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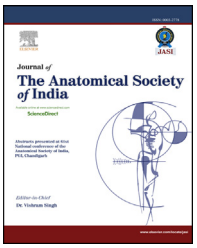

Original Article

The origin and branching of medial calcaneal nerve in newborn foetuses

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ABSTRACT

Introduction: Entrapment of the medial heel region nerves is often mentioned as a possible cause of heel pain. Some authors have suggested that the medial calcaneal nerve (MCN) may be involved in such heel pain. The aim of the present study is to describe the variations of the origin of the medial calcaneal nerve and its branching patterns in the medial aspect of the calcaneus which establishes an anatomical guide for diagnosis and therapy of some tarsal region diseases.

Material and methods: The formation and course of the MCN were traced to its branches in the distal ankle with the use of 4.8 X stereomicroscope (Carl-Zeis) or 28 X loop magnification for dissections of 36 newborn feet of formalin fixed cadavers.

Results: The MCN originated from the tibial nerve (TN) in 61.1% and from the lateral plantar nerve (LPN) 16.7%, bilaterally. It branches from the TN on the right side and from the LPN on the left side in 11.1%, from the LPN on the right side and from the TN on the left side in 11.1%.The MCN consisted of 1 terminal branch in 3 out of 36 feet, 2 terminal branches in 28 out of 36, and 3 terminal branches in 5 out of 36.

Discussion: The course and the origin of MCN on the medial aspect of the heel and its terminal branches were quite different. These variabilities will enable the surgeon to find and preserve the MCN and its terminal branches.

1. Introduction

Heel pain is a very common symptom among patients who seek orthopaedic care. Most of the literature on the subject has focused on the tarsal tunnel syndrome or the role of a heel spur in such pains.[1,2] Knowledge of the innervation of the medial heel region is also important for the diagnosis and treatment of heel pain, tarsal tunnel syndrome, soft tissue and bony ankle injury, and the secondary heel pain due to

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neuroma.[1] Even when systemic etiologies have been ruled out, some cases remain unexplained. Some authors have suggested that the medial calcaneal nerve may be involved in such heel pain.[2] In patients with heel pain of neural origin, pain is usually characterised as burning, sharp, shooting, shock-like, electric, localised or radiating either proximally or distally and occasionally as dull aching. Typically, pain is worse during or after weight-bearing activities and improves with rest. However, pain may also occur with rest and in non-weight bearing positions. Pain at night may be due to nerve compression as a result of venostasis and venous engorgement.[3]

Tarsal tunnel syndrome is a compression neuropathy of the tibial nerve or one of its branches and can be seen in children.[4–6] The medial calcaneal branch of the tibial nerve may be entrapped in a tarsal tunnel syndrome depending on the level of branching. An ankle joint ganglion within the tarsal tunnel has been reported as a cause of entrapment of this particular nerve.[7]

An overlooked and sometimes undiagnosed clinical entity that may be responsible for plantar heel pain is entrapment of the medial calcaneal nerve.[8] In cases with chronic heel pain unrelieved by conservative therapy, Koppel and Thompson,[9] Tanz[10] and Edwards et al[11] believe that compression of the medial calcaneal branches of the tibial nerve could be the cause. Tanz[10] demonstrated the vulnerable position of the nerve under the deep fascia of the abductor hallucis muscle and analysed the influence on the position of the foot and the great toe on such pain. Streching the abductor hallucis and shortening the flexors provoked pain; the symptoms decreased when these muscles were relaxed, suggesting that the nerve compression is dynamic rather than constant or static.

The anatomy and origin of the medial calcaneal nerve is highly variable.[12–14] It arises from either the tibial nerve or the lateral plantar nerve after the bifurcation of the former.[12] Furthermore, this nerve could originate from medial plantar nerve or the bifurcation point of the tibial nerve. The nerve consists of usually two terminal branches which supply the cutaneous innervation of the medial plantar aspect of the heel. The anterior terminal branch is interposed between the deep fascia of the proximal part of the abductor hallucis muscle and the medial anterior corner of the tuber calcanei. The posterior calcaneal branch is small and passes the medial edge of os calcis dorsal to the origin of the abductor hallucis muscle.[15] Nine different branching patterns have been identified, with a single nerve branch in 79% of feet and multiple branches in 21% of feet. The most common pattern is a single medial calcaneal nerve arising from the tibial nerve, which travels below the flexor retinaculum or pierces it.[13]

Knowledge of the variations in location of the medial calcaneal nerve may prevent neuroma formation during surgery and provide insight into the variability of heel symptoms associated with tarsal tunnel syndrome.[16] The aim of the present study is to describe the variations of the origin of the medial calcaneal nerve and its branching patterns in the medial aspect of the calcaneus which establishes an anatomical guide for diagnosis and therapy of some tarsal region diseases such as tarsal tunnel syndrome, fixations of fractures with external nailing, medial displacement osteotomy and nerve blocks in paediatric medicine.

2. Material and methods

In this study, 36 lower limbs, right and left side, were used from 18 Turkish newborn foetuses. All infant cadavers were supplied from the maternity hospital. All infants included in this study were born at term with no obvious external malformations. The cause of death was unknown. They were fixed in 10% formalin, and the MCN and its terminal branches dissections were carefully performed under a 4.8 X stereomicroscope (Carl-Zeis) or 28 X loop magnification. The formation and course of the MCN was traced to its branches in the distal ankle. The origin of medial calcaneal nerve with relationship to the tibial nerve's division, its course, and the number of its branches were documented.

The measurements of MCN were compared with repeated measures analysis of variance. Fischer's exact test were used to analyse the origin of the medial calcaneal nerve. Results were expressed as Mean ± SEM. A P value less than 0.05 was considered statistically significant. Statistical analyses were performed using the SPSS (V.10.0) software.

3. Results

In the present study, the rate of occurrence of the medial calcaneal nerve in medial heel region was 100%. It originated from lateral plantar nerve in 3 out of 18 (16.7%) in both sides; from tibial nerve in 11 out of 18 (61.1%) in both sides; from lateral plantar nerve on the right, from tibial nerve on the left in 2 out of 18 (11.1%), and from tibial nerve on the right, from lateral plantar nerve on the left in 2 out of 18 (11.1%) (Figs. 1–3). Also we found a high division of medial calcaneal nerve from tibial nerve in one case (Fig. 4).

The medial calcaneal nerve consisted of 1 terminal branch in 3 out of 36 feet, 2 terminal branches in 28 out of 36, and 3 terminal branches in 5 out of 36. Each of the medial calcaneal nerve branches ended in ramifications. When the medial calcaneal nerve consisted of several branches (Figs. 1, 3 and 4), the anterior branch ended close to the proximal insertion of the abductor hallucis muscle. The posterior branch innervated the superficial tissues of the medial aspect of the calcaneus opposite the insertion of the calcaneal tendon. These two branches arose either independently or from a common trunk with a medial branch. This medial branch crossed the inferomedial edge of the heel (Figs. 1–3).

The average number of terminal branch of medial calcaneal nerve was found 2 ± 0.42 on the right side and 2.08 ± 0.41 on the left side of males. In females, it was found 2 ± 0.63 on the right and 2.16 ± 0.41 on the left. Thus, in terms of number of branches between the sides by sex, there was no statistically significant difference ($P > 0.005$). Irrespective of gender, the average number of branches was found 2 ± 0.48 on the right and 2.11 ± 0.47 on the left. There was no significant difference between the sides ($P > 0.005$).

4. Discussion

The origins of the medial calcaneal nerve are essential for diagnosis and treatment for various surgical procedures, such

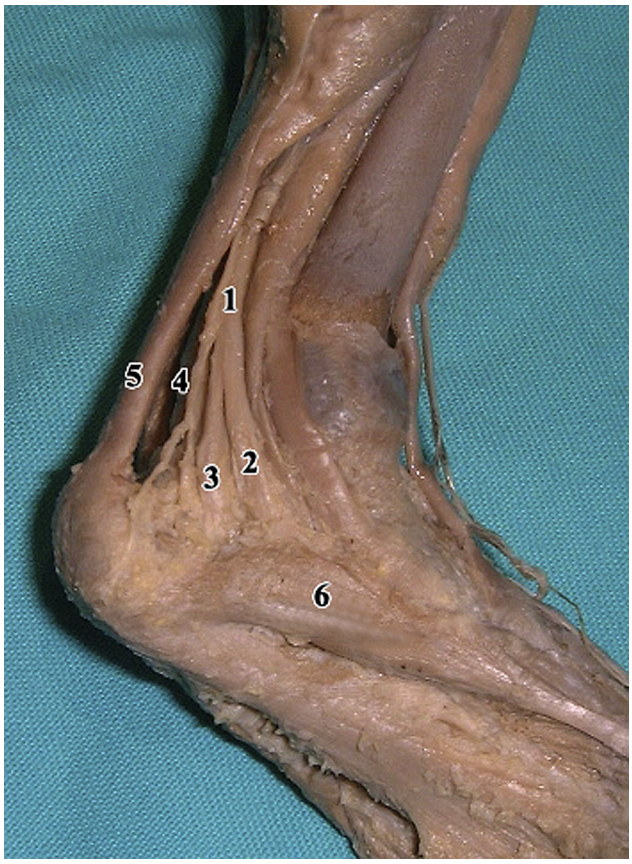

Fig. 1 – Course of MCN arising from TN and the course of its terminal branches: 1 – Tibial nerve, 2 – Medial plantar nerve, 3 – Lateral plantar nerve, 4 – Medial calcaneal nerve, 5 – Tendo calcaneus, 6 – Abductor hallucis muscle.

as heel spur fracture, calcaneal stress fracture, plantar fasciitis and bursitis. The increase in the surgery of medial heel region can be observed from recent articles on the use of surgical compression of the calcaneal nerve to treat

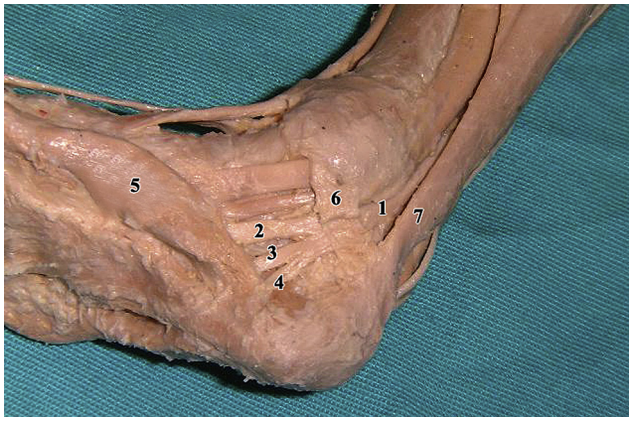

Fig. 2 – Course of MCN arising from LPN: 1 – Tibial nerve, 2 – Medial plantar nerve, 3 – Lateral plantar nerve, 4 – Medial calcaneal nerve, 5 – Abductor hallucis muscle, 6 – Flexor retinaculum, 7 – Tendo calcaneus.

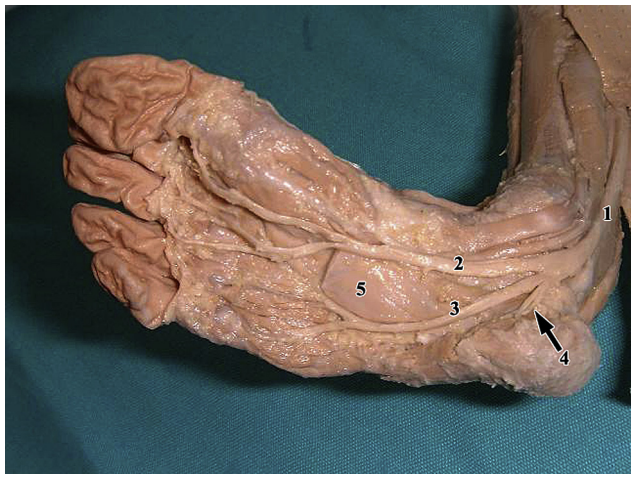

Fig. 3 – Course of MCN arising from LPN and its terminal branches: 1 – Tibial nerve, 2 – Medial plantar nerve, 3 – Lateral plantar nerve, 4 – Medial calcaneal nerve, 5 – Quadratus plantae muscle.

recalcitrant heel pain,[15,16] and recent publications suggesting that decompression of the tarsal tunnel can restore sensation to diabetic feet.[16,17]

Our results have corroborated those of Govsa et al,[1] Louisia and Masquelet,[2] Didia and Horsefall,[12] Dellon and Mackinnon,[18] Park and Del Toro.[19] Govsa et al[1] reported that the origin of the medial calcaneal nerve was highly variable. They found that medial calcaneal nerve originated from the tibial nerve in 11 out of 50 feet; from the lateral plantar nerve and tibial nerve in 9 out of 50; from the tibial nerve and medial plantar nerve in 6 out of 50; from the lateral plantar nerve in 7 out of 50 and from the tibial nerve, medial calcaneal nerve and lateral plantar nerve in 6 out of 50. Louisia and Masquelet[2] found that the medial calcaneal nerve arose from the tibial nerve in 66.6%, from the lateral plantar nerve in 20% and from both tibial nerve and lateral plantar nerve in 13.4% of the 15 cadavers. Didia and Horsefall[12] found similar results on the origin of the medial calcaneal nerve. They found that the medial calcaneal nerve arose from the tibial nerve in 62.5%, from the bifurcation of tibial nerve in 18.75%, and from the lateral plantar nerve in 18.75%. In Park and Del Toro's[19] study the medial calcaneal nerve arose from the tibial nerve in 58%, from the division of the tibial nerve in 21%, and from the lateral plantar nerve 21%.

Dellon and Mackinnon[18] determined three distinct variations about the anatomy of the medial calcaneal nerve. In 8 patients, the medial calcaneal nerve was found to arise only from the tibial nerve proximal to the tarsal tunnel and enter the heel outside the tunnel. In another 5 patients, he found two calcaneal nerves arising from tibial nerve; one arising proximal to the tunnel and the other arising within the tunnel. In the remaining 7 patients, the medial calcaneal nerve arose within the tunnel from the tibial nerve prior to its bifurcation in 5 of 7 and from the lateral plantar nerve distal to the bifurcation in 2 of 7. According to the Hortwitz's[20] results the medial calcaneal nerve arose from lateral plantar nerve in 96%. We found this result in 27.8%.

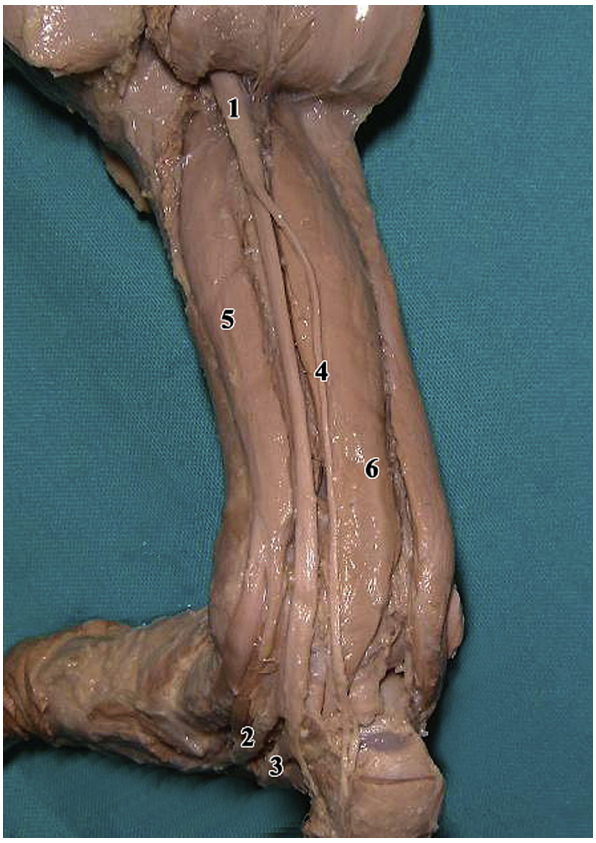

Fig. 4 – High division of MCN from TN: 1 – Tibial nerve, 2 – Medial plantar nerve, 3 – Lateral plantar nerve, 4 – Medial calcaneal nerve, 5 – Flexor digitorum longus muscle, 6 – Flexor hallucis longus muscle.

The origin of medial calcaneal nerve has a highly variable anatomy. Lau and Daniels[13] specified that this nerve arises from tibial nerve in 69%–90% of specimens, and less frequently, from the lateral plantar nerve.

Variations in the branching pattern of medial calcaneal nerve have been also reported. The medial calcaneal nerve usually divides into anterior and posterior branches.[2,15] It provides sensory innervation to most of the heel fat pad and to the superficial tissues overlying the inferior part of the calcaneus.[2] Palpation over the abductor hallucis and/or on the medial calcaneal tuberosity reproduced symptoms in all patients with suspected neurological plantar heel pain.[21] Diagnosis of entrapment of the anterior branch of the medial calcaneal nerve can be substantiated by the following palpatory findings: 1- maximal tenderness over the medial anterior part of the heel fat pad and abductor hallucis, 2- distally radiating pain with pressure on the nerve and 3- only minimal tenderness over the plantar fascia origin.[15] Louisia and Masquelet[2] found that the medial calcaneal nerve consisted of 2 terminal branches in 9 out of 15 feet, 1 terminal branch in 2 out of 15, 3 terminal branches in 2 out of 15, and 4 terminal branches in 2 out of 15. Furthermore, they found the medial calcaneal nerve originating from 10 cm above the division of tibial nerve. We also found the high division of medial calcaneal nerve from the tibial nerve (Fig. 4).

Medial calcaneal nerve is the second most commonly reported nerve that has been related to plantar heel pain of neural origin.[22] Thomas et al reported that plantar heel pain and paraesthesiae in a patient with diabetes resulted from a neuropathy of the medial calcaneal nerve and tibial nerve.[23] However, entrapment of the medial calcaneal nerve may not be a very prevalent condition as only 5 out of 200 surgical cases were consistent with medial calcaneal nerve entrapment.[21] Cozzarelli et al[24] re-evaluated for a coexistent nerve entrapment in 82 patients who fail to improve after conservative and/or surgical treatment of plantar fasciitis with the use of radiofrequency nerve ablation. Either with surgical or radioinvasive procedures branching patterns of medial calcaneal nerve are very important.

Most branches of the medial calcaneal nerve lie superficial to the abductor hallucis, flexor digitorum brevis and plantar fascia.[25] The nerves are less likely to be compressed within these structures, but can be irritated and traumatised following atrophy of the heel fat pad.[26]

We showed the variations in the origin of medial calcaneal nerve and its terminal branches on the medial aspect of the heel in the Turkish newborn foetuses. Detailed information about the anatomical variations of the medial calcaneal nerve and its branches in early ages will be beneficial, particularly in planning surgeries.

Conflicts of interest

All authors have none to declare.

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