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Circular frame fixation for calcaneal fractures risks injury to the medial neurovascular structures: A cadaveric description

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ABSTRACT

Aim: There is a risk of iatrogenic injury to the soft tissues of the calcaneus and this study assesses the risk of injury to these structures in circular frame calcaneal fracture fixation.
Materials and methods: After olive tip wires were inserted, an L-shaped incision on the lateral and medial aspects of 5 formalin fixed cadaveric feet was performed to expose the underlying soft tissues. The calcaneus was divided into zones corresponding to high, medium and low risk using a grading system.
Results: Structures at high risk included the posterior tibial artery, posterior tibial vein and posterior tibial nerve on the medial aspect. Soft tissue structures on the lateral side that were shown to be at lower risk of injury were the small saphenous vein and the sural nerve and the tendons of fibularis longus and fibularis brevis.
Conclusion: The lateral surface of the calcaneus provides a lower risk area for external fixation. The risk of injury to significant soft tissues using a circular frame fixation approach has been shown to be greater on the medial aspect.
Clinical relevance: This study highlights the relevant anatomical relations in circular frame fixation for calcaneal fractures to minimise damage to these structures.

Introduction

The calcaneus is the most frequently fractured tarsal bone and accounts for about 2% of all fractures in the human body and 70% of these are displaced.[1] Extra-articular fractures account for the remaining 30% and include all fracture patterns that do not involve the posterior facet of the calcaneus.[2] Open reduction and internal fixation (ORIF), over the last decade, has been considered the ‘gold standard’ in the surgical treatment of physiologically young patients and leads to good outcomes.[3]

There is a risk, however, of considerable early and delayed complications. Early complications often relate to surgical technique with infection and wound dehiscence remaining a feared outcome. There is a definite incidence of neurological injury with a 6% incidence of sural nerve insult.[4]

Despite these concerns, there is a body of evidence which demonstrates good outcomes following fixation of fractures via an extensile lateral approach. Buckley [5] has noted significantly higher satisfaction scores in operatively managed patients who were not receiving Worker's Compensation, were women, or were patients younger than 29 years old. Since this landmark paper, there has been real interest in fixing calcaneal fractures. Griffin’s group from Warwick describe less optimistic two year outcomes from a multi centre randomised controlled trial.[6] They have noted no difference in outcome between those who have been managed conservatively and those who have proceeded to operative intervention.

Following the publication of this paper, there has been real controversy. Some trauma surgeons are of the opinion that fixation of calcaneal fracture is now not merited. Others, however, have come to the conclusion that perhaps alternative methods of fixation should be explored. There is a developing vogue in Europe for minimal access calcaneal osteosynthesis.[7] Its long term results are yet to be described. The indications for this technique are still evolving.

Another alternative method of fixation for treating Sander’s type II, III and IV calcaneal fractures involves circular frames. Percutaneous olive wires are used to aid in reduction of the

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fracture.[8] This treatment has been found to be effective in treating intra-articular fractures in small-scale studies with a decreased incidence of complications associated with more invasive techniques.[9–11] It maintains extra-articular reductions just as effectively.[12] Ilizarov surgery is not commonly performed by most orthopaedic surgeons which when combined with a steep learning curve and the, technical difficulty of such surgery has led to a lack of uptake in this technique. The clinical results of circular frame fixation of these fractures is promising, however.[13,14]

Despite these promising results, there remains a lack of reporting within the literature regarding the incidence of neurological and soft tissue injury [15] following circular frame fixation. Some studies have attempted to divide the surfaces of the calcaneus into zones according to increasing risk of injury to neurovascular and tendinous structures [16–20] but have yet to come to a clear agreement. It has been suggested by Labronici et al. that vascular structures found superficially to the anteromedial surface of the calcaneus are at high risk of damage during wire fixation performed via the lateral aspect of the hindfoot.[20]

The optimal point of entry of transcalcaneal wires is vital for reducing the risk of iatrogenic injury to neurovascular and tendon structures.[21] In this study, we aim to describe the incidence of injury to neurovascular and tendinous structures as well as describing the presence of high, medium and low risk zones within the calcaneus to help guide the insertion of fine olive tip wires in both a medial to lateral and a lateral to medial direction.

Materials and methods

Five cadaveric ankle specimens were used in this investigation, three right feet and two left feet from 3 patients (two male and one female), that had been perfused and fixed in a solution containing methanol, phenol, formalin, glycerol, and phenoexetol. All cadaveric specimens were obtained from adults >70 years of age without any prior trauma to the heel. Mean age of the subjects was 87 (range: 74–95). The selection of specimens was from the regular stock in the Laboratory of Human Anatomy, University of Glasgow. All specimens were from the body donor programme and conformed to the Anatomy Act 1984 and the Human Tissue (Scotland) Act 2006. Criteria for use included no specific disease or trauma related to the lower limb with no previous dissection in the calcaneal region. Due to the fixation method used, the specimens were all found to be in slight plantar flexion.

Two standard trans-osseous 1.8 mm Smith & Nephew olive wires were placed through the calcanei, one directed from the medial aspect towards the anterolateral surface, and one directed in from the lateral aspect anteriorly to the anteromedial surface of the hindfoot. The crossed wires were positioned by the senior author. The wires were placed obliquely to maximise bony purchase and were placed from medial to lateral and lateral to medial to aid in fracture reduction particularly with regard to lateral calcaneal wall extrusion.

Easily palpable anatomic landmarks were recognised as the inferior tip of the lateral malleolus (A) and the superior tip of the posterior calcaneus palpable from the lateral aspect of the hindfoot (B). The base of the 5th metatarsal was also used as an additional reference point (C) on the lateral side. Medially, palpable landmarks were established as the inferior tip of the medial malleolus (D), the superior tip of the posterior calcaneus palpable from the medial hindfoot (E) and the most prominent part of the navicular tuberosity (F). These points are shown in Fig. 1. The lateral to medial, and medial to lateral olive wire exit points were identified on each aspect of the foot and varied from specimen to specimen.

Dissection was initially performed medially via a L-shaped incision from 10 cm superior to the tip of the medial malleolus to 10 cm anterior to the navicular tuberosity on the medial aspect. A similar incision was utilised on the lateral aspect extending from above the lateral malleolus to distal to the base of the 5th

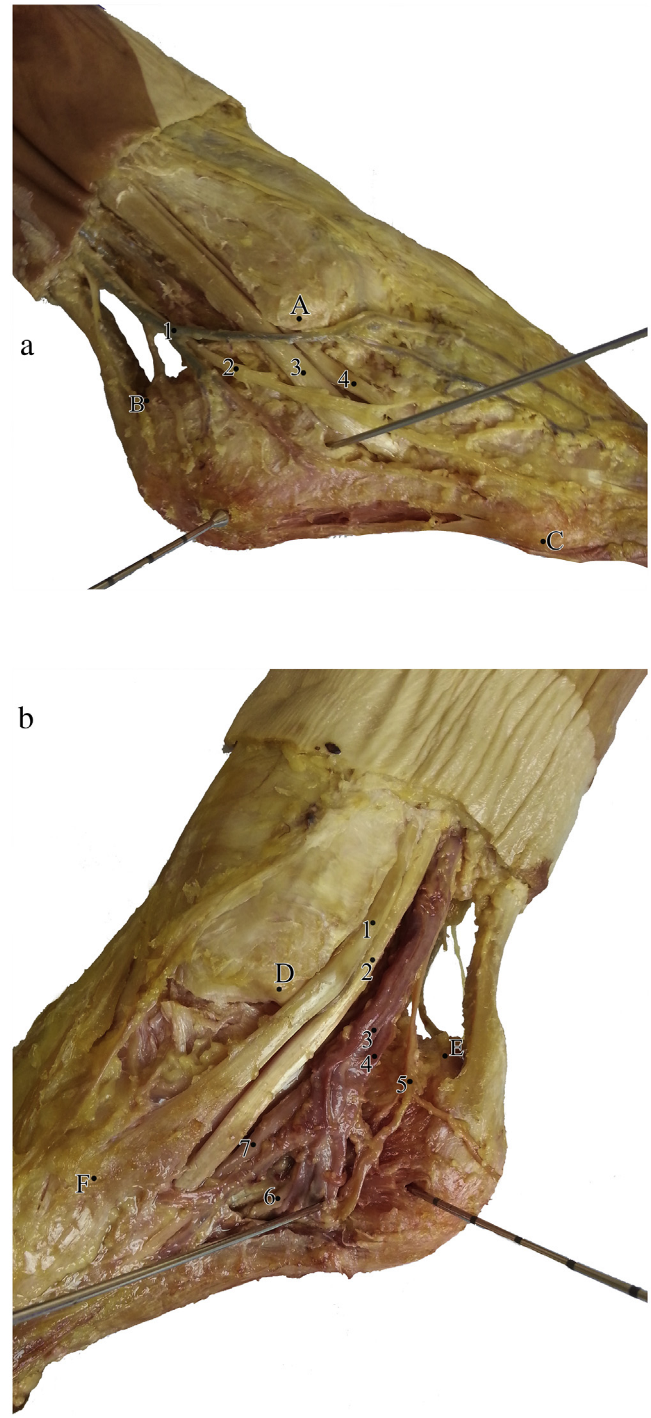

Fig. 1. Detailed dissection of the heel of specimen 5 with olive wires inserted: a. Lateral view of the inferior tip of the lateral malleolus (A), the superior part of the posterior calcaneus (B), the base of the 5th metatarsal (C). The courses of the small saphenous vein (1), the sural nerve (2), fibularis longus (3), and fibularis brevis (4) are shown. b. Medial view of the inferior tip of the medial malleolus (D), the superior part of the calcaneus (E), the navicular tuberosity (F). The paths of the tibialis posterior (1), flexor digitorum longus (2), posterior tibial artery (3), posterior tibial vein (4), medial calcaneal branch of tibial nerve (5), lateral plantar nerve (6), and the flexor hallucis longus tendon (7), are shown.