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Neurovascular branching in the tarsal tunnel

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ABSTRACT

The diagnosis and therapy of the tarsal tunnel syndrome, various surgical procedures at tarsal region and especially tibial nerve blocks requires a well understanded relationship and anatomy of the tibial nerve. For this purpose medial tarsal regions of 50 feet of embalmed human cadavers were investigated. The bifurcation level of the tibial nerve, the distance of the medial and lateral plantar nerves to the tip of the medial malleolus and the medial tubercle of calcaneus and the diameters of the nerves at the branching point were measured. The bifurcation point of the posterior tibial artery was also noted.

We classified the bifurcations of the tibial nerve and posterior tibial artery as type I, II and III respect to the reference line between medial malleolus and calcaneus. While type I was the common type for tibial nerve (n= 42, 84%), type III was common for posterior tibial artery (n=23, 46%).

Knowledge of the variations in locations of bifurcation level of the tibial nerve and the posterior tibial artery may prevent to damage any neurovascular structure during some procedures like pin insertion and nerve blocks.

Key words: tarsal tunnel, tibial nerve, medial plantar nerve, lateral plantar nerve

Introduction

The tibial nerve is the larger of the two terminal branches of the sciatic nerve. It descends along the posterior aspect of the leg with posterior tibial vessels. This neurovascular bundle lies deeper in the proximal part of the leg, but distally it becomes more superficial and covered only by fascia and skin. As this neurovascular bundle descends to the plantar area, it lies in a fibro-osseous structure named as tarsal tunnel. This tunnel is bounded by the flexor retinaculum medially, the posterior aspect of the talus and calcaneus laterally, and the medial malleolus anteriorly [1-5].

The divisions of the tibial nerve and posterior tibial artery take place in the tarsal tunnel and the level of these bifurcations are stated in many textbooks of anatomy as between calcaneus and the medial malleolus [1-5]. More detailed bifurcation point of the nerve was described by some authors. According to Horwitz [6], it is 1.3 cm above the tip of the medial malleolus. Dellon and Mackinnon [7] noted that the division is within 2 cm to the malleolar-calcaneal axis. Bareither et al. [8] indicated that the tibial nerve bifurcation point may extend from 2.8 cm distal to 14.3 cm proximal to the tip of the medial malleolus.

The purpose of present study is to describe the bifurcation point of the tibial nerve and posterior tibial artery, and the location of the medial and lateral plantar nerves in the tarsal tunnel to establish an anatomical guide for diagnosis and therapy of some tarsal region diseases including tarsal tunnel syndrome, fixations of fractures with external nailing, medial displacement osteotomy and nerve blocks in podiatric medicine [8-12].

Material and Methods

41 feet of embalmed human cadavers and 9 lower extremities (50 feet in total) were examined in the laboratory of the Anatomy Department of the Medical Faculty of the Ege University. Cadavers were selected in base of the absence of severe tibial artery diseases in association with ischemic ulceration or gangrene limited to heel or forefoot. The skin and fascia were removed from 25 cm proximal to the medial malleolus continuing distally to the plantar surface in each foot. Each foot was placed in the anatomical position consisted of positioning the foot 90° to the tibia to standardize the measurements.

The tibial nerve and posterior tibial vessels were exposed from the distal end of the leg towards the plantar surface. For this purpose the flexor retinaculum, plantar aponeurosis and the abductor hallucis muscle were cut from their origin. A reference line (1 cm width) was established from the tip of the medial malleolus to the medial tubercle of calcaneus, because these two landmarks are prominent and easy to palpate in a physical examination. This axis also represents the inferior edge of the flexor retinaculum and consequently the tarsal tunnel.

The bifurcation of the tibial nerve and posterior tibial artery were classified with respect to the defined axis.

Type I represents that the bifurcation is proximal to this axis but in the tarsal tunnel. Type II, represents that the

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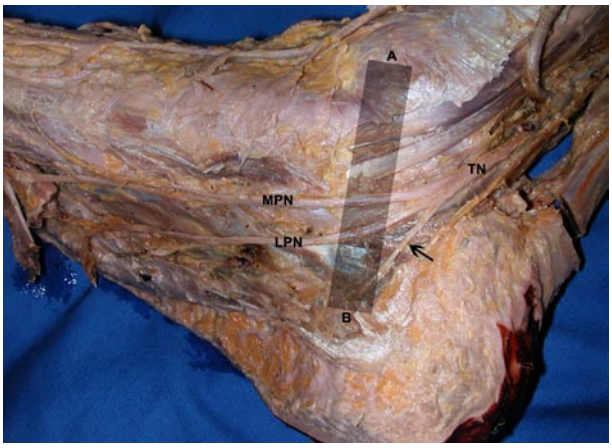

Figure 1 | Medial aspect of a right medial tarsal region. A: The tip of the medial malleolus, B: The medial tubercle of calcaneus, TN: Tibial nerve, LPN: Lateral plantar nerve, MPN: Medial plantar nerve, Arrow: Medial calcaneal branch.

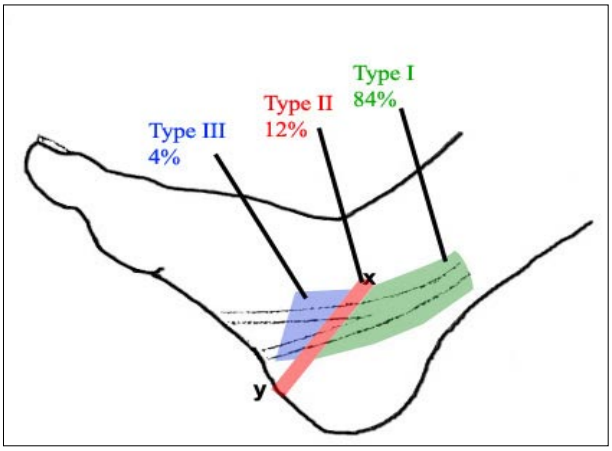

Figure 2 | The percental distribution of the bifurcation types of the tibial nerve in the tarsal tunnel.

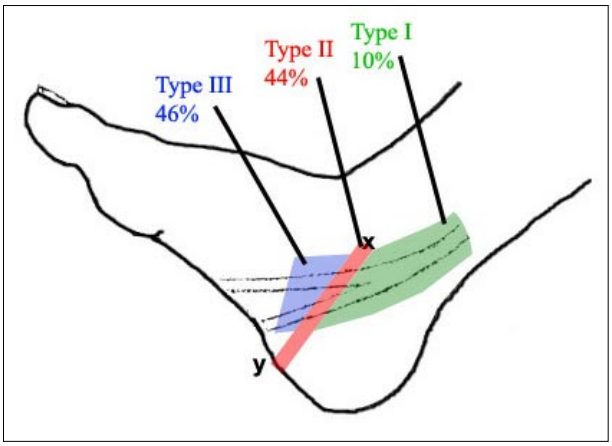

Figure 3 | The percental distribution of the bifurcation of the posterior tibial artery in the tarsal tunnel.

bifurcation is at the axis and type III represents that the bifurcation is distal to the axis and outside of the tarsal tunnel.

The diameter of the tibial nerve just before bifurcation and the diameters of the plantar nerves just after bifurcation were measured. Also the distance between the tip of the medial malleolus and medial plantar nerve and the distance between the medial tubercle of calcaneus and lateral plantar nerve were measured along the axis to help to define the location of these nerves (Figure 1).

Distances were measured with using a digital caliber. Detailed recordings of the typical findings were recorded and photographs of more significant anatomic dissection taken. Mean values of the measurements of the right and left side for each foot were statistically evaluated.

Results

In the examined 50 specimens, the classifications for tibial nerve bifurcation (Figure 2) were as follows; Type I was the common (n= 42, 84%) and no high division nor proximal bifurcation was detected. Type II was detected as 12% (n= 6) and Type III was the least 4% (n= 2).

The diameter of the tibial nerve before the bifurcation was found 5.8 ± 0.8 mm on the right (n=27) and 6.03 ± 0.91 mm on the left (n=23). Just after the bifurcation the diameter of the lateral plantar nerve (LPN) were measured 3.08 ± 0.6 mm on the right (n=27) and 3.01 ± 0.89 mm on the left (n=23); the diameter of the medial plantar nerve (MPN) were measured 3.63 ± 0.7 mm. on the right (n=27) and 3.64 ± 0.85 mm on the left (n=23) respectively.

The distance between the tip of the medial malleolus and MPN was 26.95 ± 4.13 mm. The distance between medial tubercle of calcaneus and LPN was 27.06 ± 6.06 mm.

In two samples, the bifurcations were distal to the defined axis (Type III). For this reason in these samples the distance of the plantar nerves to the landmarks were not measured.

The classification for posterior tibial artery (Figure 3) was as follows:

Type III was detected in 46% (n= 23). Type II was in 44% (n=22) and type I was in 10% (n=5).

The outcomes of the posterior tibial artery measurements show that the artery bifurcates more distally than the tibial nerve.

Discussion

The division level of the tibial nerve is an essential knowledge for diagnosis and treatment of tarsal tunnel syndrome and for various surgical procedures like external nailing of the tarsal bones [9-12]. However, the fundamental anatomical relationship of the tibial nerve to the tarsal tunnel leans on limited numbers of studies [6-8, 13].

In this anatomical study, the 1 cm width reference line was drown between the tip of the medial malleolus and the medial tubercle of calcaneus which was demonstrating the distal edge of the flexor retinaculum. The distances between nerves and the palpable landmarks and the diameters of the nerves which could be helpful for some surgical procedures were measured.

The results of this study show that, the areas approximately 25 mm postero-inferior from the medial malleolus and 25 mm antero-superior from the medial tubercle of calcaneus along the described axis are safe for pin insertions and will not damage any neural structure.

In the performance of a tibial nerve block, the injection have to be made superiorly from the defined axis. Although as a traditional method, the pulsation of the posterior tibial artery will be helpful for the desicion of an injection site because of its distally located bifurcation to the tibial nerve [8].

While the medial tarsal region still remains as an important anatomical site for clinicians, it's hoped that further anatomical studies will proceed.

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