RESEARCH ARTICLE

Gravity Reduction View: A Radiographic Technique for the Evaluation and Management of Weber B Fibula Fractures

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Abstract

Background: While various radiographic parameters and application of manual/gravity stress have been proposed to elucidate instability for Weber B fibula fractures, the prognostic capability of these modalities remains unclear. Determination of anatomic positioning of the mortise is paramount. We propose a radiographic technique, the Gravity Reduction View (GRV), which helps elucidate non-anatomic positioning and reducibility of the mortise.

Methods: The patient is positioned lateral decubitus with the injured leg elevated on a holder with the fibula directed superiorly. The x-ray cassette is placed posterior to the heel, with the beam angled at 15˚ of internal rotation to obtain a mortise view. Our proposed treatment algorithm is based upon the measurement of the medial clear space (MCS) on the GRV versus the static mortise view (and in comparison to the superior clear space (SCS)) and is based on reducibility of the MCS. A retrospective review of patients evaluated utilizing the GRV was performed.

Results: 26 patients with Weber B fibula fractures were managed according to this treatment algorithm. Mean age was 50.57 years old (range:18-81, SD=19). 17 patients underwent operative treatment and 9 patients were initially treated nonoperatively. 2 patients demonstrated late displacement and were treated surgically. Using this algorithm, at a mean follow-up of 26 weeks, all patients had a final MCS that was less than the SCS (final mean MCS 2.86 mm vs. mean SCS of 3.32) indicating effectiveness of the treatment algorithm.

Conclusions: The GRV is a radiographic view in which deltoid competency, reducibility and initial positioning of the mortise are assessed by comparing a static mortise view with the appearance of the mortise on the GRV. We have proposed a treatment algorithm based on the GRV that we found it useful in our patients in guiding treatment and achieving anatomic mortise alignment.

Keywords: Ankle fracture, Gravity stress view, Medial clear space, Superior clear space, Weber B fibula fracture

Introduction

Ankle fractures occur at a rate of 187/100,00 individuals per year and represent one of the most common injuries treated by orthopaedic surgeons (1-4). Bimalleolar equivalent fractures, classified per the Lauge Hansen classification as supination external rotation (SER) IV injuries, can represent a challenge for the orthopaedic surgeon. Extensive research has been performed regarding the assessment of stability for SER ankle fractures. While bimalleolar and trimalleolar ankle fractures are readily diagnosed radiographically, differentiating between stable Weber B fibula fractures (SER II injuries) and SER IV injuries with deltoid ligament disruption can be difficult.

Stress radiographs are a common modality used for diagnosing instability, relying upon the measurement of the medial clear space (MCS) after manual or gravity stress external rotation is applied to the fractured ankle (5). The utility of the gravity stress view (GSV) for demonstrating instability have been demonstrated in cadaveric models and confirmed in-vivo as reported

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in several clinical studies (6,7) . While stress views are routinely utilized to assess the stability of ankle fractures, more recent literature has suggested that the GSV may not provide significant benefit prognostically as patients with positive stress radiographs may have equivalent clinical outcomes with or without surgery (8). Additionally, advanced imaging modalities such as magnetic resonance imaging have not shown prognostic capabilities in assessing instability despite excellent detection of deltoid ligament injury (9).

Therefore, clinical decision-making is often based on alignment of the mortise on initial radiographs without additional stressing for the patient with a lateral malleolus fracture and an anatomically aligned mortise. As the prognostic value of external rotation stress testing has been questioned, the ability to determine whether the mortise is anatomic or not on initial views becomes increasingly important. While several radiographic criteria have been commonly utilized to determine anatomic alignment and gross displacement is easily diagnosed, subtle malalignment can still be difficult to assess (10,11).

The purpose of this paper is to propose a radiographic view for the evaluation of Weber B fibula fractures, the so-called gravity reduction view (GRV). This technique is particularly useful for determining anatomic positioning of the mortise, especially in cases where malalignment may be subtle. Moreover, this view helps the surgeon to assess reducibility of the mortise and critically assess reduction of the mortise either after cast immobilization or intraoperatively following reduction and fixation. The senior author has utilized the GRV to develop a treatment algorithm for evaluation of potentially unstable Weber B ankle fractures. In addition to describing our technique, we present results of a clinical case series utilizing the Gravity Reduction View.

Materials and Methods

Institutional Review Board approval was obtained for this study. Between February 2013 and August 2014 all patients presenting with an isolated Weber B fibula fracture to the senior author's clinic were included in the above investigation. Demographic information were obtained and patients underwent radiographic examination as described below.

Plain films of the injured ankle are first obtained with the patient supine with the traditional AP, mortise, and lateral views obtained. The traditional gravity stress view can be obtained, although not essential for the treatment algorithm described below. To obtain the GRV, the patient is positioned in the contralateral lateral decubitus position so that the injured fibula is directed upward toward the ceiling with the leg elevated with a leg holder (a foam block). The x-ray cassette is placed posterior to the heel, and the beam is directed at an angle of 15° of internal rotation to the affected ankle to obtain a mortise view [Figure 1]. Dorsiflexion of the ankle is encouraged as plantar flexed views have been previously demonstrated to artificially increase the appearance of the MCS (12). Sample views obtained for a patient with a Weber B ankle fracture with questionable MCS widening are pictured in [Figure 2A-D]. A treatment

Figure 1. Patient positioning for the gravity reduction view.

algorithm was validated based on the results of our study cohort [Figure 3]. Normal MCS is defined as a MCS that is less than or equal to the superior clear space (SCS), on the ankle mortise view. Each patient obtained at a minimum a non-weight bearing mortise view and a GRV. The treatment algorithm based on these views has three pathways:

1- If the MCS was greater than the SCS on the non-weight bearing mortise view and on the GRV (demonstrating irreducibility and non-anatomic positioning of the mortise), then operative treatment was indicated.

2- If the MCS was initially greater than the SCS on the non-weight bearing mortise view and decreased to normal limits on the GRV (demonstrating reducibility and initial non-anatomic positioning of the mortise), then operative treatment was indicated unless significant comorbid conditions favored nonoperative treatment. Reducibility indicated that nonoperative treatment, although potentially less optimal, may be a viable treatment option due to the ability to exact a closed reduction.

3- If the MCS was normal on the static view and on the GRV then non operative treatment was indicated. Repeat radiographic evaluation was performed within 1-2 weeks to ensure anatomic alignment of the mortise.

A retrospective review of all patients presenting with Weber B fibula fractures and suspected deltoid ligament injury over a 1.5 year period were analyzed and

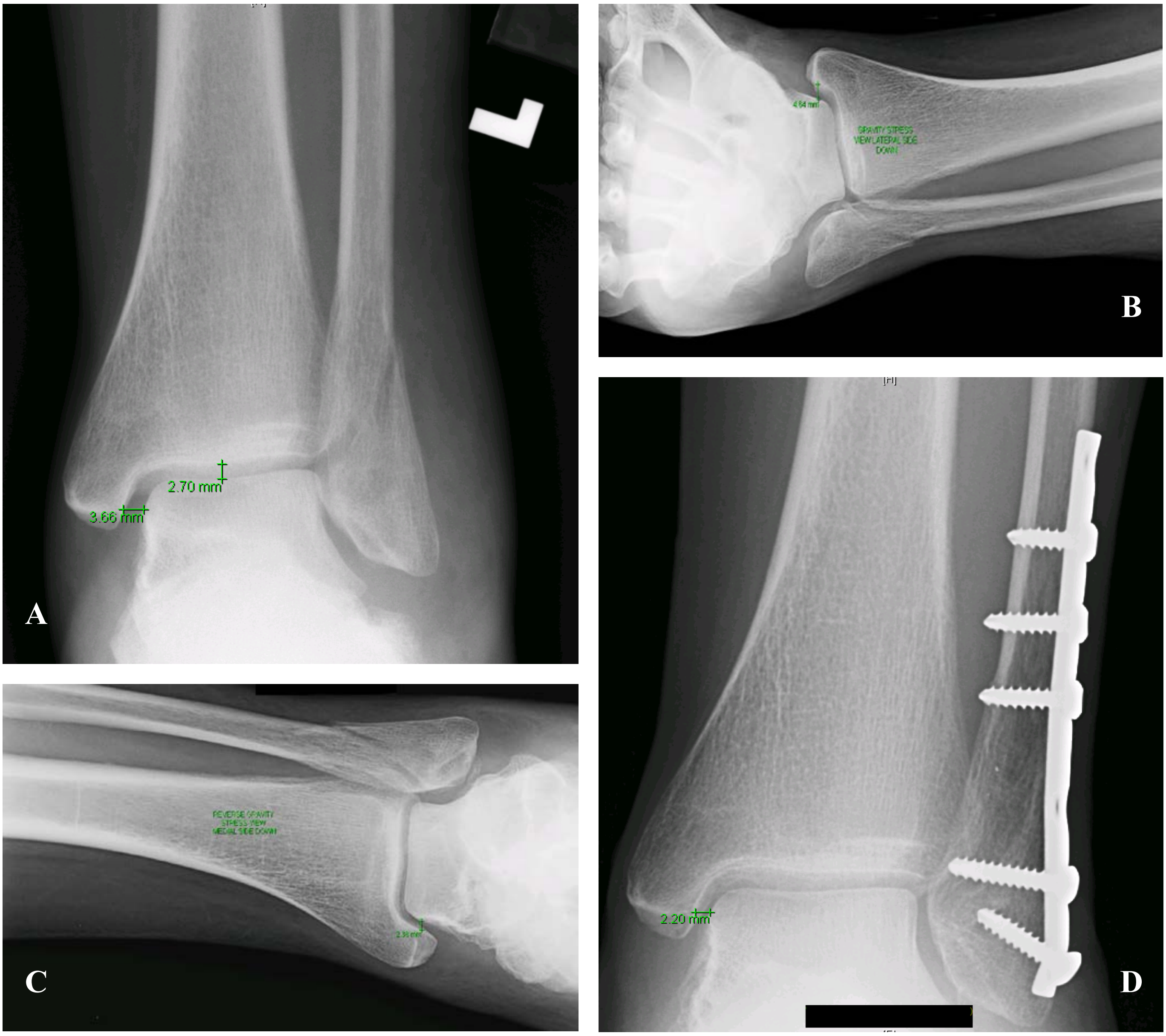

Figure 2. A- Mortise view with subtle MCS widening (SCS= 2.70 mm, MCS: 3.66 mm), B- Gravity stress view (MCS: 4.64 mm), C- Gravity reduction view (MCS: 2.38 mm), D- Postoperative view (MCS: 2.20 mm).

demographic, radiographic and fracture characteristics information was obtained.

Results

Descriptive statistics for the entire cohort is demonstrated in [Table 1]. Statistical analysis of the cohort of 26 patients demonstrated a mean age of 50.57 years of age (range: 18-81, SD=19 years). Mean follow-up was 26 weeks (range: 6-70, SD=18.4 weeks). There were 12 males (46%) and 14 females (54%). 17 cases (65%) were treated operatively and 9 cases (35%) were initially treated nonoperatively. Two patients (case ID number 17, 18) initially treated nonoperatively demonstrated late displacement and required surgical fixation. Both patients underwent standard imaging per our protocol but had suboptimal radiographs and given significant similar medical comorbidities (DM, CAD, PVD) were initially treated nonoperatively. Both were found to have displacement at 2 weeks from initial evaluation and were treated operatively. One patient in the cohort was lost to

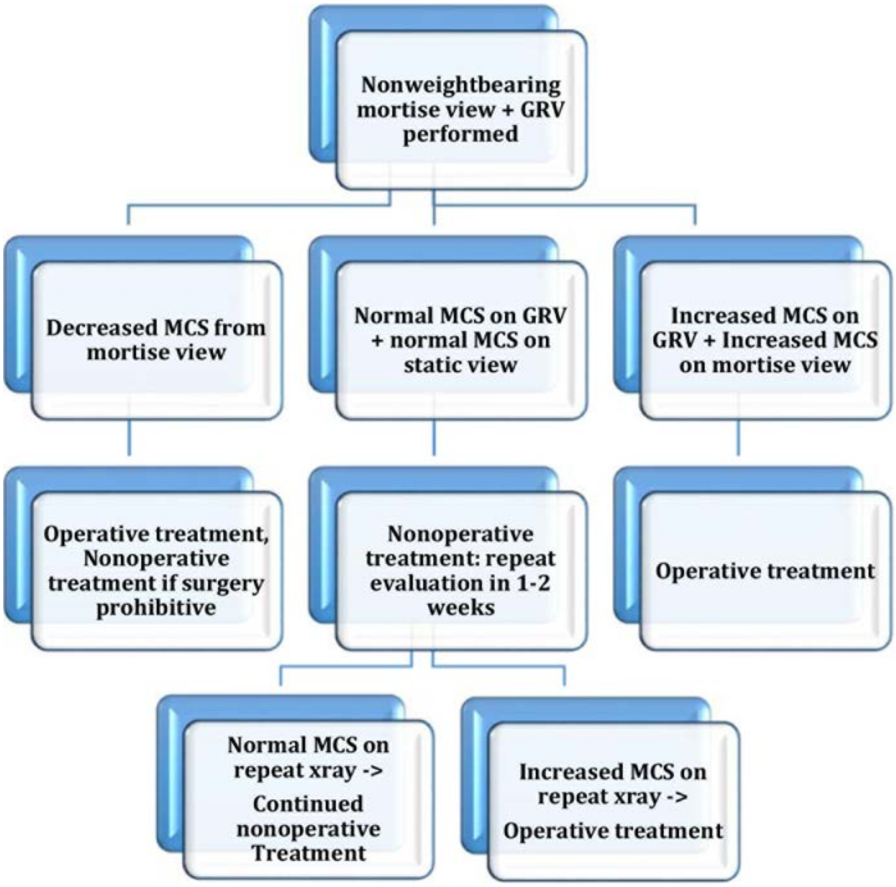

Figure 3. Flowchart for algorithm using Gravity Reduction View (GRV) for the diagnosis and management of Weber B distal fibula fractures.

follow-up immediately after initial treatment.

All radiographs were measured by a single staff orthopaedic surgeon. Analysis of the cohort of patients available for final radiographic follow-up demonstrated a mean medial clear space of 2.86 mm (range: 2.08-3.85 , SD= 0.39 mm) compared to mean superior clear space of 3.32 mm (range: 2.67-4.43 , SD= 0.39 mm) demonstrating anatomic alignment of the mortise per criteria established by Deangelis, et al. (13).

Discussion

As noted by Michelson *et al.* in their introduction of the gravity stress view, "Central to the clinical evaluation of ankle fractures is the determination of stability, defined as normal motion under physiologic conditions (6)." Stress radiographs have since become a commonly used modality for the diagnosis of such instability. In 2001, Michelson *et al.* demonstrated that after complete deltoid transection and fibular osteotomy in cadaver ankles, the talus reliably showed a lateral shift of at least 2 mm and a valgus tilt of at least 15 degrees (6). Tornetta *et al.* described their experiences with the measurement of MCS on stress radiographs to determine the need for operative stabilization, with MCS of 4.8 mm indicative of stable injuries amenable to non-operative treatment and MCS of 6.9 mm treated operatively (7).

First validated in cadaver models, manual and/or gravity external rotation stress views are frequently used to assess instability as visualized by displacement of the ankle mortise with the patient positioned in the lateral decubitus position and the medial side of the ankle positioned superiorly. When a fibula fracture is associated with a significant disruption of the deltoid ligament, the talus displaces inferiorly causing an increase in the MCS. If associated with a syndesmotic injury, the tibiofibular clear space additionally increases with a corresponding decrease in tibiofibular overlap.

Although an increase in MCS with manual external rotation or gravity stress views has been used as an indication for the need for operative intervention, recent studies have challenged the utility and prognostic nature of stress views (8,14,15). Sanders, *et al.*'s published results from a randomized multicenter trial of operative versus non-operative treatment for unstable fractures of

Table 1. Demographic data and results of superior and medial clear space measurements on non-stress view and gravity reduction view (GRV)

Patient	Gender	Age	Side	0-operative N-nonoperative	SCS on injury mortise view (mm)	MCS on injury mortise view (mm)	MCS on Gravity Reduction View (mm)	Length of follow-up (weeks)	SCS on final view (mm)	MCS on final view (mm)	COMMENTS
1	F	21	L	N	2.75	2.57	2.56	15	2.7	2.1	
2	M	57	L	N	3.94	4.17	4.20	10	3.9	3.85	
3	M	65	L	N	3.26	3.02	2.97	14	3.45	3.29	
4	F	54	L	N	3.26	2.93	3.03	11	3.13	3.1	
5	F	57	R	N	3.19	2.87	3.00	9	3.42	2.97	
6	F	60	L	N	3.77	3.39	3.22	13	3.55	3.07	
7	F	18	L	N	3.29	3.16	3.35	0	X	X	Lost To Follow-up
8	M	58	L	N	3.37	3.05	3.05	16	3.4	3.02	
9	M	81	R	N	3.20	2.80	2.82	6	3.12	2.85	
10	F	50	L	O	2.96	3.78	2.26	32	3.1	2.29	
11	F	70	R	O	3.57	5.09	3.01	44	3.27	3.14	
12	M	20	L	O	2.89	4.88	3.23	28	3.11	2.95	
13	F	23	R	O	3.31	5.20	2.38	12	3.07	2.37	
14	M	40	R	O	3.46	3.88	2.80	60	4.43	2.81	
15	F	71	L	O	3.13	4.84	3.74	48	3.16	2.9	
16	M	74	L	O	2.94	16.02	13.03	20	3.5	2.75	
17	M	71	R	O	2.93	3.03	3.10	28	2.67	2.08	Failed NonOp Rx
18	M	66	R	O	3.71	3.07	2.81	56	2.97	2.8	Failed NonOp Rx
19	F	66	R	O	3.33	2.87	2.80	8	3.42	2.93	
20	F	54	L	O	3.00	3.60	3.10	70	3	2.9	
21	M	34	L	O	4.05	6.01	4.18	12	3.97	2.75	
22	F	29	L	O	3.29	3.47	2.99	48	3.3	2.72	
23	M	52	R	O	3.44	4.42	2.76	30	3.4	2.77	
24	M	19	L	O	3.94	4.32	3.89	33	3.8	3.52	
25	F	51	R	O	3.19	4.62	2.90	13	3.24	2.91	
26	F	54	R	O	3.06	3.21	2.85	15	3.1	2.7	
Standard Deviation		19.09			0.34	2.56	2.00	18.75	0.39	0.39	
Mean		50.57			3.31	4.24	3.46	26	3.32	2.86	

the lateral malleolus (as demonstrated by MCS >5 mm with manual stress testing) and demonstrated equivalent functional outcomes for the non-operative group, albeit with an increased risk of displacement, nonunion, and malunion in this group (8). Not only did the authors find no difference in patient-reported functional outcomes at 1-year follow-up, but a subsequent study from the same group challenged the cost effectiveness of operative fixation for these injuries (16). Furthermore, others have suggested treatment algorithms based on either the results of weightbearing radiographs or a trial of protected weightbearing before reimaging as a means of a more physiologic stress testing (17-19).

Additionally, MRI has not proven to be prognostic for instability. In a recently published report, Nortunen *et al.* performed a prospective diagnostic study to assess the utility of MRI findings for the deep aspect of the deltoid ligament in evaluating the stability of the ankle mortise in patients with a lateral malleolar fracture and no widening of the MCS (9). They concluded that given the variability of the MCS in patients with similar MRI results, MRI should not be used in deciding between operative and non-operative management.

For many surgeons, clinical decision-making is based on alignment of the mortise on initial radiographs without additional stressing of the ankle. As the prognostic value of external rotation stress testing has been questioned, the ability to determine whether the mortise is anatomic or not on static views becomes increasingly important. While Deangelis *et al.* demonstrated that 98% of normal ankles demonstrate a MCS less than or equal to the SCS, the applicability of these criteria to decide treatment for the fractured ankle is uncertain as ankle fractures that do not fall into this strict criteria do not necessarily indicate instability that requires surgical intervention (13).

The gravity reduction view is a radiographic view that compares a static upright mortise film to a mortise view obtained with the medial side of the ankle closer to the ground, thus establishing whether the MCS reduces and was therefore widened following injury in the first place. Additionally, the GRV gives surgeons information regarding key aspects of operative or nonoperative treatment. Reducibility of the MCS on GRV can aid surgeons in determining the ability to exact an anatomic reduction in a plaster cast if nonoperative treatment is preferred. Reducibility, or a lack thereof, of the mortise on GRV may aid surgeons in deciding preoperatively for surgically-indicated patients whether a formal anteromedial arthrotomy is required to remove interposed deltoid ligament or hematoma which may block anatomic reduction surgically.

We have utilized the GRV view in clinical practice according to the algorithm described above and have developed a treatment algorithm for its use [Figure 3]. It is safe with minimal additional radiation exposure to the patient. Furthermore, given the lack of manual reduction, patient discomfort is minimal. Our proposed algorithm utilizing the GRV to aid in assessment of stability and determining operative versus nonoperative treatment demonstrates effectiveness based on short term follow-up of a cohort of 26 patients. While the case series reports on a cohort of patients examined over a 1.5 year period, overall mean follow-up was much shorter due to patients being discharged from routine follow-up after demonstrating osseous healing and an anatomically-aligned mortise on final radiographs. However, all patients with final radiographic follow-up demonstrated anatomic positioning of the mortise demonstrating effectiveness of technique and algorithm.

We propose a radiographic view, the gravity reduction view, to help determine anatomic alignment of the mortise and guide treatment for patients with Weber B fibula fractures.

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