Weightbearing Stable Bimalleolar Ankle Fractures—Bony Equivalents to the Ligamentous Weber B/SER4a Fracture Type? A Prospective Case Series

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Abstract

Background: In a recent study, we documented that partially unstable Weber B/SER4a fracture types reach union with preserved normal ankle congruence after treatment with a functional orthosis and weightbearing allowed. In the present article, we present a case series of weightbearing stable bimalleolar fractures treated nonoperatively that extends our previously published research.

Methods: We included 5 patients with primarily nondisplaced bimalleolar ankle fractures that were stable on weightbearing radiographs. Participants were treated with a walking boot or cast with weightbearing allowed. We also provide a qualitative anatomical analysis of fracture morphology on computed tomographic scans.

Results: Median medial clear space (MCS) of fractured ankles after union were 2.4 mm (range, 1.5-3.1). Qualitative descriptions of fracture morphology showed that all fractures were oblique starting at the intercollicular groove of the medial malleus and extended anteriorly and proximally.

Conclusion: MCS measurements after fracture union of nonoperatively treated weightbearing stable bimalleolar fractures seemed consistent with normative data of ankle congruence in our previous study. We consistently recorded oblique fracture patterns involving the anterior colliculus, leaving the origin of posterior deep deltoid ligament intact. We present our material as an argument for the existence of a bony (bimalleolar) equivalent to the ligamentous SER4a fracture.

Level of Evidence: Level IV, prospective case series.

Keywords: ankle fracture, bimalleolar ankle fracture, stability assessment, weightbearing radiograph, ankle congruence, ankle stability, tibiotalar stability, SER4a

Introduction

In treatment of fibular fractures, additional radiographic stress testing is mandatory to distinguish stable injuries without deltoid ligament injury, from the unstable with a damaged deltoid ligament. Stress testing with weightbearing radiographs has been advised.1,3,4,6,7 Because the standard view is that bi- or trimalleolar fractures are inherently unstable, recognition of a medial malleus fracture on plain radiographs is generally conclusive that the ankle is unstable, and further assessment is usually not carried out.

However, it has been shown that fibular fractures can be functionally stable even with a partial deltoid ligament injury.4,5,6 It is suggested that this is referred to as a partially unstable supination-external rotation (SER) 4a injury.4 In a recent study, we documented that partially unstable SER4a fracture types reach union with preserved normal ankle congruence after nonoperative treatment with a functional orthosis and weightbearing allowed.3 In the present article, we report on weightbearing stable bimalleolar fractures that...
were identified on the basis that they were excluded from our original study main cohort because they had a medial fracture.5

The primary objective was to develop a theoretical framework, using radiographic data, for why certain bimalleolar fractures appear stable during weightbearing. We conducted a prospective case series exploring if weightbearing stable bimalleolar ankle fractures that were treated nonoperatively heal with preserved tibiotalar congruence. Further, we provide a qualitative anatomical analysis of fracture morphology on computed tomo- graphic (CT) scans.

Materials and Methods

Approvals were the same as for the original study. Participants were prospectively identified on the basis that they were screened for inclusion in a study enrolling patients with isolated Weber B fractures.6 Recognition of a medial malleolus fracture excluded them from the main study arm, and they were included in a separate observational arm. In the present study, we included patients with primarily non-displaced bimalleolar ankle fractures (medial clear space [MCS] measurements less than 7.0 mm on initial non-weightbearing plain radiographs) that were treated nonoperatively heal with preserved tibiotalar congruence. Further, we provide a qualitative anatomical analysis of fracture morphology on computed tomographic (CT) scans.

Results

Recruitment took place between January 2019 and May 2021. Five eligible patients were identified and were included in the study. All 5 patients had weightbearing radiographs indicating stability of the ankle mortise. All 5 patients completed the 12-week follow-up. Table 1 presents baseline characteristics of the case series.

Median MCS of fractured ankles at 12 weeks were 2.4 mm (range, 1.5-3.1). Union was recorded in 5 of 5 participants. Qualitative review of fracture morphology revealed that fractures consistently had an oblique course starting at the intercollicular groove of the medial malleolus and extended anteriorly and proximally.

Discussion/Conclusion

In 5 weightbearing stable bimalleolar ankle fractures treated nonoperatively, fractures reached union with ankle congruence comparable to normative data of ankle congruence in SER2 and SER4a fracture types in our previous study.5 In contrast to the standard view that bimalleolar fractures are inherently unstable, our findings indicate that some bimalleolar fractures are stable under the circumstances of weightbearing radiography and, further, that these fractures can be treated nonoperatively with preserved normal ankle congruence after fracture union.

This finding raises some questions: What is distinctive about the portion of bimalleolar fractures that appear congruent in the weightbearing position? Why may a nonoperative treatment strategy make sense? We have tried to address them by suggesting a theory based on the results of this case series and drawing connections to previous theories and anatomical data.

In our material, we consistently recorded oblique medial malleolar fracture patterns involving only the anterior colliculus, leaving the posterior colliculus intact (Figure 1). Reviewing available literature, what specific medial

| Table 1. Baseline Characteristics of 5 Patients With a Weightbearing Stable Bimalleolar Ankle Fracture. |
|-------------------------------------------------|
| Patient Characteristics | n | Median (Range) |
| Age when injury | 75 (58-76) |
| Sex | | |
| Female | 4 |
| Male | 1 |
| Injured side | | |
| Left | 3 |
| Right | 2 |
| Diabetes mellitus | 1 |
| Smoking status | | |
| Smoker | 1 |
| Nonsmoker | 4 |
| Received treatment | | |
| Walking boot | 3 |
| Below-the-knee cast | 2 |

All participants were scheduled for follow-up appointments at 2, 6, and 12 weeks after injury.

The primary outcome was tibiotalar congruence after fracture healing. The size of the MCS on weightbearing radiographs at 12 weeks was considered an expression of tibiotalar congruence and an indirect measurement of ankle stability. Method of obtaining MCS measurements was consistent with that described in the original article.5 Secondary outcomes included loss of congruence and delayed fracture healing and were recorded as therapy failures. Fracture healing was assumed if callus formation was present on radiographs with concurrent pain-free palpation over the fracture site. Fracture healing was recorded as union or delayed fracture healing. Last, we made qualitative descriptions of fracture configuration reviewing CT scans.
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side–stabilizing structures are injured or intact in SER-type ankle fractures is not accurately defined. However, Gougoulias and Sakellariou have proposed a theory for ligamentous injuries based on anatomical data. According to their theory, all bands of the deltoid ligament are intact in SER2 injuries. As a result, the MCS appears normal independent of foot position, and forces applied, during stress radiography acquisition. In SER4a injuries, they theorize that superficial deltoid ligament components, and the anterior tibiotalar ligament, may be ruptured. This will allow for MCS widening when the ankle is plantarflexed (ie, during non-weightbearing or stress radiography). However, in SER4a injuries, the posterior tibiotalar ligament (PTTL) probably remains intact. The PTTL is loose in plantar flexion but becomes tight when the foot is plantigrade (such as when weightbearing). Tightening of the PTTL reduces the MCS, and the ankle mortise becomes fully congruent. Finally, in SER4b injuries, the theory is that all deltoid ligament bands are damaged, including the PTTL, allowing for MCS widening independent of ankle position. In summary, the ankle mortise remains functionally stable if the PTTL is intact.

The PTTL originates from the posterior colliculus of the medial malleolus and inserts onto the medial surface of the talus (Figure 1). Accordingly, medial malleolus fragments that do not affect the posterior colliculus of the medial malleolus should not alter the PTTL-stabilizing function. Reviewing CT scans of the present case series, fractures consistently involved only the anterior colliculus, leaving the origin of the PTTL at the posterior colliculus intact. Drawing connections between our findings, the theory proposed by Gougoulias and Sakellariou and anatomical data of the deltoid ligament, an argument may be made for the existence of a bony (bimalleolar) equivalent to the ligamentous SER4a first described by Gougoulias and Sakellariou.

However, there are several limitations to this study that warrant discussion. As this short report was exploratory with the purpose of founding a theoretical framework, we reported only short-term radiographic outcomes. Another substantial limitation is that only 5 participants were included. Consequently, this study does not provide conclusive results after nonoperative treatment of weightbearing stable bimalleolar fractures, and broad generalizations should not be made from them.

Yet, the above proposed theory constitutes a novel anatomical and biomechanical rationale for why some bimalleolar ankle fractures are functionally stable. It may offer a theoretical base to future hypotheses and guide how they are understood and investigated. In conclusion, the results indicate that weightbearing stable bimalleolar fractures are stable because the PTTL is intact. Thus, they may be eligible for nonoperative treatment with weightbearing as tolerated in a boot or cast. We suggest that weightbearing stable

Figure 1. Depiction of (A) a nonweightbearing radiograph showing a bimalleolar ankle fracture, (B) a weightbearing radiograph of the same ankle interpreted as stable (no medial clear space widening), (C) a computed tomographic scan showing the medial malleolus fracture of the anterior colliculus, and (D) a dissected cadaveric specimen showing the posterior tibiotalar ligament (marked green) and imitated anterior colliculus fracture (red line).
bimalleolar ankle fractures are referred to as bimalleolar SER4a injuries.

**Ethical Approval**

Ethical approval for this study was obtained from the Regional Committee for Medical and Health Research (24994), the Norwegian Centre for Research Data (237667), and the local ethics committee at the Østfold Hospital Trust.

**Declaration of Conflicting Interests**

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