Journal of Orthopaedic Trauma
Vol. 18, No. 8, pp. S39–S42

Percutaneous Pin Placement in the Medial Calcaneus: Is Anywhere Safe?

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Objective: To redefine the medial calcaneal anatomic safe zone for pin placement with respect to reproducible palpable landmarks.
Design: Anatomic study.
Setting: Medical school anatomy laboratory.
Interventions: Thirty-three fresh-frozen adult cadaveric feet were used. Three palpable anatomic landmarks were identified on each ankle and labeled as Point A (posteroinferior medial calcaneus), Point B (inferior medial malleolus), and Point C (navicular tuberosity). The medial neurovascular bundle was carefully dissected, and the medial calcaneal nerve, the most posterior branch of the lateral plantar nerve, the lateral plantar nerve, the medial plantar nerve, and the posterior tibial artery were identified. These structures were recorded at the point at which they transected a line from Point A to B and from Point A to C. Based on the findings of the first thirty-three feet, two pins were placed percutaneously into the medial calcaneus of ten additional feet. Pin 1 was placed one half the distance from Point A to B. Pin 2 was placed one third the distance from Point A to C. The neurovascular structures were then dissected and identified in relation to the pin position.
Results: The medial calcaneal, most posterior branch of the lateral plantar, and lateral plantar nerves are at significant risk for abutting the pins or being directly injured at the margins of these relative safe zones.
Conclusion: The medial calcaneus provides a small window for safe percutaneous pin placement. Posterior to the halfway point from Point A to B and posterior to the one-third mark from Point A to C remain the relatively safest regions; a more posterior placement in the safe zone is safest. Careful blunt dissection and the use of cannulas may help to avoid neurovascular injury.
Key Words: Calcaneal traction, Complications, Medial calcaneus, Palpable anatomic landmarks, Safe zone.

Percutaneous pin placement into the calcaneus is a common procedure (1,2). External fixation pins and traction and distraction pins are routinely placed from the medial side of the calcaneus. Multiple anatomic structures are at risk for iatrogenic damage during percutaneous pin placement in the medial calcaneus. Previous studies have focused on defining a safe zone with radiographically identifiable landmarks (4,5). The purpose of this study was to identify palpable anatomic landmarks that correlate to a relative safe zone for medial percutaneous calcaneal pin placement.

MATERIALS AND METHODS

Thirty-three cadaveric feet were used for the initial part of the study. Three palpable anatomic landmarks were identified on each ankle and labeled as Point A (posteroinferior aspect of the medial calcaneus), Point B (inferior aspect of medial malleolus), and Point C (navicular tuberosity) (Fig. 1). In Phase 1 of this study, a Kirschner wire was placed in each of these three landmarks. The medial neurovascular bundle was carefully dissected, and five structures were identified on each foot: the medial calcaneal nerve, the most posterior branch of the lateral plantar nerve, the lateral plantar nerve, the medial plantar nerve, and the posterior tibial artery (Fig. 2). The points at which each structure transected a line from Point A to B and from Point A to C were recorded. Based on the findings of the first thirty-three feet (see Results), two five-millimeter half pins were placed percutaneously using cannulas into the medial calcaneus of ten additional feet in Phase 2 of this study. They were placed at the margins of the safe zone. Pin 1 was placed one half the distance from Point A to B, and Pin 2 was placed one third the distance from Point A to C. These specimens were then dissected and the neurovascular structures were identified in relation to the pin position.

RESULTS

Examination of the thirty-three dissected feet showed that the distance from Point A to B averaged

Accepted December 7, 2000.
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No financial project support of this research project occurred. None of the authors received anything of value.
The device that is the subject of this manuscript is FDA-approved.

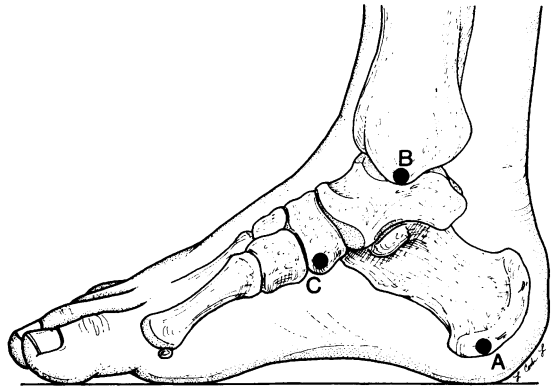

FIG. 1. Schematic diagram of easily palpable anatomic landmarks, including Point A (posteroinferior medial calcaneus), Point B (inferior medial malleolus), and Point C (navicular tuberosity).

71.3 millimeters. All neurovascular structures were identified in each specimen. The medial calcaneal nerve, on average, was located at 29 percent (20.8 millimeters) of this distance, the most posterior lateral plantar nerve at 44 percent (31.5 millimeters), the lateral plantar nerve at 48 percent (34.4 millimeters), the medial plantar nerve at 58 percent (41.2 millimeters), and the posterior tibial artery at 53 percent (37.8 millimeters). The distance from Point A to C averaged 81.7 millimeters. The medial calcaneal nerve was located at 19 percent (15.5 millimeters) of this distance, the most posterior lateral plantar nerve at 34 percent (27.5 millimeters), the lateral plantar nerve at 46 percent (37.5 millimeters), the medial plantar nerve at 61 percent (50.0 millimeters), and the posterior tibial artery at 48 percent (39.3 millimeters) (Table 1).

In the ten feet into which five-millimeter half pins were placed, the medial calcaneal nerve was found no more than three millimeters from Pin 1 in two specimens (Fig. 3); the most posterior lateral plantar nerve was found impaled or no more than three millimeters from Pin 1 in five specimens; and the lateral plantar nerve was found impaled or no more than three millimeters from Pin 1 in five specimens (Fig. 3). The medial calcaneal nerve was no more than three millimeters from Pin 2 in two specimens, and the most posterior lateral plantar nerve was no more than three millimeters from Pin 2 in four specimens (Table 2).

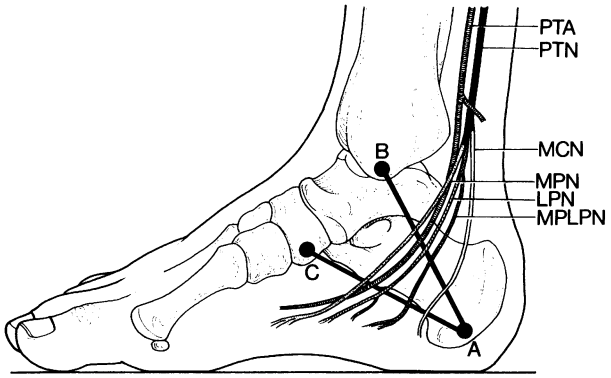

FIG. 2. Schematic diagram of the medial calcaneal neurovascular structures. PTA, posterior tibial artery; PTN, posterior tibial nerve; MCN, medial calcaneal nerve; LPN, lateral plantar nerve; and MPLPN, most posterior lateral plantar nerve.

TABLE 1. *Points at which the neurovascular structures transected lines A to B and A to C*

	A to B	MCN	MPLPN	LPN	MPN	PTA
Average (mm)	71.39	20.84	32.50	35.50	42.53	39.00
%		29%	46%	50%	60%	55%
	A to C	MCN	MPLPN	LPN	MPN	PTA
Average (mm)	81.73	15.59	27.50	37.53	50.06	39.31
%		19%	34%	46%	61%	48%

MCN, medial calcaneal nerve; MPLPN, most posterior lateral plantar nerve; LPN, lateral plantar nerve; MPN, medial plantar nerve; PTA, posterior tibial artery.

DISCUSSION

Several authors have attempted to define an anatomic safe zone for percutaneous placement of external fixation or traction pins in the medial calcaneus (4,5). Mekhail et al. (4) placed transfixing calcaneal pins in posteromedial and anteromedial sites in fifteen cadaveric feet. The anteromedial site was at the sustentaculum tali (approxi-

FIG. 3. Pin 1 abutting the lateral plantar nerve (arrowhead) and sitting in the axilla of the division between the lateral plantar and medial calcaneal nerves (arrow). Large black arrows indicate the proximal direction.

TABLE 2. *No. of neurovascular structures injuries (impaled or abutment ≤3mm)*

	A to B	MCN	MPLPN	LPN	MPN	PTA
No. injured	12	2	5	5	0	0
	A to C	MCN	MPLPN	LPN	MPN	PTA
No. injured	6	2	4	0	0	0

MCN, medial calcaneal nerve; MPLPN, most posterior lateral plantar nerve; LPN, lateral plantar nerve; MPN, medial plantar nerve; PTA, posterior tibial artery.

mately 2.5 centimeters distal to the medial malleolus), with the pin inserted transversely and angled 25 to 30 degrees. The posteromedial site was at a point three quarters of the way from the tip of the medial malleolus to the heel, with the pin inserted transversely. Specimens were evaluated with radiographs and dissection to determine the safe and danger zones. They found that the posterior tibial neurovascular bundle had a consistent course crossing the midpoint of a line joining the medial malleolus and the heel (3.2 ± 0.6 centimeters). The medial calcaneal branch of the posterior tibial bundle was inconsistent, with the posteromedial pin found posterior to or between its branches. This supports the work of Havel et al. (3), who reported nine different calcaneal nerve branching patterns. Mekhail et al. (4) found that the average and the closest distances from the anteromedial pin to the neurovascular bundle were 1.0 ± 0.2 centimeters and 0.6 centimeters, respectively. The anteromedial pin transfixed the flexor hallucis longus tendon in one specimen and the flexor digitorum longus tendon in three specimens. This may be attributed to the finding that the anteromedial pin is closer to these structures and is inserted into an oblique prominence, which may lead to inaccurate placement. The average and the closest distances from the posteromedial pin to the neurovascular bundle were 1.6 ± 0.2 centimeters and 1.2 centimeters, respectively. Therefore, they concluded that the posteromedial pin site is safer and easier to determine.

Santi and Botte (5) defined a relative safe zone for percutaneous pin placement in the medial calcaneus. They selected three medial landmarks: Point A (tip of the medial malleolus), Point D (posterosuperior tip of medial calcaneus), and Point F (navicular tuberosity). From these three points, they identified a relative medial calcaneal safe zone by drawing Lines DB and CE. Line DB was drawn parallel to the plantar aspect of the foot starting at Point D and ending at Point B (1.5 centimeters inferior to Point A). Point C was the midpoint of Line DB. Line CE was drawn perpendicular to Line DB and roughly parallel to the posterior aspect of the tibia. In all fifteen specimens, the major neurovascular structures were anterior to Line CE. The structure most at risk was the medial calcaneal branch of the tibial nerve, which had a variable branch pattern and course in the medial hindfoot. Therefore, this medial calcaneal zone bounded by Lines DB and CE was considered a relative safe zone.

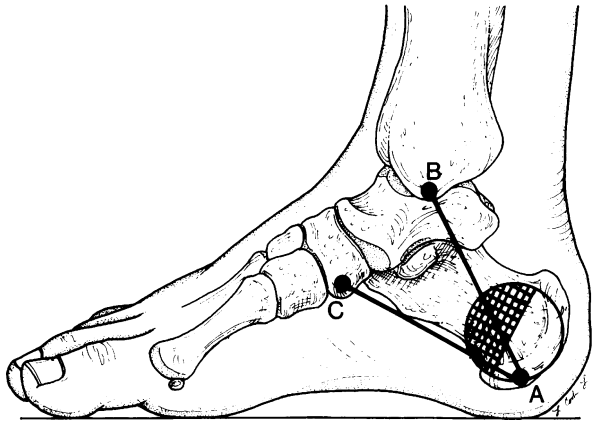

FIG. 4. Schematic diagram of the medial calcaneal anatomic relative safe zone for pin placement with respect to reproducible palpable landmarks. The hash marks represent an area that places the lateral plantar nerve, most posterior lateral plantar nerve, and medial calcaneal nerve at risk. The posterior area is safer, although the medial calcaneal nerve is always at risk.

However, this technique is cumbersome and requires radiographic assessment, thereby limiting its usefulness.

Our study was designed to redefine this safe zone with more easily reproducible palpable landmarks. Our results also showed that even with blunt dissection, the medial neurovascular structures are not out of harm's way. Based on these findings, the medial calcaneus provides a small window for safe percutaneous pin placement. Posterior to the halfway point from Point A to B and posterior to the one-third mark from Point A to C remain the safest regions, but it should be made clear that the medial calcaneal, most posterior branch of the lateral plantar, and lateral plantar nerves are at significant risk of abutting the pins or being directly injured at the margins of these relative safe zones. The medial calcaneal branch is located in previously described safe zones and is almost always at risk. Therefore, the medial calcaneal relative safe zone is posterior to the halfway point from Points A to B and posterior to the one-third mark from Point A to C. The safest areas are more posterior. Figure 4 shows the medial calcaneal relative safe zone. The hash marks represent an area that places the lateral plantar, the most posterior branch of the lateral plantar, and the medial calcaneal nerves at risk. The posterior area is safer, although the medial calcaneal nerve is always at risk.

CONCLUSION

The medial calcaneus provides a small window for safe percutaneous pin placement. The area previously thought of as safe has been shown to place multiple nerves at risk. Meticulous care should be taken when placing pins into the medial calcaneus with the understanding that iatrogenic nerve injury is a real possibility and the more posterior areas are safest. Careful blunt dissection and the use of cannulas may help to avoid neurovascular injury.

Acknowledgment: The authors thank Dr. Gene Blatt for his gracious support and Jill Bolton for her assistance with editing and preparing the manuscript.

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