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Does fracture obliquity in Weber B fibula fractures correlate with mortise instability?

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ABSTRACT

Background: The diagnosis of instability in the apparent, isolated distal fibula fracture can be challenging and often necessitates stress radiography. Danis & Weber classified lateral malleolar fractures based on the level of the fracture in relation to the syndesmosis. While Weber B fractures occur at the level of the syndesmosis, some such injuries present with a long, oblique pattern extending well above the syndesmosis. Given the well-established literature demonstrating that fractures above the syndesmosis correlate with a higher level of concomitant syndesmotic and deltoid ligament injury, we hypothesize that increased fracture obliquity, length and height of Weber B fibula fractures similarly correlates with increased mortise instability.

Methods: All patients with isolated Weber B fibula fractures who underwent gravity stress radiography met inclusion criteria. Fracture height was measured on mortise radiographs as: (1) the distance from the distal tip of the fibula to fracture apex, (2) the distance to the fracture apex as measured on a line drawn perpendicular to a line parallel to the plafond, (3) an angle subtended by a line drawn parallel to the plafond and a line drawn to the fracture apex and (4) a ratio of the absolute length as compared to fibular width.

Results: 51 patients were included in the study. The group of 39 patients with stable ankles had a mean medial clear space of 3.12 ± 0.65 mm (range, 1.5 mm to 4.0 mm). The group of 12 patients with unstable ankles had a mean medial clear space of 6.29 ± 3.11 mm (range, 4.1 mm to 14.0 mm). These groups showed no significant difference in fracture angle ($p = 0.93$), fracture height from plafond ($p = 0.49$), fracture height from tip of fibula ($p = 0.42$), and as a ratio of absolute length to fibular width ($p = 0.85$).

Conclusion: Increased fracture obliquity, length and height of Weber B fibula fractures did not correlate with a higher incidence of mortise instability. Despite the lack of positive correlation, future studies should continue to investigate and identify radiographic parameters of distal fibula fractures that are most predictive of instability.

Introduction

The diagnosis of instability in the apparent, isolated Weber B fibula fracture presenting with an anatomic mortise can be challenging and often necessitates stress radiography. Whether gravity or external rotation stress testing is performed, issues such as patient discomfort, increased radiation exposure, cost, additional time and delayed office throughput are not insignificant. Recently, Nortunen et al. examined radiographic characteristics of non-stress radiographs and concluded that patients with non-comminuted lateral malleolar fractures could be diagnosed with a stable mortise without stress testing when fracture displacement was <2 mm on lateral radiographs [1]. While a significant finding, visualization and measurement of the fracture and its displacement on lateral radiographs can be difficult.

The Danis-Weber classification of ankle fractures was developed based on the location of the fibula fracture in relation to the syndesmosis with a corresponding inference on mortise stability. While the majority of Weber B fibula fractures demonstrate a stable mortise (corresponding to the Lauge-Hansen supination external rotation II injury (SER II)), the majority of Weber C fibula fractures demonstrate both deltoid and syndesmotic disruption resulting in an unstable mortise [2–5]. While the prevailing dogma

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as initially proposed by Lauge-Hansen has been that trans-syndesmotic fractures differ in injury mechanism and foot position as opposed to supra-syndesmotic fractures, multiple challenges to the validity of his mechanistic theory have been levied [6–11]. Furthermore, Haraguchi et al. demonstrated in a cadaveric model that both a pronated and supinated foot could lead to the Weber B fracture pattern and that mechanism was a more likely determinant of fracture height [12].

Although all trans-syndesmotic fibula fractures are by definition classified as Weber B fractures, significant variations in fracture length, height and obliquity are seen clinically. Given the well-established literature demonstrating that fractures above the syndesmosis correlate with a higher level of concomitant syndesmotic and deltoid ligament injury, we postulate that Weber B fibula fractures with such a morphology are more similar pathophysiologically to Weber C fibula fractures and will demonstrate a higher degree of mortise instability [13–15]. Conversely, we hypothesize that short, oblique patterns are more similar to Weber A fibula fractures with a higher incidence of stability.

The purpose of this study was to assess whether increased height (representing a long, oblique pattern) of the fibula fracture in patients presenting with an isolated Weber B injury correlates with a higher incidence of mortise instability. If this association is found, it could give additional information to help providers determine mortise instability without the need for stress radiography.

Methods

Institutional review board approval was obtained for this study. All consecutive patients from August 1, 2017 to December 31, 2018 who presented with an apparent, isolated Weber B fibula fracture underwent prospective data collection. Exclusion criteria included patients who sustained ankle fractures from a non-rotatory mechanism of injury. Demographic data was obtained such as age, gender, fracture classification and relevant comorbidities.

All patients had non-weightbearing AP, mortise and lateral ankle radiographs as well as a gravity stress radiography performed as initially described by Gill, et al. [16] The medial clear space (MCS) was measured using a digital measuring tool (DICOM) as a line from the medial most cortical border of the talus to the lateral most border of the medial malleolus 5 mm inferior to the talar dome as described by DeAngelis and others [17,18]. Fibular height (a proxy for obliquity) was measured on mortise radiographs due to the fact that the fracture apex was best visualized on this view. Visualization of the fracture on lateral radiographs was obscured by the tibia and was often poorly characterized due to radiograph obliquity. Fracture height was measured in 4 different ways: (1) as an absolute distance (mm) from the distal tip of the fibula to fracture apex, (2) as the distance to the fracture apex as measured on a line drawn perpendicular to a line parallel to the plafond, (3) as an angle subtended by a line drawn parallel to the plafond and a line drawn to the fracture apex and (4) as a ratio of the absolute length as compared to fibular width (Fig. 1). The angular measurement as well as the ratio calculation were performed so as to have a measurement independent of patient/fibular size.

The radiographic parameters were then compared to the results of the gravity stress view to determine if any association existed between the measured radiographic parameters and instability as defined by an MCS > 4.0 mm on stress radiography [19,20]. This criteria has been utilized in many studies and is well accepted as a radiographic indication of deltoid ligament injury resulting in lateralization and non-anatomic alignment of the mortise consistent with instability. All statistical analyses were performed in SPSS version 23 (IBM Corporation, Armonk, NY). Statistical significance was defined as a two-sided alpha error of less than 0.05 ($p < 0.05$).

Results

A total of 51 patients were included in the study. The group of 39 patients with stable ankles had a mean medial clear space of 3.1 ± 0.65 mm (range, 1.5 mm–4.0 mm). The group of 12 patients with unstable ankles had an average medial clear space of 6.3 ± 3.1 mm (range, 4.1 mm–14.0 mm).

These groups showed no significant difference in fracture angle ($p = 0.93$), fracture height from plafond ($p = 0.49$), fracture height from tip of fibula ($p = 0.42$), and as a ratio of absolute length to fibular width ($p = 0.85$) (Table 1).

Table 1
Comparison of fracture parameters between stable and unstable groups.

	Stable	Unstable	P Value
Mortise Radiograph			
Fracture angle (°)	26 ± 9	26 ± 10	0.93
Fracture height from plafond (mm)	26 ± 12	27 ± 12	0.49
Fracture height from tip of fibula (mm)	51 ± 13	53 ± 4	0.42
Absolute length to fibular width ratio	2.9 ± 0.82	2.9 ± 0.72	0.85

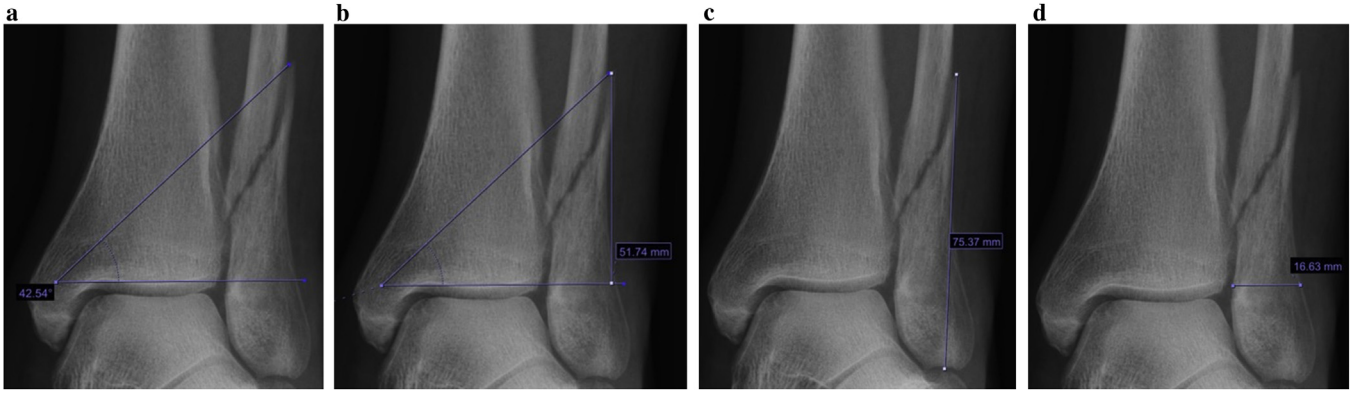

Fig. 1. Heights of isolated Weber B fibula fractures were measured on mortise radiographs and in 4 ways: (**A**) as an angle subtended by a line drawn parallel to the plafond and a line drawn to the fracture apex, (**B**) as the distance (mm) to the fracture apex as measured on a line drawn perpendicular to a line paralleling the plafond, (**C**) as an absolute distance (mm) from the distal tip of the fibula to fracture apex, and (**D**) as a ratio of the absolute length as compared to fibular width.

Discussion

The present study revealed no significant correlation between increased obliquity, length and height and mortise instability for isolated Weber B fractures. Therefore fracture height alone, in fractures classified as Weber B injuries per the Danis-Weber classification system, cannot be used as a reliable predictor for instability without stress radiography.

While previous literature has conclusively demonstrated a higher incidence of concomitant deltoid and syndesmotic injury with suprasyndesmotic fractures, our hypothesis was that fractures with long, oblique patterns extending well above the syndesmosis (despite originating at the level of the syndesmosis) would similarly have a higher incidence of instability. Given the challenges to the validity of Lauge-Hansen's mechanistic theory as well as our understanding of the above, it was our thought to investigate this hypothesis as to potentially provide a radiographic parameter on non-stress ankle radiographs that could predict instability. Although no positive correlation was discovered, previous investigations examining non-stress radiographs also did not demonstrate predictive factors of ankle mortise stability in patients with isolated Weber B fibula fractures [16,17,19,21,22]. Recently, Nortunen et al. demonstrated three radiographic variables that were highly sensitive measures of stability [1]. In their study, Nortunen and colleagues prospectively collected and reviewed non-stress radiographs of 286 consecutive patients. Their analysis revealed that a posterior diastasis of <2 mm on the lateral radiograph, only two fracture fragments, and female sex were independent factors that could be used to predict stability without further stress testing. While the results of the study were significant, one should not overlook the high-false positive rates (i.e., low specificities) of measuring posterior diastasis of <2 mm with associated measurement error [5]. Furthermore, measuring the maximum width of the fracture line on lateral radiographs can be challenging as the fracture line is often difficult to visualize.

Nonetheless, uncovering specific morphological findings on routine ankle radiographs that have the ability to predict mortise stability will have significant implications for patients and management. Future studies should continue to investigate yet to be described radiographic measurements, should they exist, that may aid in this assessment without the need for stress radiography.

There are several weaknesses that should be considered. First, although 23% of patients demonstrated instability which is similar to previously published rates, the overall cohort size was relatively small, and a larger scale study may demonstrate differential results. Second, measurements were obtained using plain radiographs. While CT scans would have allowed for more precise measurement of bony landmarks and fracture apex, the reliance on advanced imaging would have decreased any potential clinical utility if an association was demonstrated. Finally, while a lack of positive correlation was demonstrated, we feel that the findings in this investigation hold value. Understanding that fracture obliquity and height do not correlate with instability in patients sustaining apparent, isolated Weber B injuries allows both providers and researchers to focus efforts on finding other radiographic determinants of instability.

Conclusion

Increased fracture obliquity, length and height of Weber B fibula fractures did not correlate with a higher incidence of mortise instability. Despite the lack of positive correlation, future studies should continue to investigate and identify radiographic parameters of distal fibula fractures that are most predictive of instability.

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Declaration of Competing Interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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