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MRI of Isolated Distal Fibular Fractures with Widened Medial Clear Space on Stressed Radiographs: Which Ligaments Are Interrupted?

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Abstract

OBJECTIVE—Patient management choices in ankle fractures remain controversial because of ambiguities in assessing ankle stability and lack of information on the integrity of all supporting ligaments. Our objective was to use MRI to identify the range of ankle ligament injuries associated with a problematic subset of ankle fracture: isolated fibular fractures for which widened medial clear space is absent or minimal on standard ankle radiographs but evident on stress images.

CONCLUSION—In our retrospective study of 19 patients, we have categorized ligament injury and found partial or complete tears in all cases in at least two of the four major ligament groups—usually the deltoid and syndesmosis groups. The anterior inferior tibiofibular ligament of the syndesmosis suffered complete interruption in every case. The posterior tibiotalar ligament of the deltoid group, a major contributor to stability, was generally injured but, unexpectedly, most of these tears were partial.

Keywords

ankle fracture; fibula; ligaments; MRI

In cases of distal fibular fractures, as in other ankle fractures, the indication for surgical management is based on a determination of ankle stability. Ankle stability is often seen as a function of deltoid ligament integrity and has been traditionally assessed through the combination of clinical findings and standard ankle radiography. Incongruent positioning of the talus within the mortise, evidenced by a widened medial clear space, has been interpreted as an indication of deltoid ligament disruption and confirmation of a need for surgical reduction. This relatively simple approach, however, is complicated by evidence that a

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widened medial clear space is overemphasized as an indicator of deltoid integrity [1] and that the role of other ligaments has been underemphasized in ankle stability [2]. Further, radiographic measurements are indirect indicators and medial clear space can be ambiguous, as when widened medial clear space is apparent in the stress view but not in the standard mortise view. It is worth noting that this stress-positive condition may represent the largest category in isolated fibular fractures: A recent study of 101 such patients presenting with an intact mortise in standard ankle radiography series found that 65% showed widened medial clear space on stress radiographs [3].

In light of the prevalence of such injuries, the anatomic complexity of the ankle, the controversies in patient management choices, and the lack of comparable MRI studies in a clinical (as opposed to cadaveric) setting, we perceived the need for additional imaging data for this diagnostically challenging population. We report here a retrospective study on the common pattern of ligament injury evidenced on MRI of 19 patients presenting with distal fibular fractures with widened medial clear space (≥ 5 mm) on stressed radiographs but not on standard, nonstressed images.

Materials and Methods

Patients

This retrospective image review study was HIPPA-compliant and had institutional review board approval; patient consent was exempted. Review of radiologic reports between December 2003 and March 2007 found 425 fractures involving the distal fibula (either malleolar or pilon fractures). Retrospective image review of these cases identified 223 isolated distal fibular fractures. We excluded 137 patients who were stable or had normal medial clear space on both non-stressed and stressed radiographs and another 46 who were unstable or had widened medial clear space on initial nonstressed examinations. Of the remaining 40 cases with widened medial clear space on stressed examinations, only 23 underwent immediate MRI. Of these, 19 patients satisfied our remaining inclusion and exclusion criteria (outlined later). The study population ranged in age from 16 to 67 years (mean age, 42.7 years) and contained eight (42%) females (Table 1). All underwent a standardized treatment protocol for the fractures [4] and underwent MRI of the ankle soon after initial evaluation (mean interval between injury and MRI, 8.3 days; range, 0–18 days).

In those cases in which the posterior tibiotalar ligament—a component of the deep deltoid—was completely torn, patients underwent surgical treatment. If the posterior tibiotalar ligament was intact or partially torn, the patients were treated conservatively. The preferred surgical technique in our institution is open reduction internal fixation using a lateral neutralization plate and screw. The medial soft tissues, and thus the deltoid ligaments, were not examined during surgery.

Inclusion criteria were isolated distal fibular fracture, fracture line within 6 cm of the tip of the lateral malleolus, medial clear space ≥ 5 mm on a nonstressed mortise radiograph, and medial clear space ≥ 5 mm on a stressed radiograph (Fig. 1). Exclusion criteria were no pretreatment MRI or MRI delayed beyond 18 days after trauma, unstable patient requiring immediate surgical intervention for polytrauma, and open fractures.

Radiographic Imaging

Initial ankle radiography at the emergency department consisted of standard anteroposterior, mortise, and lateral views. Stress radiography was performed by a member of the orthopedic team.

MRI Protocol

The patient was placed supine in a 1.5-T MR scanner (Signa Horizon LX, GE Healthcare). With the splint removed, the injured ankle was imaged in a dedicated send–receive ankle coil in the neutral position. The following sequences were performed: sagittal T1-weighted spin-echo (field of view, 16×16 cm; TR range/TE range, 400–700/10–20; section thickness, 4 mm; section gap, 1 mm; matrix, 256×256); sagittal STIR (field of view, 16×16 cm; TR/TE, 4,000/50; inversion time, 150 milliseconds; section thickness, 4 mm; section gap, 1 mm; matrix, 256×256); oblique axial (plane bisecting axial and coronal axes) proton density–weighted fast spin-echo with fat saturation (echo-train range, 5–6; field of view, 12×12 cm; TR range/TE, 2,000–3,000/15; section thickness range, 3–4 mm; section gap, 1 mm; matrix, 512×512); axial T2-weighted fast spin-echo with fat saturation (echo-train range, 5–6; field of view, 12×12 cm; 35,000–6,000/80; section thickness, 4 mm; section gap, 1 mm; matrix, 256×256); coronal proton density–weighted fast spin-echo with fat saturation (echo-train range, 5–6; field of view, 12×12 cm; 2,000–3,000/15; section thickness range, 3–4 mm; section gap, 1 mm; matrix, 256×256).

Image Analysis

Medial clear space measurements were performed by one of the authors, a third-year radiology resident, on a PACS without knowledge of MRI findings. Medial clear space, measured on the mortise view of both routine and stress radiographs (Fig. 1), was defined as the distance between the lateral border of the medial malleolus and the medial border of the talus at the level of the talar dome.

All MRI examinations were reviewed on the hospital PACS system, first independently and then in consensus by two musculoskeletal radiologists (with 8 and 13 years of experience in musculoskeletal imaging). Patient demographics on the images were not blinded during MRI review. Components of four groups of ligaments around the ankle—deltoid, syndesmosis, lateral collateral, and sinus tarsi—were judged as intact (grade 1), partially torn (grade 2), or completely torn (grade 3) (Fig. 2). Grade 1 included cases that had severe soft-tissue edema surrounding an intact ligament. Ligaments with partial tears (grade 2) had irregular contour, fluid signal occupying part of the ligament, and some strands of residual intact fibers. Nonvisualization or discontinuity of the ligament was considered grade 3. Only the 11 most frequently visualized components were graded, and these are listed, with published sources used in establishing “normal” MR appearance, in Table 2.

Data Analysis

We used a modified binomial test to evaluate the hypothesis that the ligament grade is randomly distributed over the three defined grades. The level of significance was set at $p < 0.05$. When p was < 0.05 , the grade for the ligament was not randomly distributed or at least one grade was overrepresented.

Results

The integrity of 11 ligaments found in the four principal ankle ligament groups was retrospectively graded for 19 patients on the basis of MRI examinations after radiographic findings of widened medial clear space (Figs. 1, 3, and 4). The results are presented in Table 1, and the distribution of the three defined grades among the four groups of ligaments is summarized and charted in Figure 5.

Discussion

The results of the retrospective analysis for this subset of fibular fractures show that concomitant tears of multiple groups of ligaments are common and complex and in some cases at variance with expected results. Partial or complete tears were found in all cases in at least two of the four major ligament groups, with tears concentrated in the deltoid and syndesmosis groups. The anterior inferior tibiofibular ligament of the syndesmosis suffered complete interruption in every case (19/19). As expected, the posterior tibiotalar ligament of the deltoid group, a major contributor to stability, was generally injured (18/19), but significantly, in 83% (15/18) of cases the tears were partial. The posterior inferior tibiofibular ligament, a posterior component of the syndesmosis, remained intact in 38% (7/19) of patients despite concurrent injuries to the posterior tibiotalar ligament and the anterior inferior tibiofibular ligament (Fig. 4).

The present study is not the first to challenge the reliability of radiographic measurements as predictors of ligament integrity [5, 6]. More specifically, an arthroscopic study examined a similar but broader population of isolated fibular fractures, correlating a non-stressed medial clear space with posterior tibiotalar ligament tears, and concluded that a nonstressed medial clear space value between 2 and 6 mm is indeterminate for deep deltoid ligament tears [1], and we concur. Our study, however, is the first, to our knowledge, to systematically examine with MRI in a clinical setting the ligament injury consequent to this specific subset of distal fibular fracture. Furthermore, we report findings that differ in several important respects from earlier studies.

Although the number of complete (grade 3) posterior tibiotalar ligament tears in our study was similar to the arthroscopic study (16% vs 14%), there was a significant difference in the reporting of partial tears (grade 2). The arthroscopic study reported very few partial posterior tibiotalar ligament tears. On the contrary, we found a preponderance of partial tears (79% or 15/19) and only a single instance of an intact posterior tibiotalar ligament. The difference is striking, and one explanation is that arthroscopy can detect only those partial tears located on the inspected or articular surface.

The lack of MRI correlation in our study between widened medial clear space measurements on stress testing and interruptions of the deltoid ligament has important clinical implications. The finding suggests that most such patients may be treated noninvasively, a conclusion at odds with established practice, which has used a medial clear space value greater than 5 mm as an indicator of deep deltoid interruption, instability, and the need for surgery.

Our findings also departed from two cadaveric studies that examined changes in the medial clear space after selective transection of ankle ligaments. In one, the medial clear space became widened (≥ 5 mm) on stressed radiographs when the deep deltoid ligament was transected [7]. The second noted pronounced talar shift when both superficial and deep deltoid ligaments were transected [8]. On the contrary, our data showed that even a partially torn posterior tibiotalar ligament could widen the stress–medial clear space. Both cadaveric studies were limited by their small sample size and conditions that did not simulate clinical settings.

Our observation that the posterior inferior tibiofibular ligament, a posterior ligament, can be intact even in cases of combined tears of the posterior tibiotalar ligament (a medial component) and the anterior inferior tibiofibular ligament (an anterior component) is at variance with the cadaveric-derived Lauge-Hansen classification system and supports an earlier MRI study that raises similar objections [9] (Fig. 4).

Our study population fits into the Lauge-Hansen category of supination–external rotation (SER) injuries, for which the predicted sequence of ligament injury or fracture equivalent is an initial injury to the anterior inferior tibiofibular ligament (SER I), followed by posterior inferior tibiofibular ligament tear or posterior malleolar fracture (SER II), and, finally, by the deltoid ligament or medial malleolar fracture (SER IV). We found, however, a 37% (7/19) incidence of cases with intact posterior inferior tibiofibular ligaments despite combined tears to both the anterior inferior tibiofibular ligament and the posterior tibiotalar ligament, a pattern which is neither SER II nor SER IV and which represents a significant deviation from Lauge-Hansen expectations. This is not surprising because many of these experiments on biomechanics and classifications were based on fractures created in cadavers.

This study has several limitations. First, we relied on published MRI criteria in classifying ligament injury. Our MRI findings were not confirmed surgically because the preferred open reduction technique in our institution was to place a fibular screw supplemented by a lateral neutralization plate without exploration of the medial soft tissues. Although published imaging studies have reported high correlations between MRI and surgical findings [10, 11], the absence of direct surgical or arthroscopic confirmation of MRI interpretations must be acknowledged.

Second, we did not evaluate all components of the ligament complexes. The excluded ligaments, however, are those that are not consistently visible even in asymptomatic individuals [12], and their exclusion was deliberate. A more comprehensive evaluation would risk overdiagnosis of tears because the absence of a ligament on MRI may represent either a complete tear or a normal variant of the ligament.

Finally, several types of biases are inherent in this descriptive case series study. Imaging-based selection bias existed because the inclusion of subjects is dependent on their having undergone MRI soon after their fracture. Therefore, the study population may not be truly representative of the target population. Reviewer bias occurred because the two authors reviewing the images were aware of the diagnosis. Blinding of the examinations was difficult because of the presence of the obvious fibular fractures on MR images. Disease

spectrum bias occurred when 5 mm was arbitrarily chosen as a cutoff for categorization of medial clear space as widened. If 4 mm was used as the cutoff for a positive test [3], we would have a larger collection and probably more partial tears. Future prospective study of all cases of distal fibular fracture and a larger sample size may eliminate many of these biases.

In conclusion, we describe the MRI findings of ligament injury in 19 patients with a combination of distal fibular fracture and ambiguous radiographic evidence of ankle stability. This survey may contribute both to more precise injury classification in the clinical setting and to more systematic outcome evaluations of treatment choices for this population. The observed injury pattern is complex and less predictable than expected and reinforces the importance of MRI in cases of isolated fibular fracture when the radiographic evidence of ankle instability is ambiguous.

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Fig. 1.
27-year-old man, case 12, who had suffered distal fibular fracture. Double-headed arrow indicates medial clear space.
A, Routine mortise view radiograph shows medial clear space is 3.7 mm.
B, Stress radiograph shows medial clear space has widened to 5.9 mm.

Fig. 2.

Examples of appearance of MRI grades of posterior tibiotalar ligament, component of deep deltoid ligament with major contribution to ankle stability.

A, Grade 1, normal, in 38-year-old woman with os trigonum syndrome and no history of trauma. Patient is not in our study group. Normal posterior tibiotalar ligament (*arrow*) has well-defined borders and normal striations, and signal intensity is intermediate.

B, Grade 2, partial tear, in 58-year-old man with distal fibular fracture, case 9. Bright fluid signal within substance of ligament represents partially torn posterior tibiotalar ligament (*arrowhead*).

C, Grade 3, complete tear in 57-year-old woman with distal fibular fracture, case 19. Bright fluid signal transects ligament, representing complete tear of posterior tibiotalar ligament (*arrow*).

Fig. 3.

16-year-old boy with distal fibular fracture, case 1. Concomitant tears of multiple groups of ligaments are common.

A, Coronal proton density-weighted MR image with fat saturation shows heterogeneous posterior tibiotalar ligament and partial interruption of ligamentous fibers (*arrowhead*).

B, Axial proton density-weighted MR image with fat saturation shows complete tear (*arrow*) of anterior inferior tibiofibular ligament.

C, Axial proton density-weighted MR image shows partial tear (*arrow*) of posterior inferior tibiofibular ligament.

Fig. 4.

16-year-old boy with distal fibular fracture, case 2.

A and B, Posterior inferior tibiofibular ligament remains intact (*arrow*, **A**) despite concomitant tears of anterior inferior tibiofibular ligament and posterior tibiotalar ligament (*arrowhead*, **B**). This combination departs from predicted injury sequence based on Lauge-Hansen classification, which predicted initial anterior inferior tibiofibular ligament tear (anterior component), followed by posterior inferior tibiofibular ligament tear (posterior component), and last, deltoid tear (medial component).

Fig. 5.

Graphic shows distribution of ligament tears. pTTL = posterior tibiotalar ligament, TCL = tibiocalcaneal ligament, TSL = tibiospring ligament, AITFL = anterior inferior tibiofibular ligament, PITFL = posterior inferior tibiofibular ligament, IOM = interosseous membrane, ATAF = anterior talofibular, CF = calcaneofibular, PTAF = posterior talofibular, ICL = intercarpal ligament, CL = cervical ligament.

TABLE 2

Graded Ankle Ligaments and Reference Sources

Ligament	Components	Published Source for “Normal” Ligament Appearance
Deltoid	Posterior tibiotalar, tibiospring, tibiocalcaneal	Mengiardi et al. [12]
Syndesmosis	Anterior inferior tibiofibular, posterior inferior tibiofibular, interosseous membrane	Oae et al. [10], Brown et al. [13], Muratli et al. [14]
Lateral	Anterior talofibular, calcaneofibular, posterior talofibular	Kreitner et al. [11], Cardone et al. [15], Erickson et al. [16], Rijke et al. [17], Schneck et al. [18]
Sinus tarsi	Cervical ligament, interosseous talocalcaneal	Beltran et al. [19], Breitenseher et al. [20], Klein and Spreitzer [21], Lektrakul et al. [22]