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# A practical 'safe zone' technique for lag screw fixation of the fibula

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**ABSTRACT**

INTRODUCTION During ankle fracture fixation, iatrogenic trauma to retro fibula structures can result in morbidity and reoperation. We describe a safe zone for lag screw insertion.

MATERIALS AND METHODS This study was completed in three sections. We identified the average entry and exit points for the lag screw using 45 Weber B ankle fractures identified from our trauma database. We then analysed 26 sequentially presented ankle magnetic resonance images, concentrating on axial sections at 4, 8, 12 and 16 mm above the ankle joint. Finally, we used 63 sequentially performed magnetic resonance scans to confirm the safe zone from these consistent structures.

RESULTS The typical lag screw exit point was 14.2 mm above the ankle joint (95% confidence Interval 11.3–17.1 mm). A safe zone trajectory occurred between 31 and 45 degrees taken from the anterior aspect of the flat fibular surface at this level. The obvious palpable landmark to direct screw trajectory and avoid 'at risk' structures was found to be the medial edge of the Achilles tendon. Our final dataset confirmed in 63 scans, the medial aspect of the Achilles tendon to be a consistent safe zone with a minimum distance of at risk structures of 4 mm.

CONCLUSION This simple method of directing the fibula lag screw towards the palpable medial edge of the Achilles tendon is practical, easy to teach and directs the screw on a safe trajectory away from the most commonly injured structures around the back of the fibula.

**KEYWORDS**

Ankle Fractures – Bone Screw – Lag screw

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## Introduction

A fracture of the ankle is one of the most common injuries encountered in a trauma department, with an estimated annual incidence of around 122–184/100,000.[1,2] The most common subtype of ankle fracture is the supination external rotation injury or Danis-Weber B fibular fracture.[3,4] This can be solitary or the starting point for a more complex injury pattern.[5] Common surgical management for a displaced fibula fracture with concomitant medial injury involves a direct lateral approach, lag screw fixation of the fibular combined with neutralisation plating. Osteosynthesis for low fibula fractures does, however, carry the risk of injury to, or impingement on, soft tissues, necessitating metalwork removal.[6,7] The lag screw position can be within a few millimetres of important structures such as the syndesmosis and peroneal tendons. Trauma to these structures can necessitate reoperation in up to 43% of patients.[8,9] The identification and use of safe corridors for implant insertion form the basis of good orthopaedic practice and, to date, no previous studies have attempted to define a safe zone for lag screw insertion for this common procedure.[10]

Our study aimed to address this deficiency using a combination of postoperative radiographic and magnetic resonance images (MRI) to define typical fibula lag screw position and map a common reference point and subsequent safe trajectory for lag screw fixation in the unstable supination external rotation/Danis-Weber B type injuries.

## Materials and methods

We completed this study in three sections. Out initial aim was to identify the average entry and exit points for the lag screw. In searching our trauma database, we identified 45 ankle fractures that encompassed an AO B1.1 (Danis-Weber B) type injury treated with lag screw fixation followed by neutralisation plating, from January 2015 to January 2016. All radiographs were analysed using digital imaging software (Vue PACS, Carestream, Version 11.4.1.0324). Screw exit level in millimetres was charted relative to the ankle joint line on the lateral postoperative radiograph (Fig 1). All measurements were made three times and the mean recorded.

Figure 1 Screw exit point distance relative to ankle joint (white arrow)

These findings guided our next pilot study, when we analysed 26 sequentially presented ankle MRIs, performed for varying pathology. The analysis was concentrated at 4, 8, 12 and 16mm above the ankle joint. This section aimed to identify consistent structures that could be found intraoperative, and any safe zone in respect to these structures.

The third section of this study used 63 sequentially performed MRI scans between June 2015 and December 2015, which were completed for suspected musculoskeletal pathology. A total of 95 scans were initially screened for suitability; 32 were excluded due to significant trauma, deformity or pathology associated with either the ankle joint, peroneal or Achilles tendons or substandard MRI sequences of the ankle.

Using the consistent landmarks identified in section 2, ideal interfragmentary screw placement was estimated, with the assumption that an anteroposterior placed screw was to be performed orthogonal to a fracture line created by a rotational fibular injury. Images were reviewed at 4-, 8-, 12- and 16-mm slices from the ankle joint for an ideal screw trajectory. Distances were identified and measured from the at-risk structures to the proposed central screw trajectory in each image, intra-observer measurement repeatability tested on 44 images was acceptable with a mean variability between measurements of 0.6mm (95% confidence interval 0.5–0.7 mm).

All scans used were reported by consultant musculoskeletal radiologists and performed on Siemens 1.5-T scanners. Standardised musculoskeletal protocol magnetic resonance sequences were used to produce 4-mm thickness axial, coronal and sagittal T1-weighted spin echo images (TR/TE: 400–600 msec/15–30 msec) and additional fat suppressed T2-weighted fast spin-echo sequences (TR/TE: 2,000–4,000 msec/80-120 msec) using short tau inversion recovery technique (STIR) or frequency selective chemical presaturation pulse. All data were assessed using SPSS version 20.0 (IBM).

## Results

On review of the 45 ankle fracture radiographs; the typical lag screw exit point was found to be 14.2 mm above the ankle joint (95% confidence Interval 11.3–17.1 mm) with a mean screw length of 22 mm (95% confidence interval 20–24 mm). Using these data, we concentrated our analysis on sections between 4 and 16 mm proximal to the ankle joint.

In section 2, 26 ankle MRI scans were analysed to identify consistent structures. A constant flat surface was identified on the anterolateral aspect of the fibular on all MRI scans and a safe zone was detected using composite images. The fibular flat surface started at the joint line and was consistent throughout the sections occurring on the anterolateral aspect of the fibular. All images were stacked on top of one another to create a composite image, with the posterior incisura and peroneal tendons clearly illustrated to occur consistently in the same region (Fig 2). These results are demonstrated in Table 1. A safe zone trajectory was seen to occur between 31 and 45 degrees taken from the anterior aspect of the flat fibular surface. From this pilot study, the obvious palpable landmark to direct screw trajectory and avoid the most medial and lateral 'at risk' structures was found to be the medial edge of the Achilles tendon (Fig 3).

Our final dataset comprised 29 female and 34 male patients with a mean age of 47.4 years (range 17–86 years), 32 left and 31 right ankles. All scans included were performed for suspected foot and ankle pathology or as part of unrelated research trials and found to be normal (see Table

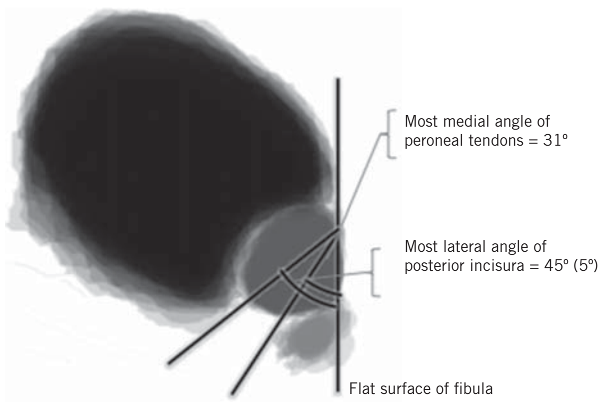


Figure 2 Composite image of 26 magnetic resonance images of the ankle 8 mm proximal to the talocrural joint, illustrating the tibia (large black), fibular (medium blue) and peroneal tendons (small red). The flat surface of the fibular is apparent and the angles measured from this show the safe zone for screw trajectory

**Table 1** Safe zone measurements.

| | Minimum angle to most medial aspect of peroneal tendons | Minimum angle to most lateral aspect of incisura | Mean angle from FSF to medial aspect of peroneal tendons | Mean angle from FSF to lateral aspect of incisura |
|---|---|---|---|---|
| Joint line | 30 | 40 | 17.2 (6.77) | 49.6 (5.95) |
| 8 mm proximal | 31 | 45 | 13.4 (6.88) | 56.4 (5.15) |
| 16 mm proximal | 30 | 68 | 6.23 (8.26) | 78.8 (6.91) |

Safe zone measurement performed on 26 magnetic resonance imaging scans at joint line, 8 mm and 16 mm proximal to talocrural joint. All angles were taken from the consistent anterolateral flat surface of fibula (FSF). Standard deviation given in brackets.

1 for MRI scan details). Table 2 demonstrates the relative distance for structures at risk using the screw trajectory of flat surface of fibular to medial aspect of tendoachilles at corresponding levels from the ankle joint (Fig 4).

One-way correlated analysis of variance demonstrated no differences in screw exit position in relation to the peroneal tendons as distances from the ankle joint increases ($P = 0.84$). Distance from incisura increased and screw distance from the flexor hallucis longus diminished moving away from the ankle joint ($P < 0.01$).

It was suspected that minor inflammation of the Achilles or peroneal tendons might influence measured distances. Seven patients were identified from the MRI analysis with inflammatory changes of these structures; however, mean distances from screw trajectory were almost identical to the same mean values, ruling this out as a potential source of bias.

## Discussion

Our study has identified in a logical progression a safe method for lag screw insertion in the surgical treatment of unstable Danis-Weber B type fractures. Acknowledging the limitations of fracture fixation, when screw trajectory is often dictated by fracture pattern, this method allows the surgeon a thoughtful process to avoid damaging other structures. Previous cadaveric studies have demonstrated the close proximity of the peroneal tendons and sural nerve which pass within millimetres of the posterior medial boarder of the fibula, however the risk remains underappreciated.[8] Our investigation supports these findings and draws attention to other 'at risk' structures such as the incisura and flexor hallucis longus.

The majority of scans used for our analysis were taken from patients attending foot and ankle clinics for unrelated pathology. Anatomical differences between this patient group and the ankle fracture population could exist. We assumed potential differences to be insignificant in relation to this analysis as mean age and gender for our study population were similar for typical patients presenting with ankle trauma and scans were essentially 'normal' for our area of interest. In our pilot study, the consistencies of the anatomical location of the structures at risk were extremely regular, as illustrated in the composite images. In the pilot study, all pathology was included, but in the last data set we excluded scans with significant pathology as we considered that normal anatomy was paramount.

Typically, a 3.5-mm screw thread would project 1.75 mm either side of the ideal screw trajectory we describe. However, 95% confidence intervals including maximum intra-observer measurement error still place structures at risk outside this potential zone of injury if the screw follows the

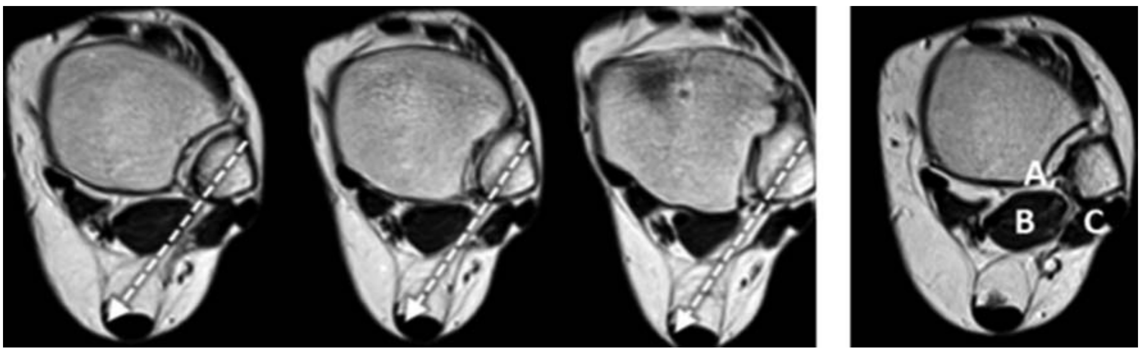


**Figure 3** Images on the left. T1-weighted axial magnetic resonance images of the left ankle descending at 12, 8 and 4 mm from the ankle joint (left to right) demonstrate proposed screw trajectory (dotted line)

**Table 2** Distance from structures at risk.

| Distance from joint | Distance from structures at risk (mm) | | |
|---|---|---|---|
| | Incisura | Flat surface of fibula | Peroneal tendons |
| 4 mm | 4.6 (4.1–6.1) | 6.6 (5.6–7.6) | 4.4 (4.0–4.9) |
| 8 mm | 4.4 (3.9–4.9) | 5.8 (5.1–6.4) | 4.5 (4.0–4.9) |
| 12 mm | 6.0 (5.4–6.5) | 5.2 (4.5–5.9) | 4.5 (4.1–4.9) |
| 16 mm | 7.7 (7.1–8.3) | 4.5 (3.9–5.1) | 4.5 (4.1–5.0) |

Using screw trajectory from the flat surface of fibular to the medial aspect of the tendoachilles, the calculated distances to the structures at risk are illustrated. Taking into account the 3.5-mm thread, the screw will come within 2.65 mm of 'at risk' structures at its closest point.

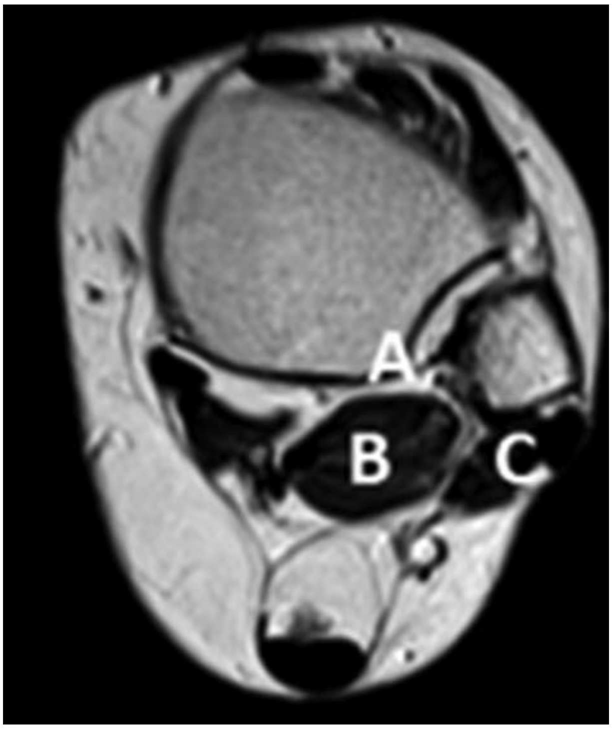


**Figure 4** Image on the right. Magnetic resonance T1-weighted spin echo sequences demonstrating 'at risk' structures around screw exit point 16 mm above the ankle and medial edge of the tendoachilles. (A) insisura fibularis, (B) flexor hallucis longus muscle belly, (C) peroneus brevis

track we describe. At-risk structures are just as easily injured from an overlong as opposed to a maldirected screw and, as such, we consider it imperative that surgeons should not overlook this important point.

## Conclusion

Our 'low tech' method relies on the operating surgeons' stereotaxic ability to direct the drill towards the palpated medial edge of the Achilles tendon. Anecdotally, we have found the technique practical, easy to teach and repeatable. In summary, we recommend this evidence based surgical method during lag screw placement for a simple Danis-Weber B fibular fracture.

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