AMERICAN ORTHOPAEDIC FOOT & ANKLE SOCIETY

Foot & Ankle International®
2018, Vol. 39(7) 865–873

DOI: 10.1177/1071100718768509
journals.sagepub.com/home/fai

Evaluation and Significance of Mortise Instability in Supination External Rotation Fibula Fractures: A Review Article

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Abstract

Evaluation and management of ankle fractures has progressed in parallel to an evolving understanding of ankle stability. While stability of the mortise had historically been attributed to the lateral malleolus, Lauge-Hansen's contributions followed by multiple other investigations increased the emphasis on the significance of medial-sided injury in destabilizing the mortise. As the importance of the deltoid ligament has been elucidated, the means of assessing ligamentous incompetence and the prognostic significance of an unstable mortise continue to be defined.

Level of Evidence: Level V, expert opinion.

Keywords: ankle fracture, ankle instability, ankle stress test, deltoid ligament, medial clear space

Ankle fractures are one of the most commonly treated orthopedic injuries. While instability of displaced bimalleolar and trimalleolar ankle fractures is readily discernable, deltoid ligament disruption leading to an unstable mortise in the "isolated" fibular fracture can be more difficult to diagnose. Given that the inability to maintain anatomic alignment of the mortise has been correlated with poor outcomes, the assessment of stability is critical.[17,21]

Danis[8] first proposed his classification of malleolar fractures in 1949, subsequently modified by Weber in 1966. While being one of the earlier attempts at classifying ankle fractures, the Danis-Weber classification also demonstrated the historic emphasis on the lateral malleolus for ankle stability.[2] Lauge-Hansen's mechanistic theory more fully introduced the concept of a rotational pattern of injury and the importance of the medial osseo-ligamentous structures in maintaining stability.[30,31] Additional clinical and cadaveric investigations over the following decades further elucidated the importance of medial structures, mainly the deltoid ligament complex.[4] This paradigm shift and evolving understanding of mortise stability resulted in a marked increase in scientific investigations examining the diagnosis, treatment, and outcomes of deltoid ligament disruption in the setting of the fractured ankle.

As such, the concept of mortise stability has dramatically evolved over a relatively short period of time with a tremendous impact on clinical practice. However, despite the existing literature, clinical practice remains variable regarding the diagnosis and treatment of the isolated Weber B fibula fracture with an apparently intact mortise. The purpose of this review is to offer a historical perspective on the conceptual evolution of our understanding of mortise stability and to explore the scientific progression that has led to current practice.

Historical Context

One of the earliest classifications of malleolar fractures was attributed to Percivall Pott in 1758 in his work "Some Few General Remarks on Fractures and Dislocations."[53] In this discussion, Pott described fractures based on the number of malleoli involved. Although Pott's description failed in its ability to predict stability, his emphasis on the lateral malleolus as the primary stabilizer to the ankle joint would persist for centuries. In 1949, the Belgian surgeon Robert Danis[8] described ankle fracture stability according to

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operative techniques for fibula fixation being developed at the time.

In 1950, a Danish physician, Niels Lauge-Hansen, fractured cadaveric limbs to describe how foot position and specific deforming forces resulted in predictable fracture patterns.[30] Based on his dissections, he predicted a sequential order of ligamentous and osseous injury for each fracture type. Lauge-Hansen's classification was based on a rotational mechanism of injury and described 4 distinct patterns: supination-external rotation (SER), supination-adduction, pronation-external rotation, and pronation-abduction. Subsequent clinical studies have examined the incidence of these various fracture types and have demonstrated the SER fracture pattern to be the most common. As such, the SER injury pattern has been most widely studied in the literature.[11,20,27,30,31,39,43,68] For the SER fracture pattern, a rotational sequence of injury focused attention on the medial osseo-ligamentous structures. These were theoretically the last to be disrupted and accounted for the final injury destabilizing the mortise. While instability is readily apparent in the case of the SER IV injury with a medial malleolar fracture, the theory postulated that comparable instability could result from a multiligamentous injury, in which the lateral malleolus was the only identifiable fracture. Although its initial utility was to guide closed reduction during an era of predominantly nonoperative treatment, the lasting legacy of Lauge-Hansen's mechanistic theory was to introduce the importance of medial structures for stability.

Despite Lauge-Hansen's work introducing the importance of the medial anatomic structures, Danis's emphasis on the fibula was subsequently popularized by Weber in 1966.[63] Weber classified ankle fractures according to the level of the fibula fracture in relation to the tibial plafond. While simplistic, the absence of any discussion of medial-sided injury for the purposes of classification implied a greater importance of the lateral malleolus. Yablon et al[67] supported the idea of the lateral malleolus as the chief stabilizer in 1977 when comparing medial versus lateral osteotomies and ligament releases in a cadaveric model. They concluded that the medial malleolus and deltoid ligament contributed little to stability while lateral malleolar incompetence led to a marked decrease in ankle stability.[67]

As operative treatment of ankle fractures increased in the 20th century with the advent of sterile technique, better operative instrumentation, and x-ray, the Danis-Weber and Lauge-Hansen classifications became the predominant means for describing and categorizing ankle fractures. During this evolution of the concept of ankle stability, an amalgamation of the 2 classifications and their respective theorems began to occur. Surgeons recognized that the level of the fractured fibula typically correlated with ankle instability based on the presence, or absence, of a concomitant medial-sided injury. In modern usage, the Danis-Weber classification, which was conceptualized without an understanding of the importance of the deltoid ligament, has been correlated with the corresponding Lauge-Hansen designation (ie, Weber B and supination external rotation) with an associated prediction of instability.

The Lauge-Hansen classification has long stood as a seminal work for our understanding of ankle fracture pathomechanics. However, it has faced multiple challenges regarding its reproducibility, prognostic nature, validity, and usefulness in guiding treatment.[1,15,29,41] As its relevance to modern-day treatment of ankle fractures has been of question, several authors have proposed a shift away from descriptive classifications to those rooted in stability-based criteria.[46,49] This concept has led to multiple studies examining means of assessing stability, establishing criteria for instability, as well as exploring outcomes of patients with unstable patterns treated both operatively and nonoperatively.[21,26,28,46,49,59,63,68] However, recently published level I studies have demonstrated that the assessment of instability may not be prognostic nor guide decision making.[55,65] Accordingly, a management strategy based on assessment of anatomic alignment of the mortise (as opposed to stability) has again become increasingly useful. While seemingly straightforward, defining what constitutes an anatomic mortise has been a challenge and source of continued investigation.

What Defines an Anatomic Mortise?

Anatomic alignment of the mortise has been demonstrated in many studies to be important for normal tibiotalar kinematics. From Ramsey and Hamilton's classic cadaveric study to Lloyd's replication of their original findings, 1 to 2 mm of talar shift has been demonstrated to significantly alter articular contact.[33,54] Traditionally, radiographic assessment of the medial clear space (MCS), tibiofibular overlap (TFO), tibiofibular clear space (TFC), and the talocrural angle have been used to assess the alignment of the mortise on plain x-rays. Various measurements, defining normal alignment of each parameter, have been described.* Normal TFO has been defined as values greater than 10 mm and 1 mm on anteroposterior (AP) and mortise views, respectively. Normal TFC is less than 6 mm as measured on an AP radiograph as the distance between the medial fibular cortex and the tibia incisura. The talocrural angle, measuring approximately 83 degrees, is an angle subtended by a line parallel to the tibial plafond and a line connecting the tips of the malleoli, and it is useful for assessing fibular length. Other parameters, such as the "dime" sign and Shenton's line, have been proposed as means to assess fibular length albeit with unknown accuracy and reliability.[14,58]

*References 3, 5, 12, 13, 19, 26, 46, 50, 55, 59.

While it has been recognized that normal measurements may not ensure anatomic alignment (especially with syndesmotic malreduction) and that anatomic variation exists,[34,37] the effects of injury on these various parameters have been commonly examined in the literature. In addition, the MCS continues to be the most utilized measurement to assess deltoid ligament incompetence and overall mortise alignment.

The MCS is defined as the radiographic distance between the medial wall of the talar body and the lateral most aspect of the medial malleolus. Normal MCS has traditionally been described to be less than 4 mm in width.[4,18,36] Tornetta[61] suggested that the MCS should be within 1 mm of the superior clear space (SCS) regardless of the absolute distance measured. DeAngelis et al[9] evaluated whether the SCS could serve as an accurate point of comparison for the MCS. In a retrospective study, they analyzed 94 asymptomatic ankles and measured the MCS on a line parallel and 5 mm below the talar dome. Their findings indicated that in the large majority (98%) of normal adult ankles, the MCS should be less than or equal to the SCS. Therefore, normalization to the SCS could be used to assess malalignment regardless of absolute measurements.

The literature is replete with studies aimed at determining the threshold MCS that indicates instability. The most widely accepted values associated with incompetence of the deltoid ligament are an absolute MCS greater than or equal to 4 to 5 mm.[†] Michelson et al[40] noted that sectioning of the deep deltoid ligament resulted in 2 mm or more of lateral talar shift with gravity stress in cadaveric specimens where a distal fibular osteotomy was created. Similarly, in a retrospective review, Pankovich and Shivaram[49] concluded that rupture of the deltoid should be considered if initial or stress radiographs revealed a relative increase of MCS >2 to 3 mm as those cases were reportedly confirmed by intraoperative exploration. Both studies reported a change or difference in MCS measurement from normal baseline to indicate deltoid insufficiency. Park et al[50] sequentially disrupted the osseous-ligamentous structures in a cadaveric model to replicate the SER IV injury pattern and demonstrated that an absolute MCS greater than or equal to 5 mm on radiographs taken in dorsiflexion-external rotation was the most reliable criterion to predict deltoid incompetence with sensitivity, specificity, and positive and negative predictive values of 100%.

Unfortunately, there is no established consensus as to the proper technique for measuring the MCS. While many studies have described the MCS as the distance measured between the medial malleolus and talus at the level of the talar dome on the mortise view,[3,5,13,26,46,55,59] others have failed to describe in their reported methodology the level at which the measurement was obtained[2,4,27] or the measurement technique.[16,21,23,42,49,52,64] Murphy et al[44] noted significant variability in MCS based on how the measurement was obtained as well as differences associated with gender/height in a retrospective radiographic study of paired uninjured ankles. They also showed a mean difference in MCS between paired ankles of 0.6 ± 0.6 mm and thereby recommended routine contralateral radiographic comparison of MCS to assess for pathologic widening in the setting of known anatomic variation and to avoid the potential for false-positives.[45] Further support for the cautious use of an absolute measurement was provided by Metitiri et al.[38] Using 3 normal ankle cadaver specimens, the authors transected the deltoid/syndesmotic ligaments and artificially widened the mortise using resin blocks to a defined distance of 4 and 6 mm (the third specimen was left intact). Radiographs were obtained of each cadaver at varying degrees of rotation, and orthopedic providers were asked to measure the MCS using a standardized technique. The authors demonstrated poor accuracy and precision of measurement of the MCS with significant measurement error.[38]

Elucidating Instability: The Advent of Stress Views

While early investigations emphasized the importance of clinical examination to assess ankle instability, the advent of stress fluoroscopy soon followed. Manual manipulation was initially advocated by Lauge-Hansen and Cedell.[4] In his examination of SER injuries, Cedell noted that a small minority of isolated fibular fractures without evidence of mortise incongruence went on to displacement with nonoperative treatment. Accordingly, he advocated for a thorough clinical examination for potential deltoid ligament injury.[4] However, subsequent works challenged the assumption that physical examination findings could predict deltoid ligament injury. Egol et al,[13] McConnell et al,[36] and De Angelis et al[10] all demonstrated relatively poor sensitivity, specificity, and predictive value of physical examination findings such as tenderness, ecchymosis, and swelling. Given that physical examination findings were not found to reliably predict the stability of the mortise, other means of diagnosis such as radiographic stressing were increasingly used.

While numerous studies have reported the use of stress radiography in one form or another dating back to initial publications in the 1950's and 60's, the origins of validating the use of gravity stress fluoroscopy to predict mortise instability can be most likely attributed to Michelson et al[42] in 2001. Michelson et al noted that in 8 cadaveric samples with an osteotomized distal fibula, deep deltoid ligament transection resulted in lateral talar shift and valgus displacement when gravity stress was applied with the specimens mounted horizontally, lateral side down.[42]

[†]References 2, 5, 10, 13, 16, 21, 23, 28, 36, 42, 44, 46, 50, 55, 64.

In 2004, both Egol et al[13] and McConnell et al[36] published results of patient cohorts with apparent isolated fibula fractures that underwent manual stress radiography. McConnell et al[36] reported on 138 patients of which 97 patients presented with an isolated fibular fracture and an intact mortise. Using manual external rotational stress testing, 36 patients (37%) demonstrated instability relative to the manual stress applied. Egol et al[13] examined 101 patients with similar pathology and noted that 66 (65%) who presented with an anatomic mortise had a positive stress radiograph. Force of stress application was not quantified in either study, and despite using the same manual external rotation test, it is notable that instability was reported as near double the rate in Egol's cohort as compared with the work of McConnell. This discrepancy may lend support to the concept that stability of the mortise is a relative concept and depends on the amount of stress applied.

While these and other earlier studies reported on the use of manual stress views, providers found that patient discomfort, operator dependence, and time investment was not insignificant. Accordingly, the use of gravity stress views, as suggested in Michelson's original work, was further investigated. In 2007, Gill et al[16] examined a cohort of 25 patients with SER injuries and assessed ankle stability based on talar shift and MCS change. A manual external rotation stress radiograph, along with a gravity stress radiograph, was performed for each patient, and radiographic results were compared. In the SER II group, the average MCS was 4.15 and 4.26 mm on the manual and gravity stress radiographs, respectively (P = .50). In the SER IV group, the average MCS was 5.21 and 5.00 mm on the manual and gravity stress radiographs, respectively (P = .69).[17] Their findings suggested that gravity stress radiography was similar to manual testing and likely better tolerated by patients. Gill's findings were duplicated by Schock et al[56] in a cohort of 29 patients. A subsequent study by LeBa et al[32] echoed Gill and Schock's findings, making the argument for gravity stress views relatively convincing.

What is the effect of gravity stress on the normal, uninjured ankle? Recently, Jastifer et al[25] examined gravity stress radiographic examination in a cohort of 50 asymptomatic patients. Mean MCS was 3.6 mm as compared with 3.3 mm and 3.1 mm on AP and mortise views, respectively. No patients displayed MCS widening more than 0.2 mm as compared with unstressed radiographs.

Physiologic Loading and Instability

Can physiologic loading (ie, weight bearing) elucidate instability? Increasingly, some have argued that the use of gravity or manual stress views may overestimate the need for surgery by eliciting subtle instability treatable by conservative means and that (1) either weight-bearing radiographs at time of injury and/or (2) a trial of protected weight bearing with repeat x-rays may be a better predictor of mortise stability.[7,10,22,47,55,64,65]

A cadaveric study by Stewart and colleagues in 2012[59] sought to elucidate the effect deltoid incompetence has on the integrity of the ankle mortise with an applied axial load. Twelve cadavers were divided into 3 groups: intact ankles, isolated oblique fibular osteotomies, and osteotomized ankles with complete deltoid ligament transection. Each group was then loaded sequentially with 0, 25, 36, and 50 kg to simulate weight bearing with radiographs taken at each successive load. Instability and therefore deltoid incompetence was defined as a greater than 2-mm change in the MCS from the intact ankle. With this criterion, the authors found no statistical MCS widening with simulated axial weight bearing with an isolated osteotomy or osteotomy in conjunction with a sectioned deltoid ligament. These findings imply that weight-bearing radiographs cannot elucidate instability or at least not instability relative to those forces applied with manual or gravity stress views. Clinical investigations have borne this out.

Hoshino et al[23] prospectively examined 36 patients with initial, non–weight-bearing radiographs demonstrating normal alignment but with MCS widening on manual stress testing. Patients were placed in a short-leg walking cast with repeat examination 7 days later, at which time weight-bearing radiographs were obtained. Nonoperative management was continued if the MCS remained less than 4 mm, while operative treatment was recommended for those demonstrating increased diastasis. At final follow-up, anatomic mortise alignment was demonstrated, and the authors advocated for the use of weight-bearing radiographs instead of manual stress views to aid in clinical decision making and prevent unnecessary surgeries. In 2010, Weber et al[64] demonstrated similar findings. His group defined instability as an MCS greater than 4 mm, MCS greater than 1 mm wider than the SCS, or lateral talar subluxation relative to the tibial plafond and concluded that weight-bearing radiographs were an "easy, pain-free, safe and reliable" method for determining ankle stability.

While these and other authors have demonstrated the utility of weight-bearing radiographs to predict eventual mortise alignment, a careful distinction should be made once again between stability and the anatomic relationship of the talus with the tibial plafond. These studies did not demonstrate the utility of weight-bearing radiographs to predict a stable mortise but instead to identify patients who may do equally well with nonoperative treatment if anatomic alignment was seen. Hoshino, Weber, Stewart, and others' works appear to demonstrate the ability of weight-bearing (axial load) to "normalize" mortise alignment in proven unstable ankles. By definition, a shift in talar alignment with gravity/manual stress as demonstrated in their patient cohorts indicates instability. Specifically, these studies identified patients who may do well with nonoperative treatment if anatomic alignment persists in the setting of being exposed to that amount of stress generated by weight-bearing in a cast or boot. In the authors' opinion, it may be that protected weight bearing will in some cases actually lead to improved alignment given the congruent nature of the tibiotalar joint.

Are stress views or a trial of weight bearing even necessary to predict instability in the patient who presents with an apparent isolated fibula fracture? Recently, Nortunen et al[47] investigated whether radiographic clues could be elicited from initial, non–weight-bearing radiographs to predict stability in a cohort of 286 patients who all underwent subsequent stress testing. The authors demonstrated that lateral malleolar fracture gapping of greater than 2 mm on initial lateral radiographs as well as other associated findings such as fracture comminution could predict instability and potentially obviate the need for additional stress imaging. While their findings are promising, the ability to accurately and precisely measure fibular fracture gapping is still unknown, and the threshold to determine stability used in their investigation may fall within a yet undefined measurement error. Further validation of their findings is required.

How about a patient's ability to weight bear immediately after sustaining an ankle fracture? Chien et al[6] recently investigated whether a patient's self-reported ability to weight bear at time of ankle fracture was predictive of radiographic stability. Examining a cohort of 121 patients, the authors demonstrated that a patient who was able to bear weight immediately after injury was more than 8 times more likely to have a stable ankle fracture. When examining a subset of 43 patients who presented with an isolated fibula fracture and anatomic mortise on initial radiographs, an odds ratio of 3.6 was found in predicting ankle stability

Magnetic Resonance Imaging and Instability

Given that ankle fractures consist of both osseous and ligamentous injury, the use of magnetic resonance imaging (MRI) to detect injury and predict instability has been investigated by several authors. In 2006, Gardner et al[15] used MRI to assess the accuracy of the predicted ligamentous injuries as hypothesized by Lauge-Hansen. Of the 49 ankle fractures classifiable per the Lauge-Hansen classification, 53% displayed patterns of ligamentous injury and fracture patterns inconsistent with the predicted injury as based on their designated classification on plain radiographs. Interestingly, the senior authors on this previous study published another report in 2015 examining a larger cohort of 283 ankle fractures classifiable per the Lauge-Hansen classification. In this series, the authors reported that 94% displayed ligamentous injury patterns, consistent with Lauge-Hansen's predictions with a high correlation with intraoperative findings.

In 2009, Cheung et al[5] performed a retrospective study of 19 patients with isolated distal fibular fractures and positive external rotation stress radiographs who underwent additional MRI imaging. They found partial or complete tears in all cases in at least 2 of the major ligament groups (typically the deltoid and syndesmosis). While 100% of specimens demonstrated an AITFL injury, the posterior tibiotalar component of the deltoid ligament was generally injured (18/19 patients) but was only partially torn most of the time (15/18 patients),[5] suggesting a high false-positive rate of stress radiographs for determining complete deep deltoid injury. Koval et al[28] also used MRI and found that of 21 patients who had stress-positive Weber B ankle injuries, 19 revealed partial tearing of the deep deltoid, with 2 revealing complete rupture.

More recently, Nortunen et al[46] in a larger prospective study of 61 patients revealed a lack of additional prognostic value of MRI where patients with both positive and negative stress radiographs demonstrated varying MRI evidence of deltoid ligament injury. While MRI was able to detect ligament injury, there was no correlation with stress views indicating an inability of MRI to predict instability. In addition, the interobserver agreement between radiologists when grading the severity of ligamentous injury was only fair to moderate.

In summary, it appears that while diagnosis of ligament injury is possible with MRI, its clinical usefulness in determining instability (and therefore treatment) is questionable. While MRI may have a role in detecting associated injuries not well visualized on plain radiographs for patients sustaining ankle fractures, further investigation is required.

Clinical and Prognostic Relevance of the Stress-Positive Ankle Fracture

What is the significance of radiographic widening of the MCS? While multiple authors have demonstrated excellent results with operative treatment, of more interest are reports that have demonstrated successful nonoperative treatment of the unstable ankle fracture, challenging the prognostic ability of stress views (ie, does it matter if they widen or not?). In light of recently published studies, it remains unknown whether these additional radiographic views (and a resultant positive finding) should indicate patients for operative treatment. However, the findings of recently published level I investigations must be interpreted with an understanding of study limitations.

In 2004, Egol et al[13] called into question whether a stress-positive radiograph was a clear indication for surgery in the SER IV equivalent fracture pattern. Among 30 fractures that had stress-positive radiographs in the setting of minimal physical findings, 20 received nonoperative management and were found to have good/excellent results on patient-based outcomes measured at a mean follow up of 7.4 months.[13] While 2 of 20 patients (10%) displayed residual MCS widening, only 1 patient was symptomatic at this short-term point of follow-up.

Similarly, in the previously mentioned study by Koval et al,[28] the authors reported on a series of stress-positive SER IV ankle fractures treated nonoperatively. Ninety percent of patients who had only partial tear of the deep deltoid ligament as assessed by MRI (19 of 21) were treated conservatively and allowed to weight bear as tolerated. At final evaluation, all fractures united without radiographic evidence of arthritis with American Orthopaedic Foot & Ankle Society (AOFAS) and SF-36 scores demonstrating excellent results. Clements et al[7] examined a similar cohort of 51 patients who underwent nonoperative treatment. While the authors found decreasing (worsening) AOFAS hindfoot scores with increasing MCS widening, patients with residual MCS widening of 4 and 5 mm demonstrated reasonably good AOFAS scores of 90.2 and 89.4, respectively.

More recently, Holmes et al[22] examined a cohort of patients with both weight bearing and gravity stress views. Fifty-one of these patients who demonstrated an anatomic mortise on weight-bearing x-rays with MCS widening less than 7 mm on gravity stress radiographs were treated nonoperatively in a pneumatic boot with full weight bearing. Functional analysis of these patients at 1 year postinjury was evaluated using the Foot and Ankle Ability Measure for Activities of Daily Living (FAAM/ADL), the Olerud Molander Ankle (OMA) score,[48] the AOFAS score, and the visual analog (VAS) pain score. Despite a mean MCS widening of 4.42 mm on initial gravity stress views, the final mean MCS after nonoperative treatment on weight-bearing x-rays was 2.64 mm. With regard to functional outcomes, the mean value was greater than 90 for AOFAS, FAAM/ADL, and OMA, indicating excellent functional results for all patients.

Similarly, Seidel et al[57] published a recent investigation examining weight-bearing versus gravity stress views. Of 104 patients with isolated lateral malleolus fractures, 44 patients who had positive gravity stress radiographs but anatomic weight-bearing x-rays were treated nonoperatively. When compared with the cohort who underwent surgery as well as 46 patients who had clearly stable ankles, all patients healed with an anatomic mortise. The authors suggested that weight-bearing views may better guide treatment as reliance on gravity stress views may lead to unnecessary surgery.

Two large-scale randomized prospective studies deserve special consideration. In 2012, Sanders et al[55] published results of a level I multicenter study evaluating 81 patients who met criteria for stress-positive SER IV equivalent fractures. Forty-one were managed with operative reduction and fixation of the fibula, and 40 fractures were treated nonoperatively. No statistically significant differences in functional outcomes were noted using the OMA and SF-36, although the study was underpowered to find a functional difference smaller than 15 points and follow-up was only 12 months. Of concern is the fact that 8 patients (20%) in the nonoperative group developed a malaligned mortise (MCS greater than or equal to 5 mm) and that 8 patients in the nonoperative group developed delayed union or nonunion.

In 2016, Willet et al[65] published the results of a large-scale randomized clinical trial examining casting versus surgery for unstable ankle fractures in patients older than 60 years. A total of 309 patients underwent operative treatment, while 311 underwent close-contact casting. The authors concluded that the use of close-contact casting compared similarly to surgery, with patients displaying equivalent functional outcomes at 6-month follow-up. While the operative group displayed increased wound complications and the need for additional procedures, 15% of the nonoperative group displayed radiographic malunion as compared with 3% who underwent surgery.

Despite equivalent functional outcomes as assessed using patient-based outcome measures with nonoperative treatment, 3 specific points should be emphasized regarding the current literature.

First, there appears to be a subset of patients with stress-positive SER IV fractures that will develop late displacement if treated nonoperatively, ranging from 10% to 20%.[7,13,55] While previous works were not able to specifically identify which patients were more likely to displace, the rate of a resultant malaligned mortise with nonoperative treatment is not insignificant. Arguably, this needs to be considered in the setting of increased risks of wound complications with operative treatment.

Second, the aforementioned investigations demonstrated only short-term follow-up (range, 3-20 months).[13,22,28,30,36] While orthopedic trauma populations have been demonstrated in previous investigations to have higher lost-to-follow-up rates, examination of functional outcomes at short-term follow-up may be misleading. As previous studies have demonstrated the negative effects of mortise malalignment on contact area, contact pressures, and the development of posttraumatic arthritis, short-term assessments are unlikely to predict long-term functional outcomes.[51,54] While these studies may represent the best available evidence, longer-term follow-up of these cohorts is required to definitively determine which treatment option is best.

Third, in past studies, patients with MCS widening upon initial presentation were near universally treated operatively, with attention of the investigations placed on the cohort with stress-positive findings. However, recent literature has demonstrated that if weight-bearing radiographs were obtained, then the widened mortise may have normalized based on joint congruency. As no current literature has addressed the issue, one may ponder the difference between the patient who presents with a wide MCS on nonstress views as compared with the patient with equivalent MCS widening on a stress view. Considering how a relative minimal change in ankle positioning (lateral decubitus positioning during gravity stress examination) can displace the mortise and that a radiograph is a "snap shot in time," future investigations may choose to focus attention on examining the best treatment option for the patient who presents with a clearly displaced mortise. Our assumptions may be challenged once again.

Is Deltoid Repair Necessary?

Multiple previously published reports stemming back from the mid-1980s have supported the lack of additional utility of deltoid repair. In 1987, Baird et al[2] reported a cohort of 19 patients who underwent operative fixation without deltoid repair and noted good/excellent results without subsequent instability. In 1989, Zeegers et al[69] reported on a cohort of 28 patients who underwent similar fixation without deltoid repair and noted no subsequent clinical instability nor radiographic findings on stress radiography. Multiple authors similarly demonstrated a lack of clinical benefit to deltoid repair.[35,60,62]

Despite the previous literature, there has been renewed interest and investigation in deltoid repair for this patient cohort likely stemming from methodologic weaknesses of previous investigations. Hsu et al[24] examined deltoid repair in a cohort of 14 National Football League players who underwent fracture fixation. While all patients underwent other concomitant procedures such as ankle arthroscopy and syndesmotic fixation and heterogenous fracture patterns existed, all patients were able to return to full sporting activities. Most recently, Woo et al[66] retrospectively examined 78 consecutive cases of deltoid ligament injury with an associated ankle fracture. All patients were treated operatively, with 41 patients undergoing deltoid ligament repair. Average follow-up was 17 months with patients assessed using Foot Function Index, AOFAS hindfoot score, and VAS. Although clinical outcomes were not significantly different between the groups, those who underwent deltoid repair were noted to have a smaller MCS on final follow-up. Interestingly, those who had concomitant syndesmotic fixation showed a similar result but with improved outcomes scores as compared with the non–deltoid repair cohort.

While previously reported literature has come under recent challenge, it is clear that not all patients require deltoid repair, although a yet undefined cohort of patients may demonstrate benefit. Higher-quality prospective studies are required to determine which patients would benefit from deltoid ligament repair as well as comparative investigations examining the best means of repair.

Conclusion

The optimal means of evaluating and treating the patient with an apparent isolated Weber B fibula fracture continue to evolve. Anatomic alignment of the ankle mortise leads to more normal joint contact forces, pressures, and kinematics. While gravity/manual stress views can reveal mortise instability, it is unclear whether surgery should be indicated based solely on an increased MCS. Weight-bearing radiographs appear to correlate more closely with subsequent mortise alignment, and reliance on gravity/manual stress views may result in unnecessary surgery. While able to detect ligamentous injury, MRI has a limited role given its inability to predict instability. Repair of the deltoid ligament may be warranted in certain cases, although higher-quality studies are required to determine which patients would benefit from repair and which repair technique is ideal. While equivalent short-term outcomes between operative and nonoperative treatment have been demonstrated in recent series, longer-term follow-up of patients with a nonanatomic mortise is necessary.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article. ICMJE forms for all authors are available online.

Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

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