Stable fractures of the ankle can be safely treated non-operatively. It is also gradually being recognised that the integrity of the ‘medial column’ is essential for the stability of the fracture. It is generally thought that bi- and tri-malleolar fractures are unstable, as are pronation external rotation injuries resulting in an isolated high fibular fracture (Weber type-C), where the deltoid ligament is damaged or the medial malleolus fractured. However, how best to identify unstable, isolated, trans-syndesmotic Weber type-B supination external rotation (SER) fractures of the lateral malleolus remains controversial. We provide a rationale as to how to classify SER distal fibular fractures using weight-bearing radiographs, and how this can help guide the management of these common injuries.

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Lateral malleolar fractures are often described as “simple”, or “straight forward” and “easy” to fix. However, there is quite a high incidence of complications after surgical treatment. Up to 20% of operatively treated distal fibular fractures will result in damage to the superficial peroneal nerve, or other complications, including prominent hardware requiring removal. Furthermore, long-term studies summarised in a systematic review in 2010, show that “stability is a key issue” in the management of isolated Weber type-B fractures of the distal fibula, resulting from a Lauge-Hansen supination and external rotation injury. These correspond to the 44-B1 type fractures according to the Arbeitsgemeinschaft für Osteosynthesefragen (AO) classification. Stable fractures can safely be treated non-operatively with good or excellent long-term outcomes. It is therefore mandatory to identify the unstable fractures accurately.

The classification of fractures of the ankle and implications in clinical practice

Isolated fibular fractures account for approximately 70% of all fractures involving the ankle and in order to manage these injuries rationally some understanding of the Lauge-Hansen classification is essential. This classification relates the mechanism of injury to the ligamentous injuries and the patterns of fracture. It was described more than 60 years ago and at the time of its proposal, strict scientific criteria and processes for validation had not been introduced. It was based on observations and assumptions. Gardner et al have reported that the Lauge-Hansen classification predicts only about 50% of ligamentous injuries accurately. However, in a more recent study involving the MRI and intra-operative findings of 300 fractures of the ankle, the Lauge-Hansen classification accurately predicted the ligamentous component of the injury in 94%. Other studies have shown that this classification does not always predict the extent of the bony component of the injury.

It has previously been thought that the integrity of the ‘lateral column’ (fibula) is essential for providing stability to the ankle mortise. This was the basis for the Danis-Weber classification, which did not take into consideration any damage to the medial structures. However, later studies have shown that the medial column, made up of the medial malleolus and deltoid ligament is more important to the stability of the ankle than the lateral structures. The ankle can, thus, be considered as a ring. If it breaks in one place it remains stable. If it breaks in two places it becomes potentially unstable. Therefore, although easy and descriptive, the Weber classification cannot guide management for the most common type-B fractures, as it does not distinguish between stable and unstable fractures.

The Lauge-Hansen classification takes into consideration the mechanism of injury causing...
the fracture and/or ligamentous injuries as each fracture has an equivalent ligamentous injury. Most injuries involving the ankle are the result of rotational forces. When the foot is supinated, the axial load causes an external rotation force; the body externally rotates in relation to the supinated foot causing a trans-syndesmotic fibular fracture. This corresponds to type-B fractures according to the Weber\(^5,6\) and AO\(^8\) classifications. When the force ceases on the lateral side and no further damage is done, two structures may have been damaged, namely the syndesmotic ligaments and the distal fibula. Thus, we describe these injuries as supination external rotation stage II (SER-II) fractures. When excessive rotational force is applied, further sequential injuries involve a posterior malleolar fracture or, a posterior ligamentous injury (SER-III) and, sequentially, a medial malleolar fracture (obvious SER-IV) or injury to the deltoid ligament (potentially occult SER-IV). When the deltoid ligament is ruptured, lateral talar shift occurs and the medial clear space, the distance between the medial malleolus and the medial surface of the talus (Fig. 1), widens on the anteroposterior radiograph. A medial clear space of > 4 mm is usually considered to be abnormal.\(^10\)

When, on the other hand, an external rotation force is applied to the pronated foot, the medial structures (the medial malleolus or the deltoid ligament) will give way first. As the external rotation force travels to the lateral side, it can cause disruption of the syndesmosis, a suprasyndesmotic fibular fracture and, finally, a posterior malleolar fracture or injury to the posterior tibiofibular ligament. So, by definition, a suprasyndesmotic type-C fracture of the fibula according to the Weber and AO classifications, indicates a more severe, unstable pattern of injury that usually requires operative management.\(^10\)

Thus, the standard view is that bi- and tri-malleolar fractures are clearly unstable as the ring has broken in at least two places, and so are pronation external rotation (PER) injuries, resulting in a type-C high fibular fracture. However, interestingly some authors have shown that suprasyndesmotic, as well as some bi-malleolar and tri-malleolar fractures, can be treated functionally in a brace with no subsequent displacement.\(^15,16\) Perhaps pronation-type fractures are less unstable than the classification predicts. Furthermore, if stability of the medial column is key, then the distinction between SER-II and occult SER-IV fractures (Fig. 1; no medial malleolar fracture, but possible deep deltoid rupture) is essential in order to decide the appropriate management. SER-II fractures are stable and should be treated non-operatively; but how can we reliably, identify these stable SER fractures?

**Methods used to assess the stability of isolated SER fractures of the ankle**

It has been proposed in the past, that tenderness around the medial aspect of the ankle, swelling, and/or ecchymosis indicate damage to the deltoid ligament and thus these fractures should be fixed. The medial tenderness sign has, however, been shown to be unreliable, as often it is only the superficial component of the deltoid ligament complex that is injured causing pain and bruising, while the deep part of the ligament is intact, providing stability to the ankle.\(^17-19\)

Therefore, it was felt that one should test the ankle for dynamic instability and the manual, external rotation stress test was introduced.\(^20\) There are several drawbacks associated with manual stress radiographs. Are they tolerated by the patient? Should they be performed under anaesthesia? How much stress should be applied? Who applies the stress, a doctor or a radiographer and what are the practical and logistical issues?

Consequently, the gravity stress (GS) radiograph\(^20\) (Fig. 2) was introduced, in which the patient lies on the side of the injury, with the lower leg hanging off the edge of the x-ray table, resulting in gravity causing external rotation, while an anteroposterior radiograph is taken in order to standardise testing in external rotation. Although it has been shown to be tolerated better by patients than the manual stress test, it was thought that instability and, consequently, the need for surgery, could be over-emphasised. This was mainly after weight-bearing radiographs were introduced as a means of identifying lateral talar shift.\(^3,21,22\)

At our institution, we have sequentially used all three methods (manual stress, gravity stress and weight-bearing radiographs) to identify unstable SER fractures. We found that when gravity stress radiographs were used, before 2011, 45% of isolated distal tibial SER fractures were shown to be unstable and were treated operatively. Operative fixation resulted in an increased rate of further surgery, including removal of hardware of 12% and an overall rate
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of complications of 20%. When weight-bearing radiographs within seven to ten days of the injury were introduced in 2011, to detect unstable SER fractures, only 3.7% of these injuries were deemed to be unstable and need surgical treatment. None of the fractures that were deemed to be stable and treated conservatively required subsequent surgery.3 Thus, gravity stress testing not only resulted in over-estimation of the need for surgery but also, in more complications. These findings confirmed those of others who reported that surgery was needed in only 3%22 and 10%21 of SER fractures, respectively, when weight-bearing radiographs were used to assess stability. Patients treated non-operatively had an excellent clinical outcome. Also, a recently published Combined Randomised and Observational Study of Surgery for type-B Ankle Fracture Treatment (CROSSBAT),23 showed that surgical management for AO type 44-B1 fractures with minimal talar shift resulted in more complications, without a better outcome compared with non-surgical management.

Anatomical and biomechanical considerations: the role of the deltoid ligament

These findings are also partly consistent with two cadaveric studies. Michelson et al24 studied eight cadaveric specimens having performed an oblique distal fibular osteotomy and complete transection of the deltoid ligament. Mortise views were normal, whereas gravity stress views showed talar tilt of > 2 mm and valgus tibio-talar alignment of > 15°. Stewart et al25 questioned the ability of simulated weight-bearing radiographs to assess the stability of fractures of the ankle. They examined 12 cadaveric specimens and prepared three experimental groups: (a) intact ankles, (b) ankles with a fibular osteotomy and (c) those with fibular osteotomy and transection of the deltoid ligament. Axial loading radiographs failed to show any difference in talar shift with widening of the medial clear space between the three groups. If we combined the findings of these cadaveric studies, we would conclude that gravity stress views detected instability in all, whereas axial loading views detected instability in none of the ankles. Therefore, one can argue that axial loading helps reduce an ankle with an isolated distal fibular fracture, whether the deltoid ligament is ruptured or not. However, findings in cadavers cannot necessarily allow conclusions to be drawn about the biomechanics of a fracture in vivo. Furthermore, it could be argued that a small sample size, as in cadaveric studies, may not also be such as to allow conclusions to be drawn, given that in the clinical studies we mentioned earlier,3,22 a small proportion (< 5%) of ankles were deemed unstable using weight-bearing radiographs. Nevertheless, if we consider the findings of all these clinical and cadaveric studies, we could conclude that, in the vast majority of cases, the axially loaded or weight-bearing position reduces the ankle mortise when examining SER fractures. Further laboratory, cadaveric and clinical studies may shed more light on this issue.

Why do stress radiographs overestimate the instability of a fracture? What is different about the small proportion of SER fractures that present with talar shift only in the weight-bearing position? No definite explanation can be given. In this annotation, we have tried to address this by proposing a theory based on what is already known about the anatomy and biomechanical properties of the medial collateral (deltoid) ligament.26,27

This ligament has a superficial and a deep layer. The superficial layer resists plantar flexion and external rotation of the talus relative to the tibia.26 The deep layer has anterior and posterior components, the anterior and posterior talo-tibial ligaments (ATTL and PTTL). The posterior ligament is the strongest and most consistently found in cadaveric specimens. It is an intra-articular, but extrasynovial ligament, originating mostly from the posterior colliculus of the medial malleolus and inserting onto an oval tubercle on the posteromedial surface of the talus, just plantar to the articular surface.26 The PTTL is tight when the foot is plantigrade such as when weight-bearing on a plantigrade foot, and loose when the foot is plantar flexed.26 Therefore, a ruptured ATTL, with an intact PTTL, may have the same effect on stability, allowing lateral shift of the talus when the foot is in a non-plantigrade position.
(when the PTTL is loose) as, for example, when presenting on a non-weight-bearing mortise radiograph, at examination under anaesthesia or, when performing a gravity stress radiograph. Thus, a partial rupture of the deltoid ligament involving the ATTL only, accompanying a SER distal fibular fracture, may result in widening of the medial clear space with talar shift, when the foot is not plantigrade, and the assumption under these circumstances would be that the fracture was unstable.

Therefore, these characteristics of the deltoid ligament have the following implications on the classification and the clinical and diagnostic features:

- when both the superficial and deep components are intact (SER-II fracture), external rotation forces can be resisted and stress tests indicate a stable ankle;
- when the superficial component is ruptured, it cannot resist external rotation which will open the medial clear space and stress radiographs will indicate instability. This could be the result of a partial rupture of the deep deltoid ligament involving only the ATTL;
- when the superficial and ATTL parts of the ligament are injured, but the PTTL is intact, and a standard non-weight-bearing radiograph is taken, the foot plantar flexes, the PTTL becomes loose, does not resist talar shift and the medial clear space widens (Fig. 3a). If however, the foot is plantigrade, as on an anteroposterior weight-bearing radiograph, the PTTL, if intact, is tight, thereby preventing lateral translation of the talus and the mortise, as a result, appears congruent (Fig. 3b). We therefore propose that, a (ligamentous) SER-IV ankle fracture, one without a medial malleolar fracture, with a ruptured superficial and/or ATTL, but an intact PTTL, be classified as a ‘SER-IV(A)’ fracture.
- with a complete rupture of the superficial and deep components (both ATTL and PTTL) of the deltoid ligament, the medial clear space will open in all positions of the foot, thus also on weight-bearing radiographs (Fig. 4). This type of fracture can be classified as SER-IV(B).

**Implications on the management of the fracture**

SER-II type fractures are stable and can safely be treated non-operatively in a brace, boot or cast depending on the patients’ characteristics and the clinicians’ preferences, allowing early weight-bearing, as tolerated. The intact deltoid ligament prevents translation of the talus in any position of the foot. Thus, immobilisation in a plaster cast or internal fixation are not mandatory requirements.

SER-IV(A) fractures are potentially unstable because if a neutral, plantigrade position of the foot is not maintained, the PTTL will not be tight, thereby potentially allowing the superficial and ATTL components to heal with lengthening, resulting in chronic instability and, ultimately, allowing late talar shift. Thus, they should be treated with immobilisation in a cast, in a neutral plantigrade position, with weight-bearing as tolerated. A boot is contra-indicated in these patients as it can be removed allowing plantar flexion which increases the chances that the partly torn ligament will heal with some lengthening, potentially allowing later talar shift.

SER-IV(B) fractures are always unstable according to our theory. Thus, we advocate operative fixation. One can argue, however, that functional bracing may still be possible for some (occult) SER-IV fractures, based on the findings of studies, referenced earlier. Prospective
multicentre studies comparing operative fixation with functional bracing may clarify this issue further.

The above proposed recommendations and algorithm are consistent with the current British Orthopaedic Association Standards for Trauma guidelines, published in August 2016.28

In conclusion, there is no absolute requirement for operative stabilisation of isolated SER Weber type-B fractures, as about 90% of them reduce in the weight-bearing position and appear stable. They can safely be treated non-operatively as internal fixation is not without its problems and complications.2,3 Stress radiographs overestimate the need for surgery, whereas weight-bearing radiographs performed for these fractures, within ten days of injury, can identify the stability of the fracture reliably and also, the potentially unstable 10% which should be considered for internal fixation. Evidence shows that even when these potentially unstable fractures are treated non-operatively, only 2.3% displaced, and this was within the first week.15

The anatomy and biomechanical properties of the deltoid ligament have important implications for the management of isolated SER Weber type-B fractures.

Take home message:
- The vast majority of SER (Weber type-B) ankle fractures are stable and can be safely treated non-operatively.
- Weight-bearing radiographs can identify unstable fractures.
- The anatomical features and integrity of the deep deltoid ligament play a crucial role in fracture stability.

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