Anatomy of deep peroneal nerve in minimally invasive plate osteosynthesis of the tibia – an anatomic study

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Introduction
Percutaneous stabilization of tibial fractures with locking plates has become a standard procedure (1–4) along side intramedullary nail osteosynthesis. The main disadvantage of this technique is the risk of damage to the neurovascular bundles in the anterior and peroneal compartments. These locking plates act as internal fixators bridging the fracture (5). Following closed reduction of the fracture under fluoroscopic control, the plate is inserted via a small skin incision distal to Gerdy’s tubercle. Commonly the distal screws are inserted percutaneously, through small stab incisions. This may lead to nerve or vessel injuries. There are only a handful of articles in the current literature reporting the risk of nerve injury in the minimally invasive technique of plating for tibial fractures (6,7).

The aim of this anatomical study was to determine the course of the deep peroneal nerve in relation to percutaneously inserted LISS plates.

Material and methods
Eighteen lower limbs preserved in accordance with Thiel’s method were examined in this study. This unique embalming procedure was developed over a 30 year period in the department of anatomy in the University of Graz. It preserves tissue colour and consistency as well as allowing an almost full range of motion at articular joints (8). Extremities with arthrosis, evidence of trauma or previous surgery were excluded from the study. Pathological skeletal changes were detected by means of plain radiographs. The length of the tibia was measured as the distance between the centre of the medial joint line at the knee and the tip of the medial malleolus (9). A mathematical method employing stature regression formulae correlates tibial length with body height (9). Percutaneous LISS plate insertion was performed according to the recommended technique. In a supine position, a five to six centimetres longitudinal skin incision was made from Gerdy’s tubercle running distally. The tibialis anterior muscle was then mobilized, and a 13-holes LISS plate was inserted submuscularly, just superficial to the tibial periostium (Figure 1). The plate was advanced to the correct position, and then checked by fluoroscopy in two different planes. Two proximal screws were inserted to fix the plate. The six distal locking screws of the 13-holes LISS plate (i.e. holes 8 to 13) were then inserted percutaneously according to the standard technique. The skin and the superficial fascia were then removed, and the deep peroneal nerve was dissected out in order to demonstrate its relation to the plate (Figure 2). Photographic documentation was obtained in all cases. The results were entered into a computerized database. All computations were performed with Microsoft Excel® 2003 (Microsoft Headquarters, Redmond, Washington, United States), p-values below 0.05 and Chi-Square values beyond 3.84 were deemed as statistically significant.
Results

A total of eighteen lower limbs from nine different cadavers (4 male, 5 female; 9 right, 9 left) were used in our study. The age of the cadavers averaged 68.5 years (55 – 83 years). The mean tibial length was 36.9 cm (±1.9 cm; 34.1 – 40.7 cm). In all cases the nerve was in direct contact with the distal portion of the plate. In 9 cases the nerve crossed the plate at the level of the 13th hole. In three cases the nerve crossed the plates at the level of the 11th hole and in a further three cases at the level of the 12th hole. In 3 cases the nerve skirted the distal edge of the plate.

In 10 cases the nerve crossed superficial to the plate and in 6 cases the nerve was trapped in-between the plate and the bone. In 2 cases, the nerve did not cross the plate, but skirted the distal edge. Chi-Square test was used to establish the presence of any statistical correlations between gender or side and our results. No significant correlation between gender (p-value=0.07; Chi-Square value=3.28, df=1) or side (p-value=0.09; Chi-Square value=2.87, df=1) and the level at which the nerve crosses the plate was found. Student’s t-test also failed to demonstrate a statistically significant correlation between the tibial length and the level at which the nerve crossed the plate (p-value=0.07). The sample size however was too small.

Discussion

There has been an increase in the popularity of minimally invasive osteosynthesis of the tibia with angularly stable plates in the past few years. In the majority of cases, closed reduction is achieved under fluoroscopic control, the plate is inserted via a small skin incision and the screws (in particular the distal screws) are inserted percutaneously. The course of the peroneal nerve is well described, accounting for its propensity to iatrogenic injury distally in the leg (10,11). Iatrogenic injury to the deep peroneal nerve in the distal portion of the leg may occur during any of the surgical manoeuvres necessary for the insertion of the distal screws including incision, dissection down to the plate, predrilling the screw hole and finally the insertion of the screw itself. There are only a handful of articles in the current literature reporting nerve injuries associated with minimally invasive plate osteosynthesis of tibial fractures. De Angelis et al. investigated the course of the superficial peroneal nerve and found it to be at significant risk during percutaneous screw placement in holes 11 to 13 of the 13-hole proximal tibial LISS plate. The authors advocated a larger incision and careful dissection down to the plate in this region to minimize the risk of damage to the superficial peroneal nerve (6). Wolinsky and Lee inserted pre-contoured plates along the anterolateral border of ten cadaveric tibiae from distal to proximal in order to determine the anatomical structures at risk. They found the deep peroneal nerve and the anterior tibial vessels to be in particular danger with this technique (7).

The findings of our study suggest that the risk of iatrogenic injury to the deep peroneal nerve is greatest between the 11th and the 13th holes, when using a 13-hole LISS plate. At the level of the eleventh hole the deep peroneal nerve, the tibialis anterior artery and the accompanying vein are invariably in very close relation to the plate putting them at great danger of iatrogenic injury. In six specimens, the nerve coursed beneath the plate, demonstrating a considerable risk of entrapment in-between the plate and the bone. In ten cases, the nerve crossed over the plate leaving it susceptible to injury from the skin incision, dissection down to the plate, drilling or insertion of the screw. The tibialis anterior muscle is on the lateral side of the tibia. Proximally the neurovascular bundle courses lateral to the muscle and further distally is in direct contact with the tibial periosteum. The percutaneous

Figure 1: Minimal invasive inserted LISS plate (cadaver specimen, P=patella).

Figure 2: Peroneal nerve under the plate.
insertion of the plate may cause the interposition of the neurovascular bundle between the plate and the bone distal to the belly of the tibialis anterior muscle. Therefore, we do not recommend inserting plates longer than ten holes percutaneously. If a long tibial LISS plate is needed, we recommend the insertion of the plate under direct vision through an open distal approach to ensure the position of the plate on the tibia without the interposition of the neurovascular structures. Extension of the distal incision also facilitates the visualisation and protection of the neurovascular bundle during surgical manoeuvres. In this study the examined cadaveric limbs had no signs of injury or pathological changes, thus percutaneous plate insertion was performed easily. In the injured patient, plate application is made more challenging by the distorted anatomy resulting from the injury. This undoubtedly makes percutaneous surgical manoeuvres about the distal tibia even more perilous.

In summary, percutaneous insertion of plates longer than ten holes is not recommended. The risk of iatrogenic injury to the neurovascular bundle is high. By extending the distal approach, visualising the neurovascular bundle, and protecting it with a surgical hook, iatrogenic injury may be avoided.

References: