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Original Research

Compatibility of Lauge-Hansen Classification Between Plain Radiographs and Magnetic Resonance Imaging in Ankle Fractures

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ABSTRACT

We evaluated the accuracy of the predictive injury sequences of the Lauge-Hansen (L-H) classification using magnetic resonance imaging (MRI) in patients with ankle fractures and determined the possible causes of mismatch. Sixty-five patients with ankle fractures who had a complete series of anteroposterior, lateral, and oblique radiographs and ankle MRI studies available were included. The fracture pattern was assigned by 2 senior orthopedic surgeons according to the L-H classification system. The syndesmotic ligaments, lateral collateral ligaments, and medial deltoid complex ligaments were evaluated on the preoperative MRI scans. Comparisons were performed between the predicted ankle ligamentous injury based on the radiographic L-H classification and preoperative MRI analysis. Of the 65 feet in 65 patients, 50 feet (76.9%) were classified as having a supination-external rotation (SER) fracture, 6 feet (9.2%) as having a pronation-external rotation fracture, 4 feet (6.2%) as having a supination adduction fracture, and 2 feet (3.1%) as having a pronation abduction fracture. The overall compatibility of the radiologic classification with the MRI classification was 66.1%. In the evaluation of 50 feet with the MRI SER designation, maximum compatibility was found for stage 4 (77.3%). The main cause for the discrepancy in the SER designation was missing the presence of deltoid ligament disruption on the plain radiographs, especially in the stage 2 and 3 SER fracture pattern. In the evaluation of deltoid complex injuries, all injuries were localized to the anterior part of the medial deltoid complex. The validity of the L-H classification system was low. A new classification system is needed to address the medial malleolus fracture or deltoid complex injuries without posterior injury. Also, stress radiographs could be added to standard radiographs for the classification to address deltoid complex injuries.

The goal of ankle fracture treatment is to restore tibiotalar joint congruency and stability; therefore, identifying ligamentous injuries in the setting of ankle fractures is critical for treatment decisions (1). Missed injuries carry an inherent risk of poor outcomes. The rate of posttraumatic ligamentous ankle osteoarthritis in a retrospective cohort was 13%, and 36% of these patients had undergone surgical ligamentous repair of the involved side (2). Additionally, persistent pain after ankle surgery at 1 year was reported by nearly 60% of patients, with 18.9% of patients reporting severe pain (3).

The mechanism of an ankle fracture is complex, and its precise definition is often difficult. In addition to damage to the bone itself, the ligaments can be injured. The Lauge-Hansen (L-H) classification system was designed to predict the mechanism and ligamentous injury patterns of ankle fractures on radiographs. Using biomechanical testing on cadaveric ankles, Lauge-Hansen reported reproducible fracture patterns depending on the foot position and direction of the deforming force (4). Although the L-H classification is accepted as a key tool for evaluation of possible ligamentous injuries, the quality, validity, and reproducibility of this system have been challenged (5–7). The low reproducibility rates for L-H classification could have resulted from the lack of stress views for evaluation of medial soft tissue injuries. Previous studies have clearly demonstrated that both gravity and manual stress radiographs have high sensitivity and specificity for medial sided injuries (8). In magnetic resonance imaging (MRI) studies, the compatibility ratio of L-H

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classification between radiographs and MRI was reported to be 47% to 85% (5,9).

The purpose of the present study was to evaluate the accuracy of the predictive injury sequences by L-H classification using MRI in a series of patients with ankle fractures and to evaluate the possible causes of mismatch.

Materials and Methods

After approval by the institutional review board, our database was scanned retrospectively for both International Classification of Diseases codes S82.841-846 S82.851-856, and S82.61-66 from January 2013 to December 2016 (10) and those patients who had undergone operative repair. Patients with a complete series of anteroposterior, lateral, and oblique radiographs and ankle MRI studies were included in the present study. Of the 153 ankle fractures treated operatively during the study period, 65 feet in 65 patients met the inclusion criteria.

The fracture pattern was assigned by 2 senior orthopedic surgeons (H.Ç., Y.İ.) as 1 of the 4 L-H designations on anteroposterior, oblique, and standard lateral radiographs. Otherwise, the injury was determined to be unclassifiable based on the constellation of osseous injuries (11). If a discrepancy was noted between the 2 reviewers, the images were viewed together to reach a consensus.

MRI was performed with extremity coil and spin echo T1-weighted axial, sagittal, and coronal sequences with a 3.5-mm thickness (Signa HDxt; 1.5 Tesla; General Electric, Boston, MA). The interval from injury to MRI was 1 to 2 days.

The ligaments around the ankle were evaluated by a musculoskeletal radiologist (F.Ç.). The ligaments were classified as syndesmotic ligaments, lateral collateral ligaments, and the medial deltoid complex. In the syndesmotic ligaments, the posterior tibiofibular ligament, anterior tibiofibular ligament (ATFL), transverse ligament, and interosseous membrane were assessed. In the lateral collateral ligaments, the calcaneofibular ligament, posterior talofibular ligament, and anterior talofibular ligament were assessed. The tibionavicular ligament (TNL), tibiospring ligament (TSL), tibiocalcaneal ligament, deep anterior tibiotalar ligament (dATTL), and deep posterior tibiotalar ligament were assessed as the medial deltoid complex (12). Ligament rupture was considered present only when a complete injury had occurred.

Comparisons were performed between the predicted ankle ligamentous injury using the radiographic L-H classification versus the preoperative MRI assessment of ankle fractures, with the MRI scans considered the reference standard.

Statistical Analysis

The mean, standard deviation, frequency, and ratio were used for the descriptive statistics. The distributions of the variables were examined using the Kolmogorov-Smirnov test. Spearman's rho correlation coefficient was used to examine the compatibility among the stages of the supination-external rotation (SER) fracture pattern.

Results

A total of 65 patients (65 feet) were included in the present study. The mean patient age was 41.3 ± 15.4 years. Of the 65 fractures, 50 (76.9%) were classified as SER, 6 (9.2%) as pronation-external rotation (PER), 4 (6.2%) as supination adduction (SAD), 2 (3.1%) as pronation abduction (PAB), and 3 (4.7%) as unclassified on radiologic evaluation. The stages of injury in terms of the L-H designations are listed in Table 1.

The overall compatibility of the radiologic classification with the MRI classification was 66.1%. The compatibility of each L-H designation is listed in Table 2. Owing to the lower number of patients in the PER, SAD, and PAB subgroups, only the SER subgroup (n = 50) was evaluated further to determine the reasons for the discrepancy.

Table 1
Distribution of injury stages using Lauge-Hansen designations (N = 62 feet in 62 patients)

L-H Classification	Stage 2	Stage 3	Stage 4
SER	15 (30)	13 (26)	22 (44)
PER	0 (0)	4 (66.7)	2 (33.3)
SAD	4 (100)	0 (0)	0 (0)
PAB	0 (0)	2 (100)	0 (0)

Data presented as n (%).
Abbreviations: L-H, Lauge-Hansen; PAB, pronation abduction; PER, pronation external rotation; SAD, supination adduction; SER, supination-external rotation.

Table 2
Correlation of standard radiographic classification with magnetic resonance imaging classification of ankle fractures (N = 62 ankle fractures)

L-H Classification	Correlation*	
	Yes	No
SER	32 (64)	18 (36)
PER	4 (66.7)	2 (33.3)
SAD	4 (100)	0 (0)
PAB	1 (50)	1 (50)
Total	41 (66.1)	21 (33.9)

Data presented as n (%).
Abbreviations: L-H, Lauge-Hansen; PAB, pronation abduction; PER, pronation external rotation; SAD, supination adduction; SER, supination-external rotation.
* Spearman's rho correlation coefficient = 0.281.

Table 3
Correlation of standard radiographic classification with magnetic resonance imaging classification of supination-external rotation designation (n = 50 ankle fractures)

Stage	Correlation*		Total
	Yes	No	
2	10 (66.7)	5 (33.3)	15 (100)
3	5 (38.5)	8 (61.5)	13 (100)
4	17 (77.3)	5 (22.7)	22 (100)
Total	32 (64)	18 (36)	50 (100)

Data presented as n (%).
* Spearman's rho correlation coefficient = 0.285.

In the evaluation of 50 patients with an MRI SER designation, the maximum compatibility was found for stage 4 (77.3%) and the lowest compatibility for stage 3 (38.5%). No significant association was found between the stage and compatibility in the patients with a SER designation (Table 3). The main cause for the discrepancy in the SER designation was missing the presence of a deltoid ligament disruption on plain radiographs. This could have also resulted from the lack of stress views, especially for the stage 2 and 3 SER fracture patterns. Most cases with a stage 3 SER fracture pattern were accompanied by a deltoid ligament complex injury. In 4 cases (26.6%) of a stage 2 SER fracture pattern, a deltoid ligament complex injury was seen without a posterior malleolus fracture or syndesmotic ligament injury. In 4 cases (22.7%) of a stage 4 SER fracture pattern, a medial malleolus fracture was seen without a posterior malleolus fracture or syndesmotic ligament injury. In 2 cases (9%) of a stage 4 SER fracture pattern, a deltoid complex injury with a medial malleolus fracture was present. An ATFL rupture was seen in only 11 patients (22%) with a SER fracture pattern. In 8 of the remaining patients (16%), no traumatic edema was found on the MRI sections of the ATFL.

In the evaluation of deltoid complex injuries, 3 TSL, 4 TNL, and 2 TNL plus dATTL injuries were identified. All injuries were localized to the anterior part of the medial deltoid complex. No injuries were detected on the posterior part of the deltoid complex (tibiocalcaneal ligament and deep posterior tibiotalar ligament) (Fig. 1).

Discussion

In our study, we aimed to evaluate the accuracy of the predictive injury sequences by L-H classification using MRI in a series of patients with ankle fractures. The most important finding was the low overall compatibility between the classification using plain radiographs versus MRI. The L-H classification has been controversial. Although Gardner et al (9) found a 53% mismatch between plain radiographs and MRI in 59 patients, Warner et al (5) found that 85% of