The Journal of Foot & Ankle Surgery 54 (2015) 531–535

Contents lists available at ScienceDirect

The Journal of Foot & Ankle Surgery

journal homepage: www.jfas.org

Manual Stress Ankle Radiography Has Poor Ability to Predict Deep Deltoid Ligament Integrity in a Supination External Rotation Fracture Cohort

Patrick C. Schottel, MD [1], Peter D. Fabricant, MD, MPH [1], Marschall B. Berkes, MD [2], Matthew R. Garner, MD [1], Milton T.M. Little, MD [3], Keith D. Hentel, MD [4], Douglas N. Mintz, MD [5], David L. Helfet, MD [6], Dean G. Lorich, MD [7]

[1] *Resident, Orthopaedic Trauma Service, Hospital for Special Surgery, New York, NY*
[2] *Department of Orthopaedic Surgery, Landstuhl Regional Medical Center, Landstuhl, Germany (United States Air Force)*
[3] *Fellow, Orthopaedic Trauma Service, Harborview Medical Center, Seattle, WA*
[4] *Chief, Emergency and Musculoskeletal Imaging, and Associate Professor, Department of Clinical Radiology, New York Presbyterian Hospital/Weill Cornell Medical College, New York, NY*
[5] *Associate Attending Physician, Department of Clinical Radiology, Hospital for Special Surgery, New York, NY*
[6] *Director, Orthopaedic Trauma Service, Hospital for Special Surgery and Weill Cornell Medical College, New York Presbyterian Hospital, New York, NY*
[7] *Associate Director, Orthopaedic Trauma Service, Hospital for Special Surgery and Weill Cornell Medical College, New York Presbyterian Hospital, New York, NY*

ARTICLE INFO

Level of Clinical Evidence: 2

Keywords:
ankle fracture
deep deltoid ligament
SER
stress ankle radiography
supination external rotation

ABSTRACT

Stress ankle radiographs are routinely performed to determine deep deltoid ligament integrity in supination external rotation (SER) ankle fractures. However, variability is present in the published data regarding what medial clear space (MCS) value constitutes a positive result. The purposes of the present study were to evaluate the diagnostic accuracy of different MCS cutoff values and determine whether this clinical test could accurately discriminate between patients with and without a deep deltoid ligament disruption. MCS measurements were recorded for stress ankle injury radiographs in an SER ankle fracture cohort. Preoperative ankle magnetic resonance imaging studies, obtained for all patients, were then read independently by 2 musculoskeletal attending radiologists to determine deep deltoid ligament integrity. The MCS measurements were compared with the magnetic resonance imaging diagnosis using receiver operating characteristic analyses to determine the sensitivity, specificity, and optimal data-driven cutoff values. SER II-III patients demonstrated a mean stress MCS distance of 4.3 ± 0.98 mm compared with 5.8 ± 1.76 mm in the SER IV cohort ($p < .001$). An analysis of differing MCS positive cutoff thresholds revealed that a stress MCS of 5.0 mm maximized the combined sensitivity and specificity of the external rotation test: 65.8% sensitive and 76.5% specific. Using the receiver operating characteristic curve analysis of the MCS measurement, the calculated area under the curve was 0.77, indicating inadequate discriminative ability for diagnosing SER pattern fractures with or without a deep deltoid ligament tear. Judicious use of additional diagnostic testing in patients with a stress MCS result between 4.0 mm and 5.5 mm is warranted.

The deltoid ligament is a broad and strong ligament that is commonly considered the primary medial-side static stabilizer of the ankle and is composed of superficial and deep components (1–3). The deep deltoid ligament is of primary importance in preventing lateral displacement and external rotation of the talus (4–6). Close (4) found that cadaveric specimens with an excised fibula and intact deep deltoid ligament demonstrated not more than 2 mm of lateral talar translation (4). Additionally, clinical studies have found that patients with an isolated lateral malleolus fracture and intact deep deltoid ligament (e.g., supination external rotation II or SER II fracture) have excellent outcomes after nonoperative treatment (7–9). However, in cases of greater injury severity, such as with supination external rotation IV (SER IV) equivalent ankle fractures, deep deltoid ligament incompetence is the hallmark of an unstable ankle joint. Clinical studies have found improved patient outcomes when unstable SER IV injuries were treated with open reduction and internal fixation

Financial Disclosure: None reported.
Conflict of Interest: None reported.
Address correspondence to: Patrick C. Schottel, MD, Orthopaedic Trauma Service, Hospital for Special Surgery, 535 East 70th Street, New York, NY 10021.
E-mail address: Schottel@gmail.com (P.C. Schottel).

1067-2516/$ - see front matter © 2015 by the American College of Foot and Ankle Surgeons. All rights reserved.
http://dx.doi.org/10.1053/j.jfas.2014.07.007

(10–12). Therefore, the accurate diagnosis of a deep deltoid ligament tear in an SER ankle injury cohort with an isolated lateral malleolus fracture is of great clinical importance, because this information can significantly influence the decision between nonoperative and operative treatment.

A common method for detecting a deep deltoid ligament disruption in patients with an isolated lateral malleolus fracture and no evidence of lateral talar subluxation is manual external rotation stress radiography (13). This examination is performed by internally rotating the tibia to obtain a mortise view and then firmly dorsiflexing the ankle and externally rotating the foot. The medial clear space (MCS) is the measured distance between the medial aspect of the talus at the talar dome and the lateral articular surface of the medial malleolus. Clinical studies have established different MCS values ranging from 4 to 5 mm for diagnosing a deep deltoid ligament disruption (14–16). However, to our knowledge, no study has clinically examined the sensitivity and specificity of different MCS distances or whether other predictor variables such as an MCS increase, percentage of MCS increase, or the ratio between the MCS and superior clear space (SCS) are of greater clinical value.

Therefore, the purpose of the present study was twofold: (1) to determine the diagnostic accuracy of 4 stress ankle radiograph MCS measurements (absolute MCS, MCS increase, MCS percentage of increase, and MCS/SCS ratio) in identifying deep deltoid ligament disruption in magnetic resonance imaging-confirmed SER II/III and SER IV ankle fractures; and (2) to determine whether any of these 4 predictor variables were able to accurately discriminate between patients with and without a deep deltoid ligament disruption.

Patients and Methods

Patients with an isolated SER pattern Weber B lateral malleolus fracture (Orthopaedic Trauma Association type 44-B1) were identified from an institutional review board–approved registry of the senior author's (D.G.L.) patients with ankle fracture treated at New York Presbyterian Hospital/Weill Cornell Medical College from October 2006 to January 2013 (17). All patients with injury radiographs, an external rotation stress radiograph, and an ankle magnetic resonance imaging (MRI) study within 1 week of the injury were initially included for analysis. Patients with obvious lateral talar subluxation and an injury nonstress absolute MCS greater than 5 mm were excluded, because these patients were clinically judged to have an incompetent deltoid ligament. All stress radiographs were performed by an on-call orthopedic resident who had received previous training on the proper ankle stress radiograph technique by 1 of 2 dedicated orthopedic trauma surgeons and a chief orthopedic resident. Ankle MRIs were obtained for all patients with an ankle fracture with an isolated SER pattern Weber B lateral malleolus fracture by the senior investigator. MRIs were either performed at the time of injury in the emergency department or on the patient's initial outpatient office visit to evaluate the integrity of the deltoid and syndesmotic ligaments. All patients with evidence of deep deltoid disruption were encouraged to undergo open reduction and internal fixation of their lateral malleolus fracture.

The MCS was measured as a line extending from the medial articular talar surface at the level of the talar dome to the lateral articular surface of the medial malleolus (Fig. 1). The MCS was measured on both a nonstress mortise view and a stress mortise radiograph by 3 independent orthopedic surgeons (M.B.B., M.R.G., M.T.M.L.), who were unaware of the clinical findings. SCS was measured as the vertical distance of the lateral tibiotalar articulation for the stress mortise radiograph. Four predictor variables were created by averaging the values from each rater: the absolute stress radiograph MCS, the MCS increase (stress MCS minus the nonstress MCS), percentage of MCS increase (calculated from the MCS increase divided by the nonstress MCS), and the MCS/SCS ratio. The percentage of MCS and the MCS/SCS ratio were used to normalize the data to account for the inherent variability in the size of each individual's joint space.

To correctly classify the ankle fractures as either an SER II/III or IV injury, 2 fellowship-trained musculoskeletal attending radiologist (K.D.H., D.N.M.), who were unaware of the findings, retrospectively and independently read all preoperative ankle MRI studies with particular attention to the integrity of the deep deltoid ligament. An ankle fracture was classified as an SER II/III injury if the deep deltoid was judged to be either intact or to have a low-grade tear. Low-grade tears were characterized by only partial loss of the normal ligament striation pattern and a minimal or no increase in ligament signal intensity. SER IV equivalent fractures had either a high-grade or complete deep deltoid ligament tear. High-grade tears were characterized by diffuse loss of normal ligament architecture, as evidenced by sporadically oriented or absent ligament striations and abnormally increased ligament signal intensity. MRI studies were performed on a 1.5 Tesla unit (Signa Horizon LX, General Electric Medical Systems, Milwaukee, WI) with an extremity coil. All discrepancies in the MRI readings were settled by consensus between the attending musculoskeletal radiologists to create a single outcome variable.

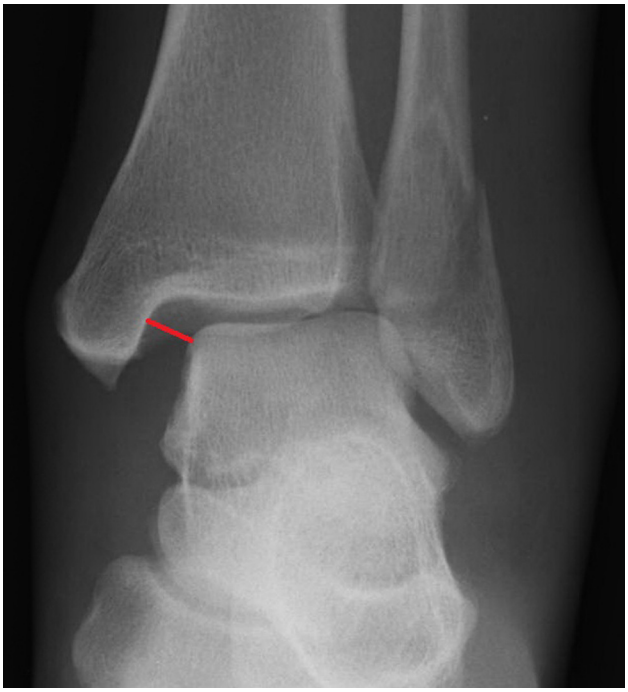

Fig. 1. The medial clear space was measured as a perpendicular line extending from the medial articular talar surface at the level of the talar dome to the lateral articular surface of the medial malleolus.

A total of 53 patients fulfilled the inclusion criteria for the present study. One patient was excluded because of a nonstress radiograph MCS measurement of 5.74 mm (the stress radiograph MCS was 12.35 mm). The mean patient age of the remaining 52 patients was 48 (range 22 to 86) years, and 54% (28 of 52) were male. An SER II/III diagnosis was made in 26 patients (50%) from the preoperative MRI findings. The remaining 26 patients (50%) were classified with an SER IV-equivalent injury.

Statistical analyses were performed by 1 of us (P.D.F.) with advanced training in biostatistics using Statistical Analysis Systems software, version 9.3 (SAS Institute, Cary, NC). Descriptive statistics were used to evaluate the distribution of continuous variables. The predictor variables were assessed for normality and compared between those subjects with SER II/III or IV injury status using an unpaired Student's t test. The inter-rater reliability of absolute MCS measurements was evaluated using the intraclass correlation coefficient (2,1). For outcome variables (MRI diagnosis), the percentage of agreement and Cohen's kappa were calculated for agreement between radiologists. Receiver operating characteristic (ROC) analyses were performed using a customized SAS macro to investigate whether any of the 4 predictor variables were able to adequately discriminate between those with an SER II/III or IV injury. The area under the curve (AUC) for each ROC curve was calculated, and the predictor variable discrimination adequacy was determined by comparing these with the currently accepted standards of discriminative acceptability (AUC >0.80) (18). All comparative analyses were 2-tailed, and $p \leq .05$ was used as the threshold for statistical significance.

Results

A total of 52 patients met the inclusion and exclusion criteria for our study. The mean absolute stress MCS of the SER IV group was significantly greater than that of the SER II/III cohort (5.80 ± 1.76 mm versus 4.33 ± 0.98 mm, $p < .001$). The SER IV cohort also had a significantly greater MCS increase (1.82 ± 1.39 mm versus 0.84 ± 0.76 mm, $p = .003$), percentage of MCS increase (47.01% ± 31.73% versus 24.92% ± 21.98%, $p = .005$), and MCS/SCS ratio (1.72 ± 0.58 versus 1.38 ± 0.32, $p = .012$) than the SER II/III cohort (Table 1). An absolute MCS positive cutoff value of 5 mm was 66% sensitive and 77% specific for the diagnosis of a deep deltoid ligament disruption, corresponding to a positive and negative predictive value of 74% and 69%, respectively. An alternative measurement technique