Ultrasonography as a Diagnostic Tool in Assessing Deltoid Ligament Injury in Supination External Rotation Fractures of the Ankle

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abstract

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The medial deltoid ligament is the primary stabilizing structure in the ankle joint following lateral malleolar fracture. However, medial deltoid ligament ruptures are difficult to diagnose using current imaging modalities. We hypothesized that ultrasonography can be used to accurately allow early clinical assessment of ankle fracture stability, thereby negating the need to perform plain film stress views of the acutely injured ankle. This prospective study included 12 patients (age range, 18-72) with supination external rotation fractures requiring operative fixation. Following induction of anesthesia, ultrasonography examination was performed, followed by an arthrogram under fluoroscopic screening. Radiographs, ultrasonography, and arthrographic findings were compared.

There was 100% correlation between ultrasonography and arthrogram findings. Ultrasonography accurately diagnosed medial deltoid rupture with a sensitivity of 100% and specificity of 100%. Plain film radiographs of the ankle had a sensitivity of 57.1% and a specificity of 60%. The difference between these was significant (χ² = .0091). This study demonstrates diagnostic ultrasonography to be an accurate diagnostic modality in assessing medial deltoid ligament integrity in patients with supination external rotation fractures. It offers the same sensitivity and specificity as arthrography without the need for additional invasive procedures. Its relative ease of use and lack of ionizing radiation make it a potentially useful tool, particularly in a busy trauma service.

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Supination external rotation fractures are the most common type of ankle fracture.\(^1\)\(^4\) In this fracture pattern, the supinated foot undergoes external rotation with resultant sequential failure of the bony and ligamentous structures of the ankle. First, the anterior tibiofibular ligament ruptures (stage I). As the external rotation force continues, the fibula then fractures (stage II) followed by rupture of the posterior tibiofibular ligament or fracture of the posterior malleolus (stage III).\(^5\) Finally, the medial structures fail, with either rupture of the deltoid ligament or fracture of the medial malleolus (stage IV).\(^6\)

Differentiating between a stage II and a stage IV supination external rotation fracture is clinically important, as a stage II injury signifies an intact deltoid ligament and consequently a stable ankle joint, an injury that can be potentially treated conservatively.\(^1\)\(^6\)\(^7\) In contrast, a stage IV injury implies the ankle mortise is unstable due to deltoid rupture or medial malleolar fracture with operative treatment indicated to stabilize the mortise until the fracture has healed.\(^1\)\(^6\) It is recognized that the deep deltoid ligament is the primary stabilizer of the ankle and prevents lateral talar shift and external rotation of the talus.\(^8\)

Multiple studies have shown that rupture of the deep deltoid ligament results in ankle instability after isolated lateral malleolar fracture.\(^5\)\(^6\)\(^8\)\(^11\) The problem remains as to how to definitively diagnose a deltoid ligament injury.\(^12\)\(^13\)

A variety of imaging modalities have been used to diagnose deltoid ligament rupture. Studies have shown that ecchymosis, swelling, and tenderness are not reliable signs of deltoid ligament rupture.\(^12\)\(^14\) Schuberth et al\(^15\) demonstrated deltoid ligament integrity cannot be reliably predicted by the medial clear space on radiographs of displaced lateral malleolar fractures. Manual and gravity stress radiographs have shown good reliability,\(^16\)\(^19\) but these are painful to perform on the acutely injured patient. Both scenarios are not ideal for a busy trauma service. Magnetic resonance imaging (MRI) is highly reliable in evaluating medial deltoid ligament integrity.\(^20\) However, this is an expensive and time-consuming tool that does not allow early decision making in busy trauma services. Arthroscopy has been used and described as the gold standard for assessing deltoid ligament injury,\(^15\) but this is an operative intervention.

Ultrasoundography is a safe, portable tool that can be used in an emergency department and trauma clinic. The purpose of this study was to assess the accuracy of ultrasonography as a method of diagnosing deltoid ligament injury, thereby differentiating between stage II and stage IV supination external rotation ankle fractures.

**Materials and Methods**

Study approval was obtained from our institutional ethics committee. During a 4-month period, patients with isolated lateral malleolar fractures that required surgery were recruited prospectively. This was not a consecutive series, as the primary author (S.H.) was not always available to perform the ultrasonography.

All patients had given informed consent prior to enrollment in the study and were approached on admission to hospital. Inclusion criteria included all patients >18 years who had isolated lateral malleolar fractures and underwent operative fixation. Exclusion criteria were patients with injuries that had occurred >48 hours before examination, non-English speaking patients, and patients who had renal impairment or allergies to contrast.

Plain radiographs (anteroposterior, lateral, and mortise views) were reviewed immediately after injury by the responsible operating surgeon who did not have a role to play in the study. A decision for operative fixation was made based on the plain radiographs. The deltoid ligament was considered ruptured if the medial clear space was >4 mm or was 1 mm greater than the superior joint space, or if lateral talar subluxation was present.\(^12\) If the deltoid ligament was considered ruptured according to these criteria or if there was significant displacement of the fibula, the patient was offered the option of operative fixation as per institutional protocol.

The primary author (S.H.) was blinded to the patient’s plain radiographs prior to performing ultrasonography. After induction of anesthesia and prior to tourniquet inflation, ultrasonography was performed on the injured ankle. All ultrasonographies were performed by the primary author, who completed a 3-day musculoskeletal ultrasonography course prior to the study. To assess competency, the primary author performed a number of ankle soft tissue ultrasonographies under the supervision of an experienced ultrasonographer.

A Sonosite Titan Portable Ultrasoundography machine (Sonosite, Bothel, Washington) with a standard 4-mm probe was used. The ultrasonography was conducted by placing one end of the ultrasound probe (4 cm) on the tip of the medial malleolus with the distal end of the ultrasonography probe anterior to the coronal plane. With the proximal part of the probe held fixed, the distal end of the probe was rotated posteriorly, allowing full visualization of the deltoid ligaments (Figure 3). Ultrasonography finding of complete disruption of the normal linear pattern of ligamentous fibers was taken to signify deltoid rupture. The status of the ligament was documented prior to arthrography.

The limb was then sterilized and draped, and a tourniquet was applied. Under fluoroscopic screening, 4 mL of radiopaque contrast mixed with 16 mL of normal saline was injected into the joint, and continued screening allowed determination of deltoid injury. Rapid and significant extravasations of the contrast outside of the capsule on the medial side was taken to imply significant disruption of the deltoid ligament as anything less than significant disruption would lead to the contrast exiting through the lateral malleolar fracture (the path of least resistance).

The results of the arthrogram, ultrasonography, and plain films were compared.
Descriptive statistical analysis and receiver operating characteristic (ROC) analysis were used to analyze the data.

RESULTS

During the 4-month study period, there were 16 isolated lateral malleolus fractures in adults requiring operative intervention. Twelve patients (8 men and 4 women) consented to the study. Average patient age was 41 years (range, 18-72 years). Indications for surgery were talar shift/angulation, displaced lateral malleolar fractures, or both. All patients underwent open reduction and internal fixation, consisting of an interfragmentary compression screw and a lateral neutralization plate and screws. None of the patients had surgery to the medial side; none required a syndesmosis screw, and none had a posterior malleolar fracture.

Regarding assessment of deltoid ligament integrity, arthrography was considered to be the gold standard.21 Arthrography demonstrated that 7 of the 12 patients had complete deltoid ligament rupture (prevalence, 58.3%). Review of the radiographs for widening of the medial clear space at the time of injury yielded a true positive of 4 cases and false negative of 3 cases, for a sensitivity of 57.1% (confidence interval [CI], 18.4%-90.1%) and a specificity of 60% (CI, 14.7%-94.7%). Ultrasonography of the ankle (Figures 1, 2) yielded 7 true positive findings and 5 true negative cases, for a sensitivity of 100% (CI, 95.2%-100%) and a specificity of 100% (CI, 47.8%-100%). Comparison of the diagnostic methods using ROC analysis (0.59 for plain radiographs and 1.00 for ultrasonography) demonstrated a significant difference between the 2 diagnostic modalities ($\chi^2 = 0.0091$) (Table).

DISCUSSION

Differentiation between stage II and stage IV supination external rotation injuries as defined by Lauge-Hansen5,22 is of clinical importance. In stage II injuries, the intact deltoid ligament stabilizes the ankle mortise, allowing the undisplaced fibular fracture to be treated nonoperatively.13 In contrast, stage IV injuries, in which either the medial malleolus is fractured or the deltoid ligament is ruptured, require operative fixation due to an unstable ankle mortise.

Diagnosis of a medial malleolar fracture supination external rotation stage IV injury is easily achieved via plain radiographs. The area of controversy lies in those injuries that show no displacement and no medial malleolar fractures on plain radiographs. As seen by previous studies, rupture of the deep deltoid ligament results in ankle instability after isolated lateral malleolar fractures.1,6,9-11 Identifying the absence or presence of a deltoid ligament injury in an undisplaced isolated lateral malleolar fracture remains key to differentiating between stage II and stage IV supination external rotation injuries. A reliable evaluation of the deltoid ligament integrity is essential to assess whether there is an indication for surgery in the minimally or undisplaced supination external rotation ankle fracture.5

Our results showed ultrasonography to be a highly accurate diagnostic modality (100% sensitivity and specificity) in the assessment of deltoid ligament. This compares favorably with other modalities in other studies. Physical examination studies including swelling, ecchymosis, and swelling have reported sensitivities ranging from 20% to 59% and specificities ranging from 59% to 97%.12-14

The use of widening of the medial clear space on plain radiographs as an indicator of deltoid ligament integrity also has been
shown to be unreliable, as controversy exists on what represents pathologic widening, with studies reporting abnormal figures to be between 4 and 5 mm. Stress radiographs have been shown to be more useful than plain radiographs alone if clinical findings also are taken into consideration. Stress radiographs are as reliable as manual stress radiographs; however, they are not accurate. In a study comparing arthroscopy to manual stress views, Schuberth et al demonstrated medial clear spaces ≥4, 5, and 6 mm had false-positive rates of 53.6%, 26.9%, and 7.7%, respectively. Koval et al observed that 19 of 21 patients (90%) who had a positive manual stress radiograph (medial clear space >2 mm) had evidence of only a partially torn deltoid ligament on MRI.

Thus, widening of the medial clear space is not reliable as an indicator of deltoid rupture. Similarly, a normal medial clear space on plain radiographs does not indicate an intact deltoid ligament. In our study, 3 patients (21%) had a ruptured deltoid ligament at arthrography despite having a normal medial clear space on plain radiographs. These patients all had shortened and displaced lateral malleolus.

Our findings corroborate earlier studies demonstrating poor sensitivity and specificity of plain radiographic examinations in supination external rotation ankle fractures. Furthermore, ultrasonography evaluation appears to be as accurate as arthrography, the gold standard selected for this study.

Limitations of our study include the small number of patients enrolled in the study. Only 1 operator performed and interpreted the ultrasonographies, which did not permit calculation of interobserver reliability. In addition, although the findings of the ultrasonography were documented prior to performing the arthrogram, the ultrasonography operator was not blinded to the results of the arthrogram. Finally, we acknowledge the most accurate method of assessing deltoid integrity is by exploration; however, this was felt to be ethically unacceptable, and although MRI would be preferable to arthrogram, this modality was not readily available within the constrained time frame.

Nonetheless, this study demonstrates the accuracy of ultrasonography in assessing deltoid ligament integrity in supination external rotation fibular fractures, and this may prove a useful adjunct in assessing the stability of ankle fractures in the future. Although further study is required, especially in assessing individual components of the deltoid ligament and their incidence of rupture, ultrason proved more accurate than plain radiographs in this study.

As the incidence of ankle fractures increases in the context of an aging population, the importance of a reliable, simple, and early diagnostic tool to allow correct and prompt diagnosis of these fractures will only increase. Although further study and trials are required, we have shown that with training, ultrasonography is an accurate tool for deltoid ligament assessment. Ultrasonography of the acutely injured ankle should be considered as a potential imaging modality that can be used in busy trauma units to help expedite clinical decision making.

### References


