The ‘Retro-Fibular Wire’
AN ANATOMICAL STUDY DESCRIBING A SAFE CORRIDOR FOR PLACEMENT OF FINE WIREs IN THE DISTAL TIBIA

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Anatomical atlases document safe corridors for placement of wires when using fine-wire circular external fixation. The furthest posterolateral corridor described in the distal tibia is through the fibula. This limits the crossing angle and stability of the frame. In this paper we describe a new, safe Retro-Fibular Wire corridor, which provides greater crossing angles and increased stability. In a cadaver study, 20 formalin-treated legs were divided into two groups. Wires were inserted into the distal quarter of the tibia using two possible corridors and standard techniques of dissection identified the distance of the wires from neurovascular structures.

In both groups the posterior tibial neurovascular bundle was avoided. In group A the peroneal artery was at risk. In group B this injury was avoided. Comparison of the groups showed a significant difference (p < 0.001).

We recommend the Retro-Fibular wire technique whereby wires are inserted into the tibia mid-way between the posteromedial border of the fibula and the tendo Achillis, at 30° to 45° to the sagittal plane, and introduced from a posterolateral to an anteromedial position. Subsequently, when using this technique in 30 patients, we have had no neurovascular complications or problems relating to tethering of the peroneal tendons.

An important factor affecting the bending stability of fine-wire circular external fixators is the crossing angle of the wires, with an angle of 90° conferring optimal stability.1-3 Safe anatomical corridors have been described for insertion of wires in order to avoid injury to neurovascular structures. The position of the posterior tibial neurovascular bundle limits the available crossing angle to between 40° and 70° when inserting wires into the tibia.3-6 Therefore the potential risk of neurovascular injury must be balanced against the mechanical benefits of maximising the crossing angle.

The posterior tibial artery and tibial nerve preclude the placement of a tibial wire in the sagittal plane at most levels. In the distal quarter of the leg these structures pass medially to run behind the medial malleolus. This potentially facilitates the insertion of a wire starting behind the fibula and passing from a posterolateral to an anteromedial position. This is termed a ‘Retro-Fibular Wire’ and although it is considered to be a safe corridor for wire placement theoretically, this technique has not been described previously. An anatomical study was undertaken to identify structures at risk during placement of a Retro-Fibular wire, to assess the safety of two potential methods of insertion and determine the level at which this technique can be used safely.

Materials and Methods
The study was carried out using 20 cadaver legs provided by the School of Biomedical Sciences at our University. They were treated with formalin and stored at room temperature for the duration of the study. The work was carried out in the dissection rooms and the handling of specimens complied with University guidelines. Medical grade 1.8 mm external fixation wires were used (Smith and Nephew, Memphis, Tennessee) and inserted with a standard wire driver (Synthes, Oberdorf, Switzerland) as in clinical practice. The wires were not tensioned.

The wires were inserted at increments along the tibia (Fig. 1). As the technique is proposed for use in the distal tibia, an increased concentration of wires was inserted into its distal quarter (wires 3 to 5). In order to reproduce the clinical technique the legs were not disarticulated and wires were introduced freehand from posterolateral to anteromedial, between 30° and 45° to the sagittal plane.

At levels 3, 4 and 5 in the distal quarter of the tibia wires were inserted using two different techniques, with legs being allocated
randomly to two equal groups (Fig. 2). In group A, wires were placed against the posterior surface of the fibula and ‘stepped’ medially past its posteromedial border onto the tibia. In group B, wires were inserted mid-way between the posteromedial border of the fibula and tendo Achillis. As these structures are not readily identifiable more proximally, the wires at levels 1 and 2 were ‘stepped’ off the fibula in both groups.

With all five wires in place, a mixture of sharp and blunt dissection was used to identify the path of the wires and their distances from neurovascular structures. The initial dissection was at the entry points, where Mitutoyo slide callipers (Mitutoyo, Tokyo, Japan), accurate to 0.01 mm, measured the distance of each wire from the common peroneal nerve, posterior tibial neurovascular bundle, peroneal artery, sural nerve and short saphenous vein. Once the posterior dissection was completed, the exit points on the anteromedial surface were explored and any tethering of tendons noted. The deep peroneal nerve and anterior tibial artery were specifically identified in each specimen to ensure they had not been damaged.

**Statistical analysis.** This was carried out using Analyse-it software (v2.1) for Excel (Microsoft, Redmond, Washington). The experimental hypothesis was that there would be a difference between the mean distance of wires from the posterior tibial neurovascular bundle and peroneal artery using the different techniques. As the data was found to be normally distributed using a Shapiro-Wilk test, statistical significance was tested using a two-tailed unpaired t-test. A p-value of < 0.05 was considered statistically significant.

**Results**

At levels 1 and 2, in the proximal half of the tibia, the wires passed dangerously close to, or damaged neurovascular structures. At level 1 the wires passed between the popliteal artery at a mean distance 6.8 mm (0 to 15.1); one wire piercing the artery, and the common peroneal nerve at a mean distance of 6.3 mm (0 to 15.4) with one wire piercing the nerve. The wires at level 2 passed close to the peroneal artery at a mean distance of 4.25 mm (0 to 18.2). A total of seven wires passed < 1 mm from the artery without piercing it but avoided the posterior tibial neurovascular bundle by a mean distance of 12.9 mm (1.9 to 20.2).

In group A the wires in the distal quarter of the tibia avoided the posterior tibial neurovascular bundle at a mean distance of 21.7 mm (13.8 to 30.7) (Fig. 3). However, they passed close to the peroneal artery at a mean distance of 1.2 mm (0 to 3.6). Where wires passed close, it often appeared that the artery had bent around around the wire after its insertion (Fig. 4) and in one case the wire had pierced the artery.

In group B, wires in the distal quarter of the tibia also avoided the posterior tibial neurovascular bundle at a mean distance of 15.5 mm (12.7 to 21.4) and, in contrast with group A, the peroneal artery was preserved using this
The wires in group A were significantly closer than those in group B (1.2 mm vs 7.1 mm, p < 0.001) and these differences remain significant when considering wires at individual levels (Tables I and II).

Anterior dissection showed that the anterior neurovascular structures were not damaged in any of the specimens, although tethering of the anterior tendons occurred in a small proportion. In group A, the anterior tendons were tethered by four of 30 distal tibial wires (13%), while in group B they were tethered by five of 30 distal tibial wires (17%). The difference between the groups was not statistically significant (p > 0.05).

In both groups, the short saphenous vein and sural nerve were not threatened by the wires. The mean distance of wires from the short saphenous vein was 8.6 mm (3.9 to 18.4), and the mean distance from the sural nerve was 9.8 mm (4.5 to 19.2). The difference between the groups was not significant (p > 0.05).

**Discussion**

Fine-wire circular fixators are increasingly used in the treatment of complex injuries of the leg. The placement of wires depends on the fracture pattern but must provide a stable construct without risk of damage to neurovascular structures. A larger crossing angle adds to the stability but can also increase the risk of neurovascular damage.

Although anatomically safe corridors are described in a number of cross-sectional atlases there are few reports in recent literature. The furthest posterolateral safe corridor in the distal tibia previously described is transfibular, thereby limiting the crossing angle and the stability of the frame. Recent research into placement of wires in the distal tibia has concentrated on minimising the risk of infection, advances in pin-site care and advice on placing wires
outside joint capsules. We were unable to identify any previous report of Retro-Fibular Wire placement in the available anatomical atlases or published literature.

The Retro-Fibular Wire allows for a larger crossing angle in the distal tibia and we favour this technique, as represented by wires 3 to 5 in this study. Wires 1 and 2 posed significant danger to neurovascular structures and we do not advise Retro-Fibular placement at this level. Such placement in the distal quarter of the tibia does not threaten the posterior tibial neurovascular bundle when inserted using either of the techniques described. Wires in group B were closer than in group A, but no wire in either group passed within what we would consider a dangerous distance from the bundle. However, the wires in the former group were significantly (p < 0.001) further from the peroneal artery (mean 7.1 mm, 5.6 to 11.2) than in the latter (mean 1.2 mm, 0 to 3.6). Group B provided what we consider to be safe distances from the posterior tibial neurovascular bundle and the peroneal artery. These distances were larger than those described for safe corridors in the distal quarter of the tibia is unclear. At this level, the peroneal artery is often of small calibre and was not always seen in the cadaver specimens. At the level of wire 3 the artery was always present, but was absent in two limbs at the level of wire 4 and seven limbs at the level of wire 5.

We recommend the technique used in group B as a new, safe corridor for insertion of a Retro-Fibular Wire in the distal tibia. The wires are inserted mid-way between the postero-medial border of the fibula and the tendon Achilles, at 30° to 45° to the sagittal plane and from a posterolateral to antero-medial position. The use of this corridor confers optimal stability and avoids damage to neurovascular structures.

Subsequently we have used the technique in 30 patients, often to treat posterior malleolar fragments in pilon fractures and occasionally in the treatment of fractures of the ankle. It has also been used to provide a mechanical advantage in certain situations, for example, where there is a short distal tibial segment. The Retro-Fibular Wire can then provide an extra corridor for an additional wire to maximise distal fixation. It can provide greater stability of the distal segment due to the increased crossing angle and may remove the need to span the ankle joint due to a stronger hold on the distal segment.

This is a cadaver study and therefore, the clinical outcome of the use of the Retro-Fibular Wire has not been described in detail. One possible complication is that wires inserted using this corridor may transfixed the peroneal musculature or flexor hallucis longus. Inversion of the ankle and planter flexion of the great toe may reduce this risk. We have had no neurovascular complications using the technique and no problems relating to tethering of the peroneal tendons.

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No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References