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Minimal Invasive Dorsal Plate Osteosynthesis of the Tibia – Are Nerves and Vessels at Risk? An Anatomical Study

Minimálně invazivní osteosyntéza zlomenin tibie dorzální dlahou – jsou nervy a cévy v ohrožení? Anatomická studie

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ABSTRACT

PURPOSE OF THE STUDY

Purpose of this anatomic study was to develop a new and safe technique of minimal invasive dorsal plate osteosynthesis for tibia shaft fractures.

MATERIAL AND METHODS

Sixteen paired adult lower limbs of eight different cadaveric specimens were examined. Anatomical prebending for each plate was done. Plates were inserted percutaneously, following plate fixation the neurovascular bundle was dissected out. The distance between the neurovascular bundle (posterior tibial nerve, posterior tibial artery) and the plate was measured at two different positions. The distance to the origin of the flexor digitorum longus muscle and the arch of the soleus muscle was measured.

RESULTS

The mean distance between the neurovascular bundle and the plate amounted 1.4 cm (±0,2 cm; 1.0–1.7 cm) at hole number six and 1.1 cm (±0.4 cm; 0.6–2.0 cm) at hole number ten. The nerve was never directly in contact with the plate. The flexor digitorum longus muscle had its origin along the plate and was between the plate and the neurovascular bundle in all cases.

CONCLUSIONS

Dorsal percutaneous plate insertion is a safe and easy method for osteosyntesis of tiba shaft fractures. Especially in case of poor skin and soft tissue conditions this technique offers a good alternative.

Key words: tibia fracture, dorsal approach, posterior tibial nerve, posterior tibial artery, percutaneous plating.

INTRODUCTION

Stabilization of tibia fractures by using locking plates has become a standard procedure beside nail osteosynthesis (2, 3, 10, 14, 16). In particular metaphysic tibia fractures, with or without intra-articular involvement are appropriate for plating. Current systems like the LISS (Less Invasive Stabilisation System; Synthes GmbH, Glutz Blotzheim-Str. 1-3, 4500 Solothurn, Switzerland) or the LCP metaphysical plates (Locking Compression Plate; Synthes GmbH) allow minimal invasive percutaneous plate insertion. These plates are locking internal fixator constructs allowing to bridge the fracture (19).

Minimal invasive plate osteosynthesis seems to be more advantageous for soft tissue and bone biology, nevertheless prolonged healing was observed in simple fracture patterns when a bridging plate technique was used (4). The proximal and distal metaphyseal areas of the tibia have a rich extraosseous blood supply provided primarily by branches of the anterior and posterior tibial arteries (15). No literature may be found dealing with the risk of nerve and vessel injury when performing dorsal minimal invasive plate osteosynthesis of tibia fractures.

MATERIAL AND METHODS

Sixteen paired lower limbs preserved according to Thiel's method were examined. This special embalming technique, which was developed over a 30-year period, provides a close to life model through the preservation of the original tissue colour, consistency and degree of transparency (18).

Extremities with arthrosis, evidence of trauma, or other pathological changes were excluded from the study. Pathological skeletal changes were detected by means of X-rays. On the basis of anthropological literature the length of the tibia can be related to the body height of the specimen. On this account the tibia length was measured in all specimens. Referring to tibia measuring technique described in literature, we measured the distance between the edge of the medial condyle and the tip of the medial ankle (7).

In a ventral prone position, a dorso-medial five centimetre long skin incision was made proximally 1 cm below the posterior edge of the tibia. The fascia was incised at the medial border of the gastrocnemius muscle, the medial origin of the popliteus and soleus muscle were identified. The popliteus and soleus muscle were mobilised with a raspatory on the dorso-medial side of the tibia. The insertion canal was extended distaly along the dorsal side of the tibia using a raspatory, position of raspatory was checked by fluoroscopy. Distally a three centimetre long skin incision was made at the dorso-medlial edge of the tibia and the soft tissue was mobilised. The anatomy of the tibia was checked by fluoroscopy, individual anatomical prebending of a 12-holes LCP-Philos plate (Synthes GmbH) was done for each bone. A 12 hole LCP-Philos plate was used because there is no anatomical prebended plate for the posterior tibia existing and the LCP-Philos plate had the best anatomical fitting to the proximal posterior surface of the tibia in our meaning. Following the LCP-Philos plate was inserted proximal submuscularly, directly in contact to the bone (Fig. 1). The linea musculi solei was identified as an orientation mark for the right direction of the plate. The plate was advanced to correct position, and then checked by fluoroscopy in two different planes (Figs 2 and 3). The proximal end of the plate was fixed 1 cm distal to the tibia plateau using two self-drilling and tapping screws. Position of plate and screws was checked by fluoroscopy. The specimens were dissected

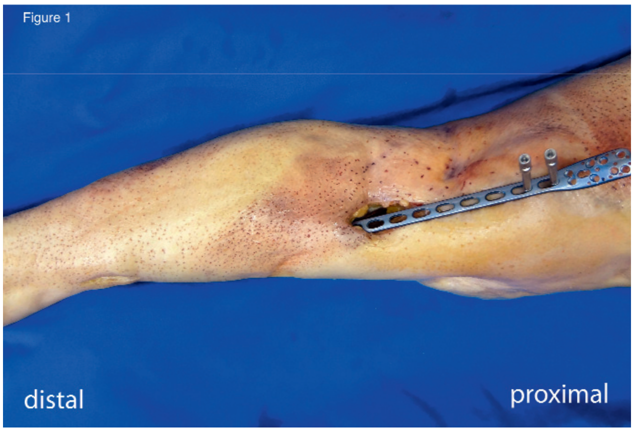

Fig. 1. Percutaneous minimal invasive insertion of Philos plate (cadaver specimen).

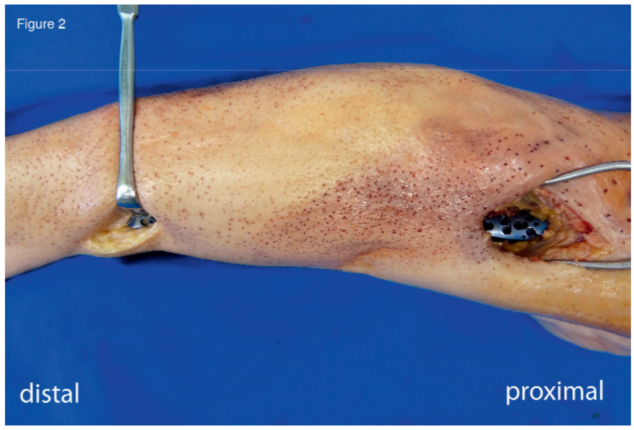

Fig. 2. Inserted plate, proximal and distal minimal invasive dorsal approach.

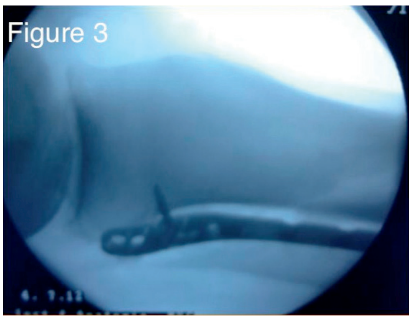

Fig. 3. Fluoroscopy of proximal tibia, checking position and pre-bending of the plate.

in order to identify the relation between the neurovascular bundle and the plate (Fig. 4). The distance between the neurovascular bundle (posterior tibial nerve, posterior tibial artery) and the plate was measured in millimetres using a sliding gauge. Measurements were done at the positions of holes number six and ten of the LCP-Philos-plate. The origin of the flexor digitorum longus muscle and the arch of the soleus muscle were also measured. The tibia-length was measured between the edge of the medial condyle and the tip of the medial ankle (7).

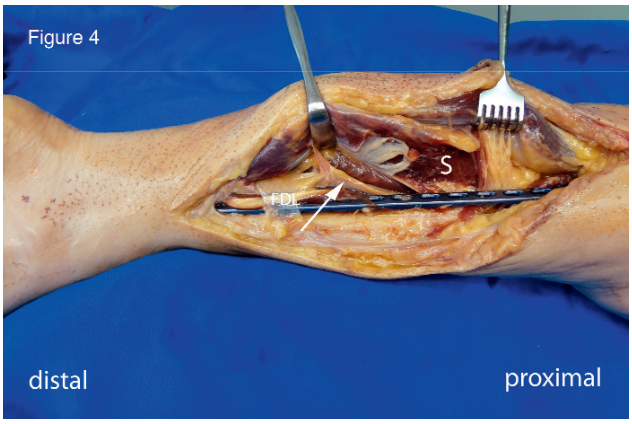

Fig. 4. Dissected specimen; S: soleus muscle, FDL: flexor digitorum longus muscle, arrow: neurovascular bundle.

The relation between the nerve and the plate was analyzed; all cases were documented by photography. Results were entered into a computerized database. All computations were done using Microsoft Excel® 2003 (Microsoft Headquarter, Redmond, Washington, United States), p-values below 0.05 were seen as statistically significant.

RESULTS

A total of sixteen lower limbs of eight different specimens (4 male, 4 female; 8 right, 8 left) were investigated. Age of cadavers averaged 68.5 years (55–83 years). The length of the tibia averaged 39.8 cm (±1.3 cm; 37.6–42.0 cm). We documented the distance between the nerve and the plate at holes six and ten of the 12-holes Philos-plate. The mean distance between the neurovascular bundle and the plate was 1.4 cm (± 0.2 cm; 1.0–1.7 cm) at hole number six of and 1.1 cm (± 4 cm; 0.6–2.0 cm) at hole number ten. The flexor digitorum longus muscle had its origin along the plate (between holes 1 and 12) and was between the plate and the neurovascular bundle in all cases.

The arch of the soleus muscle was between the holes 3 and 5 and its origin was between the holes 3 and 10. Student's t-test failed to demonstrate a statistically significant correlation between the measurements, side and gender. The sample size however was too small.

DISCUSSION

The use of minimally invasive techniques with angular stable plates is fast becoming popular with ever increasing indications. Usually closed reduction is done under fluoroscopic control, the plate is inserted via a small skin incision and the screws (in particular the distal screws) are inserted percutaneously. Intramedullary nailing still remains the treatment of choice for most uncomplicated diaphyseal fractures of the tibia, but minimally invasive plate osteosynthesis offers a reliable and reproducible technique in the treatment of closed unstable fractures of the distal tibia with intra-articular or peri-articular fracture extensions and proximal tibia fractures (2, 3, 4, 10, 14, 16, 19).

Various study's report about the antero-lateral plating technique of the tibia and relation between the plate and anatomical important structures like the deep and superficial branch of the fibular nerve and the dorsal artery of foot (1, 11, 12, 13, 17). Main disadvantages of the antero-lateral approach are the soft tissue coverage proximally and potential neurovascular irritations due to the plate distally (12). To date no literature may be found dealing with the risk of nerve and vessel injury when performing dorsal minimal invasive plate osteosynthesis of tibia fractures. The course of the posterior tibial nerve and the artery described in literature hypothesizes that the risk of iatrogenic injury caused by percutaneous dorsal plating is low (15). The proximal and distal approach to the dorsal tibia used in this anatomical study is well described in literature (5, 8, 9).

The findings of our study suggest that the risk of iatrogenic injury to the posterior neurovascular bundle is low. Exact preoperative examination of the leg is mandatory to exclude nerve, vessel, muscle and tendon injuries (6).The tibial nerve and the artery were never in direct contact with the plate. The neurovascular bundle was always protected by the muscle belly of the flexor digitorum longus muscle. The risk of iatrogenic injury to the vas nutritium of the tibia is low, since this vessel courses lateral to the approach. This minimal invasive dorsal plating technique offers a good option particularly in case of proximal tibia fractures and poor skin and soft tissue conditions. Good soft tissue coverage of the plate may be achieved.

CONCLUSIONS

We conclude that dorsal minimal invasive plating of tibia fractures may be considered as a safe and easy method of osteosynthesis. In the injured patient, plate application may be more demanding due to the distorted anatomy resulting from the injury. In the same way the risk of iatrogenic soft tissue injuries may be increased. Exact preoperative examination of the leg is mandatory to exclude nerve, vessel, muscle and tendon injuries.

Conflict of interest

The authors declare that they have no conflict of interest.

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