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Preprint statement: This article is a preprint and has not been peer-reviewed, under consideration and submitted to ScienceOpen Preprints for open peer review.

Funder: non

DOI: 10.14293/S2199-1006.1.SOR-.PPUPRTS.v1

Preprint first posted online: 21 March 2021

Keywords: Tarsal tunnnel, tibial nerve, Sudanese, posterior tibial artery, tarsal tunnel syndrome

Cadaveric Study of the Neurovascular Bundle in Tarsal Tunnel Region among Sudanese - 2020

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Abstract

Background:

Tarsal tunnel is situated medial to the ankle lying deep to the flexor retinaculum. Within which lies the neurovascular bundle in separate compartments. This study examines the level of bifurcation points of tibial nerve and posterior tibial artery, and the location of medial and lateral plantar nerves in the tarsal tunnel. As well as the origin of the medial calcaneal nerves.

Methods:

This study was a descriptive observational cross sectional study. Step by step dissections of the tarsal tunnel were performed on 30 Sudanese cadavers, the contents of the tarsal tunnel were explored.

Results:

The tibial nerve was found to bifurcate before the the medial malleolus calcaneal axis (MMCA) in (n=4/30, 13.3%) specimens , and inside the tunnel (n=26/30, 86.7%). The branching point of the posterior tibial artery was found before the MMCA in (n=10/28, 35.7%) of specimens, at the MMCA in (n=16/28, 57.1%), and after the MMCA in (n= 2/28, 7.1%). Medial calcaneal nerves were found to be derived from the LPN plus the TN in (n=13/30, 43.3%), while in (n=6/30, 20%) were derived from LPN plus MPN plus TN. only (n=5/30, 16.7 %) were derived from LPN alone.

Conclusion:

anatomical knowledge of the bifurcation points of tibial nerve and posterior tibial artery is of great importance in many medical procedures like external fixation of medial malleolus fractures, medial displacement osteotomy and nerve blocks in podiatric medicine.

Key Words: Tarsal tunnel Tarsal Tunnel Syndrome tibial nerve and the posterior tibial artery medial malleolus calcaneal axis medial calcaneal nerves

Introduction:

Tarsal tunnel is situated medial to the ankle lying deep to the flexor retinaculum. It is also termed as portapedis. It transmits the tendons of tibialis posterior, flexor digitorumlongus and flexor hallucislongus muscle along with the posterior tibial vessels, tibial nerve and their bifurcations. The neurovascular bundle, as well as, other tendons lie in separate compartments deep to the flexor retinaculum ⁽¹⁾.

Compromise of the Tarsal tunnel space by any cause can lead to the development of Tarsal Tunnel Syndrome (TTS). This syndrome results from entrapment of tibial nerve in the tarsal tunnel.

Joshi et al ⁽²⁾ studied anatomy of the tarsal tunnel among Indian cadavers and its applied significant, and have shown the bifurcation of tibial nerve to be of type I in 85.2%, type II in 14.7% and type III in 0.89%. they also had shown that the arterial bifurcation was type I in 16.17%, type II in 72.04% and type III in 11.76%.

Bilge et al. ⁽³⁾dissected the tarsal tunnel region in 60 cases and found types of arterial bifurcation to be type I in 10%, type II in 46% and type III in 44%.

Nīdaye et al ⁽⁴⁾ studied the tarsal tunnel and found the presence of "one" Medial Calcaneal Nerve (MCN) in 80% cases, where asDellon et al ⁽⁵⁾ reported it in 37% and in the present series it was found to be 6.7%.

Dellon et al. ⁽⁵⁾ also described great variability in the number of MCNS, Davis &Schon⁽⁶⁾ have also shown multiple MCN branches.

The purpose of the 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 safe interventions of some tarsal region diseases such as tarsal tunnel syndrome, fixations of fractures with external nailing, medial displacement osteotomy and nerve blocks in podiatric medicine.

Methodology:

This was a descriptive observational cross sectional cadaveric study conducted in the period from January 2020 to February 2020. Thirty lower limbs of formalin fixed embalmed cadavers were dissected in the dissection rooms of some medical schools in Khartoum State – Sudan.

Inclusion criteria: bifurcation points (medial malleolo calcaneal axis MMCA).

Exclusion criteria: high bifurcation points.

The bifurcation of the tibial nerve and the posterior tibial artery were classified with respect to the medial malleolus calcaneal axis into type I, II and III with bifurcation proximal to the axis, at the axis and distal to the axis respectively. And the number and origin of medial calcaneal nerves were studied.

Results:

In all the specimens, the flexor retinaculum was not clearly demarcated at its superior and inferior borders and it was merged with deep fascia of leg and foot. Also fibrous septae were observed arise from deep surface of the flexor retinaculum and heading towards the bones giving rise to 4 osteofacial compartments. The contents of these compartments were found to be (from medial to lateral order): the tendon of the tibialis posterior muscle, the tendon of the flexor digitorum longus muscle, the neurovascular bundle and the tendon of flexor hallucis longus muscle. The neurovascular bundle which was enclosed in a separate compartment was surrounded by a delicate fibro fatty cushion.

Table (1) Pattern of bifurcation points of the tibial nerve according to the reference line MMCA. n=28

Bifurcation point of the tibial nerve	Number of specimens
Type I	10
Type II	16

Table(2) Pattern of bifurcation points of the posterior tibial artery according to the reference line MMCA. n=30

Bifurcation point of the posterior tibial artery	Number of specimens
Type I	5
Type II	15
Type III	10

Table (3) Number of medial calcaneal nerves inside the tarsal tunnel. n=30

Number of medial calcaneal nerves inside the tarsal tunnel	Number of specimens
1 branch	2
2 branches	13
3 branches	14
4 branches	1

Table (4) Origin of medial calcaneal nerves from the tibial nerve (TN), the lateral planter nerve (LPN)and the medial planter nerve (MPN) and from the combination of them. n=30

origin of medial calcaneal nerves	Number of specimens
LPN	5
TN+LPN	13
LPN+MPN	6
TN+LPN+MPL	6

In (n=29/30, 96.6%) specimens the tibial nerve was occupying a deeper position in the neurovascular bundle. In both lower limbs belonging to a female cadaver, the bifurcation of the tibial nerve occurred too high in the leg giving the medial and the lateral planter nerves. Both

nerves were lying at the same level with the blood vessels at the level of the tarsal tunnel. (figure 1)

Figure (1) shows the tibial nerve and the posterior tibial artery lying at the same level at the level of the tarsal tunnel.

Figure (2) shows the tibial nerve lying superficial to the artery

In the examined 30 specimens, 28 specimens were included in the classification of tibial nerve bifurcation points according to the MMCA, 2 specimens were excluded due to their too high bifurcation points. (Figure 3) The classification of bifurcation points were as follows: type I was detected in (n=10/28, 35.7%) specimens, The majority were of type II which were detected in (n=16/28, 57.1%) specimens. (figure 4)

Figure (3) shows high bifurcation of tibial nerve

Figure (4) shows type II bifurcation of the tibial nerve

Regarding the classification of the posterior tibial artery bifurcation according to MMCA was found to be as follows: type I was found in (n=5/30, 16.7%) specimens, type III in (n=10/30, 33.3%) specimens and the majority were type II (n=15/30, 50%) specimens. (Figure 5).

Figure (5) shows type II bifurcation of the posterior tibial artery

In the majority of specimens (n=27/28, 96.4%) specimens the tibial nerve has been to bifurcate very much proximal to the bifurcation of the posterior tibial artery. (figure 6)

Figure (6) shows the tibial nerve bifurcating proximal to the bifurcation of the posterior tibial artery

Regarding the pattern of the tibial nerve ramification in the tunnel, the majority of the specimens (n=16/28, 57.1%%) showed three terminal branches namely (the medial calcaneal nerve, the medial plantar nerve and the lateral plantar nerve) (Figure 7).

Figure (7) shows 3 terminal branches of the tibial nerve

Regarding the number of medial calcaneal nerves observed inside the tunnel, the majority of specimens ($n=14/30$, 46.6%) specimens) were seen to have 3 nerve, followed by 2 MCNs seen in ($n=13/30$, 43.3%) specimens (Figure 8).

Figure (8) shows the origin of MCNs from both tibial nerve and lateral plantar nerve

Discussion

Thorough knowledge of the tarsal tunnel anatomy is essential for any clinician aiming to manage diseases involving the tarsal region. Unfortunately there is poor published literature and studies neither anatomical nor clinical done in Sudanese population about the tarsal tunnel up to my knowledge.

In this study it was observed that the flexor retinaculum was not clearly demarcated at its superior and inferior borders, also there is no clear demarcation between its borders and deep fascia of the leg. Observations of the flexor retinaculum are in agreement with Nagaoka⁽⁷⁾ and Standring et al⁽⁸⁾ They had also described the formation of separate compartments deep to flexor retinaculum by means of fibrous septae extending from the deep surface of the retinaculum.

The neurovascular bundle being lodged in an independent compartment within the tarsal tunnel. My findings during the dissections in this study are in agreement with the above researcher.

Within the tarsal tunnel, distinct superficial and deep relationship was observed between the vessels which are lying superficial and the nerve which is lying deeply. During the dissection of the tarsal tunnel the posterior tibial vessels were seen to form characteristic superficial strata which partially hides the terminal part of the tibial and the beginnings of the medial and lateral plantar nerves from view. This was seen in 90% of the specimens. Based on this observation I suggest more investigations to be done using more specimens to demonstrate the relation between the vessels and the nerve and to match the description giving in concern of such relation by Standring et al ⁽⁸⁾Romanes⁽⁹⁾ and McMinn ⁽¹⁰⁾.

The majority of the specimens used in this study, (n=27/28. 96.4%), the tibial nerve was seen to bifurcate very much proximal to the bifurcation of the posterior tibial artery.

Bilge et al.⁽³⁾ and Joshi et al. ⁽²⁾ had also described a higher level of bifurcation of the tibial nerve; whereas, McMinn ⁽¹⁰⁾ states that the nerve ends at a slightly lower level than the artery. Similar description was given by Romanes⁽⁹⁾ and Standring et al. ⁽⁸⁾

Dellon and Mackinson⁽⁵⁾ Have described the bifurcation of the tibial nerve 1 cm of MMCA (90% cases). Havel et al. ⁽¹¹⁾ have observed the bifurcation of the nerve within the tunnel (in 93% cases) and in 7% of those it was proximal to the tunnel. Davis & Schon⁽⁶⁾ have stated that bifurcation of the nerve, takes place 2 cm of the MMCA (in 90% of cases). These workers, although, have utilized MMCA as a reference but have not recorded the type of their observations (namely type I, type II and type III).

Accordingly it will not be very appropriate to compare my findings with their finding. Bilge et al. ⁽³⁾ in a detailed study of tarsal tunnel among Turkish cadavers have shown the bifurcation of tibial nerve to be of type I in 84%, type 1 in 12% and type III in 4%. Also Joshi et al⁽²⁾ in their study among Indian cadavers have shown the bifurcation of tibial nerve to be of type I in 85.2%, type II in 14.7% and type III in 0.89%, the result of the Turkish and Indian studies are approximately similar to each other. In my study, type I was seen in (n=10/28. 35.7%) and type II was seen in (n=26/28. 57.1%) and no bifurcation has been seen distal to the flexor retinaculum, i.e. No bifurcation was seen outside the tarsal tunnel. So the level of bifurcation of the tibial nerve in the present series is lower than the level that has been mentioned by the above two authors as the majority of bifurcations points was classified as type II (57.1%). However my

findings are in support of to those mentioned by the majority of cases (50 %) was classified as type II e. within the MMCA.

The arterial bifurcation point was always distal to that of the nerve except in one case where they were at the same level. Joshi et al⁽²⁾ in their study had shown that the arterial bifurcation was type I in 16.17%, type II in 72.04% and type III in 11.76% and the corresponding figures in Bilge et al.⁽³⁾ series are type I in 10%, type II in 46% and type III in 44%. In the present series the corresponding figures are type I in (n=5/30. 16.7%), type II in (n=15/30. 50 %) and type III in (n=10/30. 33.3%) Among the three studies it's obvious that the majority of arterial bifurcation points are of type II i.e. within the MMCA.

Nīdaye et al⁽⁴⁾ found the presence of "one" Medial Calcaneal Nerve (MCN) in 80% cases, where as Dellon et al.⁽⁵⁾ reported it in 37% and in the present series it was found to be 6.7%. More ever, I found 2 MCNs have been found in 43.3%. Such finding is close to that reported by Dellon et al.⁽⁵⁾

Dellon et al. ⁽⁵⁾ also described great variability in the number of MCNS, Havel et al.⁽¹¹⁾ described nine different branching patterns of MCN and attributed this factor as an explanation for heel sparing in cases of TTS. Davis & Schon⁽⁶⁾ have also shown multiple MCN branches.

In this study MCNs were mostly derived from the LPN plus the TN in (n=13/30. 43.3%) while (n=6/30. 20%) from LPN plus MPN plus TN. so as we can see the most constant nerve which gives origin to MCN in the above mentioned combinations is LPN and in all the specimens it gives at least one MCN (100 %).

Conclusion

1. Deep to the flexor retinaculum there is an independent compartment which lodges the neurovascular bundle.
2. The vascular plane is superficial to the plane of the nerves.
3. Bifurcation of the tibial nerve is at higher level (proximal) to that of the posterior tibial artery.

4. Most of the neurovascular bifurcation and branching occur between the tip of medial malleolus and the medial calcaneal tuberosity (MMCA).
5. There are more than one medial calcaneal nerves which mainly arise from the lateral plantar nerve and the tibial nerve.

Acknowledgment

Greate thanks and sincere gratitude to faculty members in different Khartoum state colleges for their support to do this study.

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