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PŮVODNÍ PRÁCE

The Risk of Neurovascular Injury in Minimally Invasive Plate Osteosynthesis (MIPO) when Using a Distal Tibia Anterolateral Plate: A Cadaver Study

Riziko poranění neurovaskulárních struktur při miniinvazívní dlahové osteosyntéze (MIPO) s použitím distální tibiální anterolaterální dlahy. Studie na kadaverech

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ABSTRACT

PURPOSE OF THE STUDY

Percutaneous plating of the distal tibia via a limited incision is an accepted technique of osteosynthesis for extra-articular and simple intra-articular distal tibia fractures. The aim of this study was to analyze structures that are at risk during this approach.

MATERIAL AND METHODS

Thirteen unpaired adult lower limbs were used for this study. Thirteen, 15-hole LCP anterolateral distal tibial plates were percutaneously inserted according to the recommended technique. Dissection was performed to examine the relation of the superficial and deep peroneal nerves and anterior tibial artery relative to the plate.

RESULTS

The superficial peroneal nerve was found to cross the vertical limb of the LCP plate at a mean distance of 63 mm (screw hole five) but with a wide range of 21 to 105 mm. The neurovascular bundle (deep peroneal nerve and anterior tibial artery) crossed the plate at a mean of 76 mm (screw hole six) but also with a wide range of 38 to 138 mm. The zone of danger of the neurovascular structures ranges from 21 to 138 mm from the tibial plafond. In one specimen, a significant branch of the deep peroneal nerve was found to be entrapped under the plate.

CONCLUSION

Caution is advised when using anterolateral minimally invasive technique for plate insertion and screw placement in the distal tibia due to great variability in the neurovascular structures that course distally in the lower leg and cross the ankle.

Key words: distal tibia, percutaneous plating, neurovascular injury.

INTRODUCTION

Percutaneous plating of the distal tibia via a limited incision is an accepted technique of osteosynthesis for extra-articular and simple intra-articular fractures of the distal tibia. Depending upon fracture pattern, extent of soft tissue injury and coverage, an anterolateral minimally invasive approach to the distal tibia may be considered for osteosynthesis. With a relatively sparse soft tissue envelope, and great variability in neurovascular structures around the ankle, there is the potential for injury to the superficial peroneal nerve and the neurovascular bundle consisting of the deep peroneal nerve and anterior tibial artery. Wolinsky and Lee previously described that the superficial peroneal nerve was not at risk when positioning an anterolateral plate in a retrograde manor over the distal tibia (9). In clinical practice we have found that it may be injured and the danger zone for placement of percutaneous screws is also larger then previously reported (9).

This study was performed to examine the neurovascular structures that are at risk when performing minimally invasive plate osteosynthesis (MIPO) for plating the anterolateral distal tibia.

MATERIAL AND METHODS

Thirteen unpaired (7 right and 6 left) whole lower limb cadaveric specimens embalmed with the method of Thiel were used (8). The mean age of the donors was 75 years (52 to 82) at the time of death. There was no evidence of previous injury, pathological changes or implanted prosthesis. The whole leg specimens were placed in a supine position to simulate patient position intraoperatively. The surgical approach utilized was as de-

Table 1. Complete data set for the superficial peroneal nerve and neurovascular bundle crossing the vertical and horizontal limbs of a 15-hole LCP anterolateral distal tibia plate

			Vertical limb of 15-hole LCP plate								Horizontal limb of 15-hole LCP plate							
			Superficial peroneal nerve				Neurovascular bundle				Superficial peroneal nerve				Neurovascular bundle			
			Distance from tibial plafond (mm)				Distance from tibial plafond (mm)				Distance from lateral tibial margin (mm)				Distance from lateral tibial margin (mm)			
Patient	**Side**	**Tibia length (cm)**	**Mean**	**Min**	**Max**	**Screw hole**	**Mean**	**Min**	**Max**	**Screw hole**	**Mean**	**Min**	**Max**	**Screw hole**	**Mean**	**Min**	**Max**	**Screw hole**
1	R	37.6	77	72	83	6 to 7	65	61	72	5 to 6	21	15	27	3	34	32	39	lateral
2	R	33.7	73	61	83	5 to 7	63	61	72	5 to 6	19	14	22	3	33	31	37	lateral
3	L		65	47	93	4 to 8	47	38	61	3 to 5	18	13	23	3	21	17	26	3
4	L	31.2	61	38	72	3 to 6	116	94	138	8 to 12	22	18	26	3	20	21	28	3 to 4
5	R	36.3	25	23	28	1	64	47	83	4 to 7	7	7	15	1	28	27	29	4
6	L	41.7	48	25	83	1 to 7	94	83	105	9 to 7	13	6	29	1 to 4	24	19	27	3 to 4
7	R	40.4	23	21	25	1	72	61	83	5 to 7	26	21	27	3 to 4	22	22	25	3
8	L	36.2	49	31	83	2 to 7	61	47	72	4 to 6	25	21	28	3 to 4	29	27	31	4
9	L	33.5	61	47	72	4 to 6	93	83	105	7 to 9	14	12	18	2	23	21	24	3
10	L	38.8	97	80	105	7 to 9	38	38	38		20	17	23	3	32	32	43	lateral
11	R	37.4	79	62	94	5 to 8	116	105	127	9 to 11	16	12	21	2 to 3	20	19	29	3 to 4
12	R	32.2	96	83	105	7 to 9	94	83	105	7 to 9	27	22	31	4	21	20	28	3 to 4
13	R	34.3	70	61	83	5 to 7	61	61	61	under 5	23	22	25	3	13	8	19	under 2 & 3
		Average	**63**	**21**	**105**		**76**	**38**	**138**		**19**	**6**	**31**		**24**	**8**	**43**	

scribed by Bohler (3) whereby an anterolateral incision was made between the fibula and tibia distally in line with the 4th metatarsal. A 15-hole 3.5 mm LCP (Locking Compression Plate) anterolateral distal tibia plate (Synthes, Solothurn, Switzerland) was positioned in a retrograde fashion in a submuscular and extraperiosteal plane into its optimal position of fit upon the tibia. A small incision was made to position the proximal end of the plate upon the tibia towards the crest. The plate was secured distally with a Kirchner wire and proximally with a locking screw. Plate position was confirmed using an image intensifier with radiographs taken in orthogonal planes.

Further dissection was performed to identify the path of the superficial peroneal nerve and the neurovascular bundle consisting of the deep peroneal nerve and anterior tibial artery as they crossed the vertical and horizontal limbs of the 15-hole LCP anterolateral distal tibia plate. The structures were examined as they crossed the vertical limb of the plate as measured from the tibial plafond, and from the most lateral border of the tibia at the syndesmosis, as they crossed the horizontal limb of the plate. All distances were measured using a calibrated Vernier micrometer (Mitutoyu, Kawasaki, Japan) and recorded in millimetres, to an accuracy of ± 1 mm. The tibial length was also recorded as the distance between the centre of the medial joint line of the knee and the tip of the medial malleolus.

RESULTS

The complete sets of results are shown in table 1. The mean tibial length was 36.1 cm (31.2 to 41.7 cm). All vertical measurements were from the tibial plafond (Fig. 1). The superficial peroneal nerve was found to cross the vertical limb of the LCP plate at a mean distance of 63 mm (screw hole five) but with a wide range of 21 to 105 mm (Fig. 2). This corresponded to screw holes one to nine. The neurovascular bundle crossed the plate at a mean of 76 mm (screw hole six) but also with a wide range of 38 to 138 mm. This corresponded to screw holes three to twelve.

Over the horizontal limb of the plate, measurements were made medially from the most lateral border of the tibia at the syndesmosis (Fig. 3). The superficial peroneal nerve had a variable course over all four screw holes (Fig. 4). The nerves crossed at a mean of 19 mm (screw hole three) and a range of 6 to 31 mm (screw holes one to four) from the lateral tibial edge. The neurovascular bundle had a slightly more lateral course, crossing at a mean of 24 mm (screw hole three) and a range of 8 to 43 mm (screw holes one to four) from the lateral tibial edge. In three of the specimens the anterior tibial artery coursed lateral to the plate. A large branch of the deep peroneal nerve was found to be entrapped under the plate in one specimen (Fig. 3).

DISCUSSION

There are only limited studies that have been published regarding the risk to neurovascular structures using a minimally invasive approach to the distal tibia (4, 5, 9). MIPO offers attractive benefits; it protects the soft

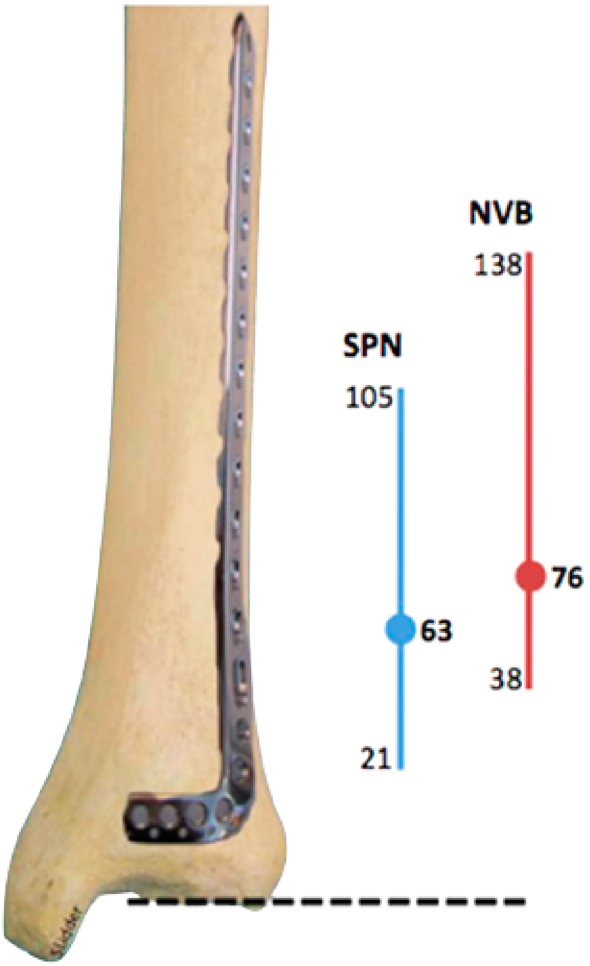

Fig. 1. Diagram illustrating position of superficial peroneal nerve (SPN) and neurovascular bundle (NVB) above the tibial plafond (dashed line) and in relation to the distal tibia and 15-hole LCP distal tibia plate. Mean distance (in bold) and range illustrated. All values in millimeters.

Fig. 2. Photograph of superficial peroneal nerve (*) crossing obliquely over the vertical limb of the anterolateral distal tibia plate.

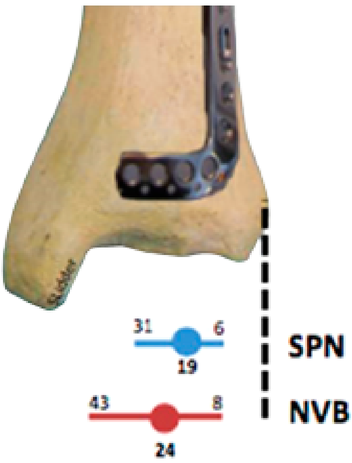

Fig. 3. Diagram illustrating position of superficial peroneal nerve (SPN) and neurovascular bundle (NVB) crossing the horizinatal limb of the LCP distal tibia plate. Distances measured from lateral edge of tibia (dashed line) with mean values (bold number) and range in millimeters.

tissue envelope, potentially allows for a 5-quicker operative time, and results in less soft tissue contusion and mobilization, with a concomitant potential for an improved healing process (6).

The superficial peroneal nerve, which is a branch of the common peroneal nerve, courses the anterolateral compartment of the leg. It pierces the deep fascia between 5 and 15 cm above the lateral malleolus, dividing distally into the medial and intermediate dorsal cutaneous nerves of the dorsum of the foot (7). There is great variability in the course of the nerve (1, 2), and this needs to be considered during percutaneous screw fixation when using the anterolateral distal tibia plate. In our study, we found that the nerve coursed obliquely, often over multiple screw hole positions. Wolinsky and Lee reviously recommended a non-percutaneous approach in the area 40 to 110 mm above the distal incision when using Bohler's approach to the anterolateral distal tibia (9). This equates approximately to a zone from 70 mm to 140 mm proximal to the tibial plafond. In our study the superficial peroneal nerve was located between 21 to 105 mm from the tibial plafond. This extends the zone distally where care is needed for percutaneous screw fixation. In four of the 13 cadavers, the superficial peroneal nerve had already divided into the intermediate and medial cutaneous nerves above the level of the horizontal limb of the LCP distal tibia plate.

The neurovascular bundle consisting of the deep peroneal nerve and anterior tibial artery crossed the deep fascia more proximal then the superficial peroneal nerve, however again showed great variability in its course. It

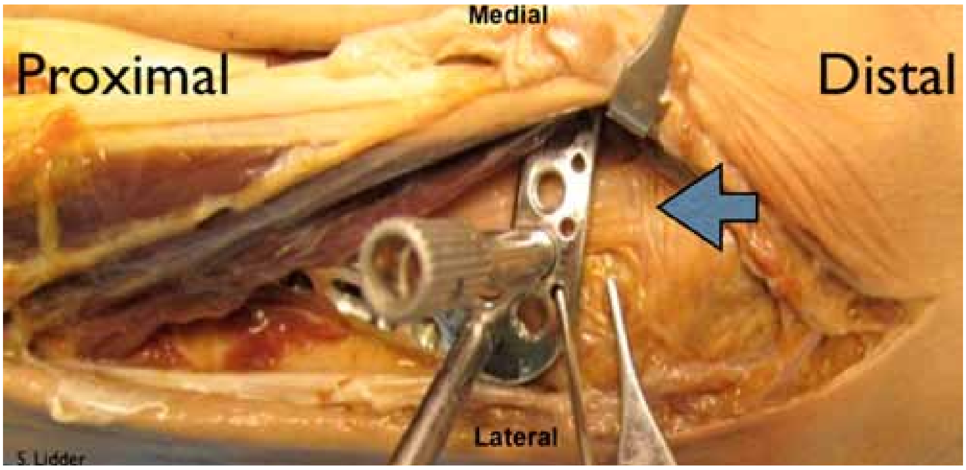

Fig. 4. Photograph of superficial peroneal nerve (*) crossing over the horizontal limb of the anterolateral distal tibia plate.

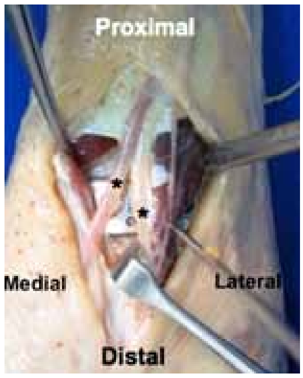

Fig. 5. Clinical photograph of right distal tibia with LCP anterolateral distal tibia plate in situ. A branch of the deep peroneal nerve under the plate is shown (blue arrow).

coursed in an oblique fashion from a proximal posterior to a distal anterior direction in a range 38 to 138 mm from the tibial plafond. Over the horizontal limb of the LCP plate, the anterior tibial artery crossed in nine out of 13 specimens over the third or fourth screw holes in a range between 8 and 43 mm from the lateral margin of the distal tibia.

This study demonstrates that great variability is present in both the superficial peroneal nerve and also the neurovascular bundle. Meticulous attention is needed during plate placement and placement of screws making sure that tissues are protected. The zone is which the neurovascular structures were present range from 21 to 138 mm from the tibial plafond, and also across most of the ankle in a horizontal plane. Although a submuscular and extraperiosteal technique was used to place the LCP plate, in one specimen a significant branch of the deep peroneal nerve was found under screw hole five of the vertical limb and screw holes two and three of the horizontal limb of the LCP plate (Fig. 5). Local anatomy may further be distorted with fractures of the distal tibia.

We agree with Wolinsky and Lee (9), that the deep peroneal and anterior tibial artery are at risk as they course from a posterior position proximally to a more anterior position distally but due to great variability in the superficial peroneal nerve (1, 2, 7), this is also at risk.

There are some limitations to this cadaver study. The method of Thiel used for embalming allows excellent preservation of tissue but there may be some differences in the soft tissue characteristics compared with fresh frozen cadavers. We believe however that any differences to measurements of neurovascular structures would be minimal.

CONCLUSION

In summary, a minimally invasive technique for osteosynthesis has many benefits however due to the great variability in the course of the superficial and deep peroneal nerves and the anterior tibial artery, caution is advised when performed percutaneous screw placement. A more generous incision with adequate protection of the neurovascular structures would prevent injury to these structures.

Conflict of interest

The authors declare that they have no conflict of interest.

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