cotton test was associated with only fair-to-poor reliability [1, 2]. Interestingly, the positive predictive values for all tests were low, whereas the negative predictive values of all tests were high. Although each single test appears to be inappropriate as a useful tool in the diagnosis of syndesmotic lesions, using multiple tests may be a reliable tool to exclude SI. In other words, if several tests are negative, syndesmosis injury will be unlikely. The best predicted diagnostic accuracy of syndesmotic rupture was calculated for pain at rest; this reveals the importance of pain in the diagnosis of SI and is supported by the observation of Sman et al. [31], who found the highest diagnostic accuracy for pain, although they described it as pain out of proportion to the injury.

The circumference of the affected ankle was only moderately increased in our study; this is line with observations that, in the acute stage of high ankle sprains, the typical swelling in the region of the anterior inferior tibiofibular ligament is often missing [21, 22]. Therefore, clinicians should be aware that they might underdiagnose the ankle trauma by missing a considerable swelling.

A total of fourteen patients (15 %) showed total or partial rupture of the AITFL in the MRI. This is in line with data from other studies [3, 8, 9, 14, 30]. There was a high frequency of peri-, intraligamentous oedema in both the anterior (49 %) and the posterior (28 %) tibiofibular ligaments. This indicates that, even in simple ankle sprains, the syndesmotic ligaments are considerably stressed. This may explain the heterogeneous duration of healing processes in ankle sprains [16, 37].

The predominance of AITFL lesions in syndesmotic injuries is in good agreement with recent studies. This may be explained by the primary trauma mechanism of dorsiflexion combined with an external rotational component [5, 26, 32]. In the present study, 81 % of the study participants only remembered hyperdorsiflexion as trauma mechanism. The detailed foot positioning during the injury could not be described by the patients, and information from witnesses was lacking. It may be a limitation of the present study, but it may be also an indication that questioning the patient about the trauma mechanism is an insufficient diagnostic tool.

In 8.3 % of the cases, MRI additionally revealed body lesions (three osteochondral lesions and five fractures) that would have been missed in conventional radiography alone. In 21.4 % of the cases with SI, an additional fracture was diagnosed. These findings are consistent with previous reports [4, 5, 37]. The increased frequency of associated lesions in acute ankle sprains and their heterogeneity may explain the different courses of recovery from such injuries. MRI may therefore be helpful in detecting not only syndesmotic injuries, but also associated osteochondral lesions in acute ankle sprains with normal findings on plane radiographs.

Precise diagnosis of acute ankle sprains is mandatory for adequate treatment. Incorrect treatment in undiagnosed syndesmotic injuries may lead to subsequent development of joint instability, chronic pain, and degenerative changes [29].

This study has several limitations. All patients were independently examined by a senior consultant and a resident doctor; the clinical skills of these physicians should theoretically be different, which might have introduced a bias in the inter-observer reliability assessment. Additional weight-bearing radiographs that might have increased sensitivity were not carried out [7]. Interestingly, current data suggest that this method may be of questionable usefulness [18, 19]. These measurements are often limited by pain and extremity rotation, particularly immediately after injury. Therefore, weight-bearing radiographs are recommended to be made a couple of days after injury, as soon as patients tolerate bearing weight. According to our study protocol, patients received their MRI within 24 h after injury. Apart from a possible scientific benefit, additional radiographs taken a couple of days later likely would not have revealed any new, clinically relevant information for our study patients. On the other hand, they would have been exposed to additional radiation and possibly pain, which is why we decided against this examination.

Furthermore, a uniform classification system for SI without associated fractures is still missing. It may help to estimate the clinical significance of the different severity of ligament injuries detected using MRI. Future studies should focus on the development of such a grading system.

The results of this study have influenced the diagnostic and therapeutic regime in our clinic: In ankle sprains with high pain levels at rest, we now routinely recommend performing an additional MRI. In cases of partial AITFL tears, we treat with partial weight bearing using a walker. In patients with complete tears, we recommend surgical treatment, particularly in young and active patients.

Conclusion

This is the first single-centre study that has investigated reliability and accuracy of clinical tests for the diagnosis of syndesmotic injury in ankle sprains using MRI as a reference standard. The diagnostic accuracy of the clinical presentation and the common clinical diagnostic tests were insufficient to reliably detect syndesmotic injuries within 24 h post-injury. MRI revealed not only many syndesmotic injuries but also concomitant lesions to the bony structures directly after a simple ankle sprain. MRI scanning should be recommended in patients with ongoing pain at rest following ankle sprains.

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