

# The risk of nerve injury with minimally invasive plate osteosynthesis of distal fibula fractures: an anatomic study

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## Abstract

**Aim** The aim of our study was to identify the structures which may be at risk of injury when using a minimally invasive technique for the osteosynthesis of the lateral malleolus and the influence of the size of the implant on the frequency of injury to these structures.

**Method** Forty plates were percutaneously inserted in 20 cadaveric legs. The region around the plate was then dissected to examine the relation of nerves and soft tissues to the plate.

**Results** The superficial peroneal nerve was in direct contact with the plate in 11 of the 20 cases (55%) of the 10 hole plates. We encountered only one case of the superficial peroneal nerve skirting the proximal edge of a 6 hole plate ( $p = 0.0164$ ).

**Conclusion** Consequently we recommend meticulous attention is paid to the dissection of soft tissues in both the

proximal and distal incisions. The length of the plate may be checked with intraoperative imaging prior to its insertion, and the site of both proximal and distal incisions may be marked on the skin. After careful dissection down to the bone, preserving nerves and tendons, the periosteal elevator should be introduced both from the proximal as well as the distal incisions to prepare the extra-periosteal tunnel for the insertion of the plate, in order to avoid the entanglement of the superficial peroneal nerve with the metal work, particularly in plates of longer than six holes.

**Keywords** Minimal invasive plating fibula · Complications · Malleolar fractures

## Introduction

Fractures about the ankle are amongst the commonest injuries treated by orthopaedic surgeons. Operative treatment of displaced fractures is well-established and usually accomplished by open reduction and internal fixation (ORIF) using lag screw osteosynthesis and a neutralisation plate. Complications associated with surgical stabilisation have been reported with regard to the surgical approach [2, 10] as well as the hardware [4, 29]. In an attempt to resolve these issues alternative techniques have been developed focussing on the anatomical position of the plate [19, 20, 29], the use of lag screws without the accompanying neutralisation plate [26] and alternative implants such as the intramedullary (Knowles) pins [13]. The application of a minimally invasive technique for the plate osteosynthesis of the lateral malleolus is seldom reported in the literature [11]. In recent years the development of plate systems providing reliable angular stability have extended the indications for the use of these devices. It is important to note that

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the use of smaller incisions and minimally invasive techniques may carry a higher risk of injury to neurovascular structures in this neutralisational region [5, 7, 27].

The aim of our study was to identify the structures which may be at risk of injury when using a minimally invasive technique for the osteosynthesis of the lateral malleolus and the influence of the size and type of the implant on the frequency of injury to these structures.

## Materials and methods

Twenty lower extremities comprising 14 paired and 6 unpaired specimens from 13 cadavers were used for this study. There were 7 male and 6 female cadavers with a mean age of 76 years (59–98) at the time of death, preserved using the method of Thiel which preserves tissue colour and consistency as well as allowing an almost full range of motion at articular joints [25].

We used four different Locking Compression Plates® (LCP) (Synthes Betlach) which were of two different designs: the straight 3.5 mm LCP and one-third tubular LCP. These included two lengths of the one-third tubular LCP plate: 6 holes (76 mm) and 10 holes (124 mm); and two lengths of the 3.5 mm straight LCP: 6 holes (85 mm) and 10 holes (137 mm).

Each specimen was used to first assess a 6 hole plate and then the 10 hole plate of the same design. We therefore acquired data for 11 of each length of 3.5 mm LCP and 9 of each length of one-third tubular LCP, culminating in 40 sets of data.

## Surgical technique

A 10 mm longitudinal incision, midway between the anterior and posterior margins of the distal fibula, was made 5 mm proximal to the tip of the lateral malleolus. Care was taken not to breach the periosteum. An extra-periosteal tunnel was then fashioned on the lateral aspect of the distal fibula with a blunt periosteal elevator. The plate was introduced through the distal incision and advanced proximally. Once it was felt that the plate was adequately positioned distally a 10 mm incision was made over the proximal end of the plate. The plate was then lined up with the longitudinal axis of the fibula. By inserting two distal and two proximal locking head screws (LHS) the plate was secured to the bone. The proximal and distal 10 mm incisions were then connected and careful dissection of the soft tissues around the plate undertaken to identify the superficial peroneal nerve (SPN), the sural nerve (SN) and the peroneal tendons or muscle belly and their relation to the plate. This dissection was performed in the immediate vicinity of the plate and did not extend into the surrounding soft tissues. The

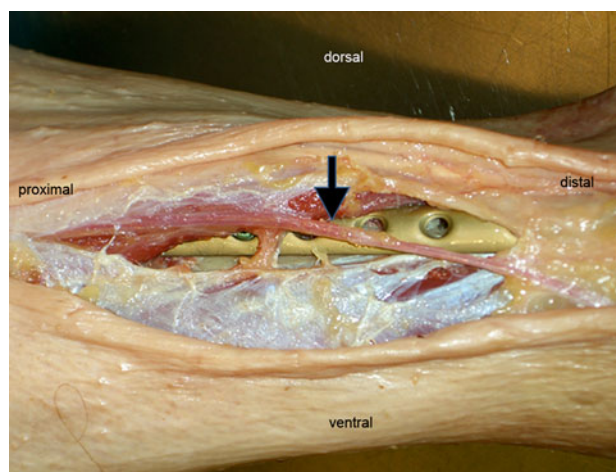
plate was then removed and the proximal extent closed with continuous suture leaving the initial 10 mm incision open. The same procedure as described above was then performed with the 10 hole plates of the same design first to fix it to the fibula and then to assess the relation of the soft tissues.

For statistical analysis descriptive results SPSS 14.0 was used. Further analyses were performed using SAS 9.1. All *p* values < 0.025 are considered as statistically significant. The critical boundary of 0.025 results from the correction for multiplicity according to Bonferroni due to the number of tests (2 tests were performed,  $0.05/2 = 0.025$ ).

## Results

We found that the superficial peroneal nerve (SPN) was in direct contact with the plate in 11 of the 20 cases (55%) of the 10 hole plates (5 cases with one-third tubular and 6 cases with the 3.5 mm LCP). In 1 of the 20 (5%) of the 6 hole plates the SPN came into contact with the anterior edge of the one-third tubular plate. The sural nerve was posterior to the plate in all cases and did not come into contact with it. We observed that in 4 of the 20 legs the sural nerve was at the tip of the lateral malleolus but never more proximal.

With the ten hole plates in three cases the superficial peroneal nerve came into contact with the anterior edge of the plate. In six cases the nerve was found to be crossing over the plate (Fig. 1), and in two cases the nerve was trapped beneath the plate. In all of these cases the nerve injury occurred at the level of the proximal four holes of the plates at a distance of 76–124 mm from the tip of the lateral malleolus in the one-third tubular LCPs and 85–137 mm



**Fig. 1** Superficial peroneal nerve (*arrow*) crossing a ten hole one-third tubular LCP

**Table 1** Plate type and nerve injury

Plate type	6 hole		10 hole	
	3.5 mm LCP	1/3 tubular	3.5 mm LCP	1/3 tubular
No nerve injury	11	8	5	4
Superficial peroneal nerve	0	1	6	5
Sural nerve	0	0	0	0
Total	11	9	11	9

from the tip of the lateral malleolus in the 3.5 mm straight LCPs. (Table 1).

There was a statistically significant correlation between the length of the plate and contact with the superficial peroneal nerve ( $p = 0.0164$ ).

## Discussion

Ankle fractures represent one of the most commonly encountered skeletal injuries [22] and make up to one-third of orthopaedic work load [30]. It is well accepted throughout the orthopaedic community that displaced malleolar fractures with shortening and rotation of the distal fragment, as well as those associated with distal tibiofibular joint diastasis and talar shift, benefit from surgical reduction and fixation, which is most often accomplished by open reduction and internal fixation with a lag screw and a neutralisation plate applied laterally onto the fibula. The exact restoration of anatomy with adequate length and rotation of the distal fibula are the prerequisites for a good functional result. Though overall complication rates are low and outcome is usually good [14, 22] soft tissue problems are not uncommon in these procedures and are reported in up to 22% of cases [9]. Patients with complex fracture patterns (fracture-dislocation, bimalleolar and trimalleolar fracture), poor bone stock and a compromised soft-tissue envelope either due to the injury or other co-morbidities including diabetes mellitus peripheral vascular disease are prone to high complication rates [6, 22, 23]. Serious complications after ankle osteosynthesis lead to poor functional outcome in these fractures [8, 18].

To avoid compromise of the thin lateral soft tissues, Weber et al. [29] described a dorsal approach with application of an “antiglide” plate to the posterior aspect of the fibula. This technique is also biomechanically advantageous in certain types of fractures. Although the lateral soft tissues remain intact, the plate may irritate the peroneal tendons [12, 14, 15]. In a series of 193 patients, Lamontagne et al. [12] showed the functional outcome and infection rate to be equal for both approaches, though he reported a

higher proportion of discomfort over the implant in the lateral approach.

Following the promising results seen in minimally invasive plate osteosynthesis for distal tibia fractures, the technique was also utilised in the fixation of some distal fibula fractures [11], predominantly for pronation–eversion injuries, comminuted fractures and in cases where the soft tissues envelope had been compromised. Krenk et al. [11] reported good results in 19 cases of comminuted fractures of the lateral malleolus which were treated with minimally invasive distal fibular plate osteosynthesis. They used much larger incisions (2–3 cm) in order to visualise the superficial peroneal nerve prior to fixation of the proximal end of plate. Although not strictly minimally invasive an extra-periosteal plating technique has been described by Siegel et al. A standard skin incision is made but care is taken not to incise the periosteum [19, 20].

New plate systems providing angular stability have facilitated the expansion of minimally invasive techniques which are accompanied by a reduction in the surgical violation of soft tissues [28], but may be associated with greater risk of iatrogenic nerve lesions. The deep peroneal nerve has been shown to be at risk with the use of anterolateral locking plates for the tibia especially in its distal course [17, 24]. It is notable that injuries to the superficial peroneal nerve resulting directly from tibial and ankle fractures have also been reported [16, 31].

The superficial peroneal nerve is a branch of the common peroneal nerve, which divides into a deep and superficial branch at the level of the fibular neck. The superficial peroneal nerve runs distally between peroneus longus and brevis muscles, piercing the crural fascia at 10–12 cm proximal to the ankle joint where it divides into its terminal branches, the medial and the intermediate dorsal cutaneous nerves. It innervates the peroneal muscles and provides the sensory supply for the anterior aspect of the leg and the dorsum of the foot. The level where the nerve divides into the two terminal cutaneous branches and perforates of the crural fascia as well as the relation of the branches of the superficial peroneal nerve are remarkably variable [1–3, 10, 21]. This variability is undoubtedly a factor in the frequency of iatrogenic injury to this nerve. Redfern et al. [18] found significantly more symptoms associated with the superficial peroneal nerve in the operatively treated group (21%) compared to those who were treated conservatively (9%) 2 years after an ankle fractures.

The findings of our study mirror those of others as regards the high rate of injury to the superficial peroneal nerve when operating on the lateral malleolus. This however has not been previously investigated with the minimally invasive method of distal fibular fixation. This is particularly the case with longer plates. We encountered

only one case of the superficial peroneal nerve skirting the proximal edge of a 6 hole plate. The other 11 cases of nerve injury, including interposition of the nerve between the plate and bone occurred within the proximal 4 holes of the longer 10-hole plates.

The sural nerve did not cross the fibula or the line of the incision in our group of specimens. It was found to be in close proximity of the tip of the lateral malleolus. Although this makes it less likely to be injured with the minimally invasive technique of fibula fixation, careful attention must be paid when extending incisions beyond the tip of the lateral malleolus.

According to the findings of our anatomical study meticulous attention is paid to the dissection of soft tissues in both the proximal and distal incisions. The length of the plate may be checked with intraoperative imaging prior to its insertion and the site of both proximal and distal incisions may be marked on the skin. After careful dissection down to the bone, preserving nerves and tendons, the periosteal elevator should be introduced both from the proximal as well as the distal incisions to prepare the extra-periosteal tunnel for the insertion of the plate. The soft tissues must be carefully retracted in order to avoid injury to the superficial peroneal nerve and its branches during the final positioning of the plate and screw insertion, particularly when using plates longer than six holes.

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