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Original Research Article

TOPOGRAPHIC ANATOMY OF TIBIAL NERVE AND ITS TERMINAL BRANCHES IN RELATION WITH THE POSTERIOR TARSAL TUNNEL WITH CLINICAL CORRELATIONS

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ABSTRACT

Background: Variations in the level of terminal branching of tibial nerve into medial and lateral plantar nerve in the posterior tarsal tunnel and its relations with posterior tibial artery has tremendous clinical importance. Tibial nerve and its terminal branches are at risk of entrapment in the posterior tarsal tunnel which is called as tarsal tunnel syndrome. The results of surgeries for tarsal tunnel syndrome are variable or suboptimal. The reason could be poor understanding of detailed anatomy of the tarsal tunnel and potential sites of nerve compression. Information regarding the same can help in endoscopic decompression surgeries for tarsal tunnel syndrome with minimal exposure of the region to be operated. Knowledge regarding these variations can also help the anesthetists to give ultrasonography guided ankle block without puncturing the blood vessels.

Materials and Methods: The authors have studied topographic anatomy of tibial nerve and its terminal branches in relation with posterior tarsal tunnel in 50 formalinized cadaveric feet. Authors divided the location of division of tibial nerve in posterior tarsal tunnel (PTT) into seven levels and also categorized the distance between the point of terminal division of tibial nerve (TN) and point of terminal division of posterior tibial artery (PTA) in four categories.

Results and conclusion: Tibial nerve divides relatively higher than the posterior tibial artery in the PTT. Both lie in the same compartment in the tarsal tunnel. The tibial nerve is situated deep to posterior tibial blood vessels .The neurovascular bundle is covered by an unyielding fibrous tissue which could be the reason for the entrapment. Commonest division level of tibial nerve in PTT is level 4 which means the division lies in the range of 6mm to 10mm above the distal border of flexor retinaculum. In 52% of feet the distance between point of division of TN and point of division of PTA is in a range between 0-5mm above the distal border of flexor retinaculum falling under category 1.

KEY WORDS: Posterior tarsal tunnel syndrome, Ankle block, Tibial nerve, Medial plantar nerve, Lateral plantar nerve.

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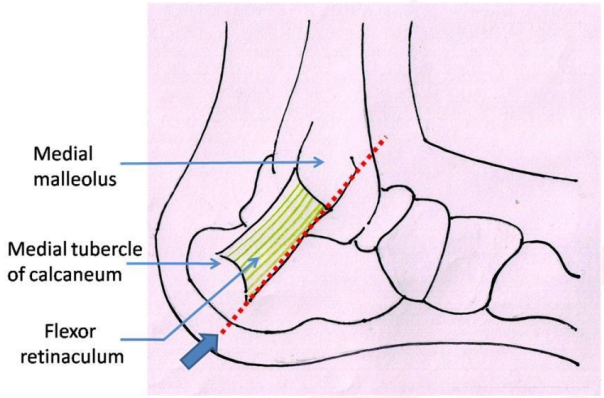
INTRODUCTION

The tibial nerve (TN) enters into the plantar aspect of the foot through the fibro-osseous tunnel called as posterior tarsal tunnel (PTT) which is located on the medial aspect of the foot. Roof of the tunnel is formed by the flexor

retinaculum extending from the medial tubercle of calcaneum posteriorly to the medial malleolus in front. The floor is formed by the posterior aspect of the talus and calcaneus. The anterior wall is formed by the medial malleolus. The distal end is defined by a line joining the tip of the medial malleolus to the medial tubercle of the calcaneus which represents the distal border of the flexor Retinaculum [1]. (figure 1).

Fig. 1: Medial aspect of foot showing posterior tarsal tunnel deep to flexor retinaculum and MMC axis (arrow)



Tibial nerve divides in the PTT into its terminal branches as medial and lateral plantar nerves. The nerve itself and its terminal branches are at risk of entrapment in the posterior tarsal tunnel. This is called as tarsal tunnel syndrome (TTS) [2].

Based on the site of entrapment of tibial nerve or its branches, compression of these structures can lead to a variety of foot and heel pain. Knowledge of topographic anatomy of tibial nerve in relation with the PTT can help to provide patients with needed pain relief by using various conservative or surgical treatment modalities [3-5].

Frequently the tibial nerve entrapment in posterior tarsal tunnel is managed as the heel pain only which denotes that the diagnosis of tarsal tunnel syndrome is much more complicated .This situation makes further study of this region more demanding [2].

Many cases of tarsal tunnel syndrome in India are reported in various journals [6-8] which boosted the authors to take up this region for study.

Many authors conclude that the outcome of decompression surgeries for PTT are variable or suboptimal. The reason could be poor understanding of detailed anatomy of the tarsal tunnel and potential sites of nerve compression [9,10].

Tibial nerve block at ankle also requires a better understanding of relations of tibial nerve with nearby structures as posterior tibial vessels in the PTT. Anatomical knowledge about the same can also help surgeons to come up with better prognosis of surgical procedures such as external nailing of the tarsal bones, medial displacement osteotomies [11-13].

Few authors also have discussed the topographic anatomy of the tibial nerve in relation with PTT [11-13,16,17,19]. Most of them have classified broadly tibial nerve terminal branching in three types as in the PTT, distal to the tunnel and at the lower edge of the flexor retinaculum. Authors in this study have classified the location of tibial nerve branching in seven levels with a reference range of 5mm in relation with PTT.

Authors also noted the distance between the point where the tibial nerve divides into medial and lateral plantar nerves and the point where posterior tibial artery divides into medial and lateral plantar arteries.

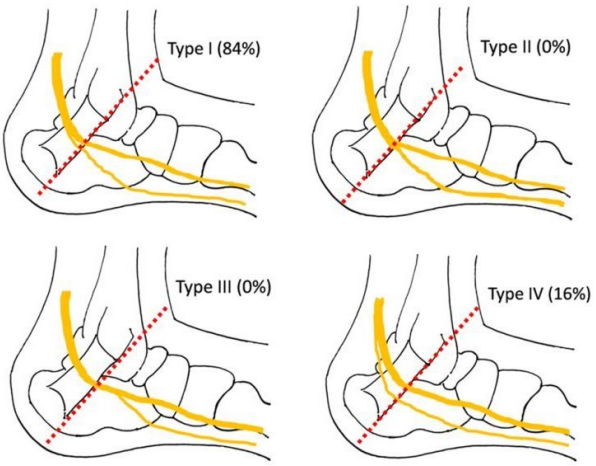
MATERIALS AND METHODS

This is a descriptive type of study. Fifty formalinized cadaveric feet from Dr. D Y Patil Medical Collage, Hospital and Research Centre, Dr. D Y Patil Vidyapeeth, Pune,Maharashtra ,India were used as the study material. To expose the tarsal tunnel and structures within it authors followed the steps given in the Cunningham's dissection manual [14]. The flexor retinaculum was identified and divided at its anterior end and reflected posteriorly to visualize the structures in PTT. All the structures in PTT were cleaned and photographed.

Authors followed the method of O Bilge et al to study and classify the location of division of the tibial nerve in the posterior tarsal tunnel.O Bilge et al used a reference line extending from the tip of medial malleolus (MM) to medial tubercle of calcaneum (C) called as 'Medio- Malleolar-Calcaneal axis' (MMC axis) (figure 1) to classify the location of division of tibial nerve into three types. Type I, II and III signify bifurcations proximal to the reference line but in the tarsal tunnel i.e. within 2cm range, at the line

and distal to the posterior tarsal tunnel respectively [11]. Authors also have added a type IV in the classification (Table 1 and figure 2) for the nerve dividing above the flexor retinaculum i. e. 2cm or more proximal to MMCA. All the measurements were taken with the help of measuring tape in millimeters.

Fig. 2: Percentage of cadaveric feet showing various types of division of tibial nerve in relation with MMC axis



As this is the era of minimal invasive surgeries ;considering same in mind authors also divided the location of division of TN into seven levels (Table 1) with the reference range of 5mm for the vertical distance between the point of division of TN and the reference line MMCA (figure 3).

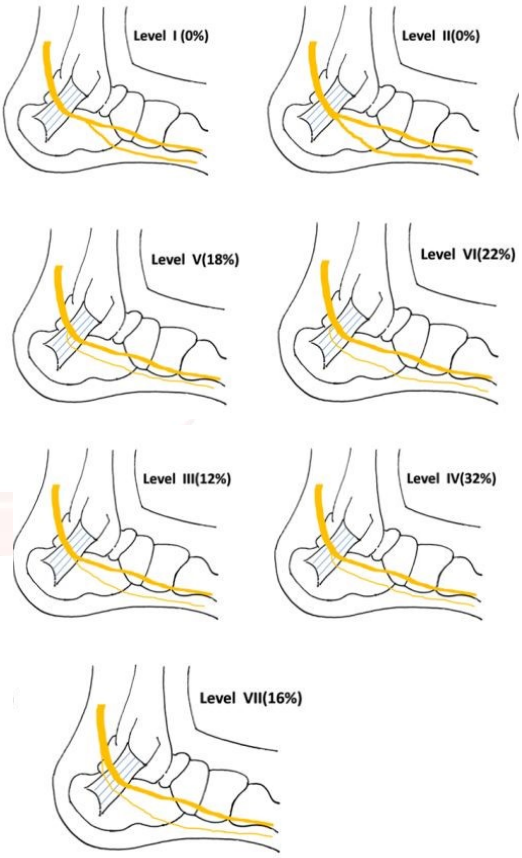
Authors also noted the distance between terminal division point of tibial nerve and terminal division point of posterior tibial artery in cases where the tibial nerve was dividing at higher level than the posterior tibial artery. These distances were again divided into four categories (Table 2 and figure 4) with a reference range of 5mm.

Authors observed that the flexor retinaculum as condensed white glistening deep fascia which can be easily visualized as approximately 20mm broad extending from medial malleous to medial tubercle of calcaneum. The observations for the tibial nerve terminal branching in PTT are mentioned in table 1 and pie chart 1.

In 92 % of cases the tibial nerve was dividing little higher than the level of division of posterior tibial artery. In 4% of cases both TN and PTA were dividing at the same level. In 4% of cases the posterior tibial artery was dividing little higher than tibial nerve. In all the specimens studied the posterior tibial artery was superficial to the tibial nerve. The tibial nerve flattening was seen before the terminal division in all the specimens.

In pie chart 2 and table 2 authors have shown percentage of feet falling under various categories for the distance between point of terminal division of TN and point of terminal division of PTA. In 52% of feet the distance between point of terminal division of TN and PTA was falling under the category 1 which means the distance between these two division points is falling in the reference range of 0 mm to 5mm.

Fig. 3: Percentage of cadaveric feet showing various levels of terminal bifurcation of tibial nerve



Pie chart 1: Pie chart showing percentage of feet falling under various levels of terminal bifurcation of tibial nerve in relation with the posterior tarsal tunnel.

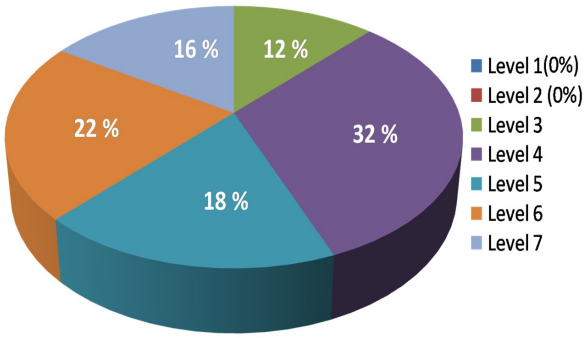


Fig. 4: Percentage of feet showing various categories for the distance between point of terminal division of TN and PTA

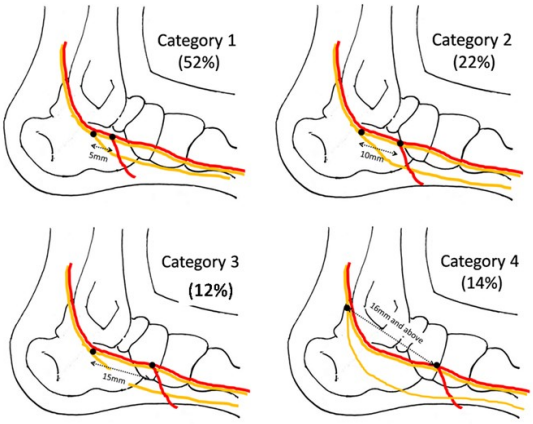


Fig. 5: Terminal division of tibial nerve into medial plantar nerve and lateral plantar nerve in the posterior tarsal tunnel, A:Tibial nerve, B:Medial plantar nerve, C: Lateral plantar nerve,……..Line represents MMC axis.

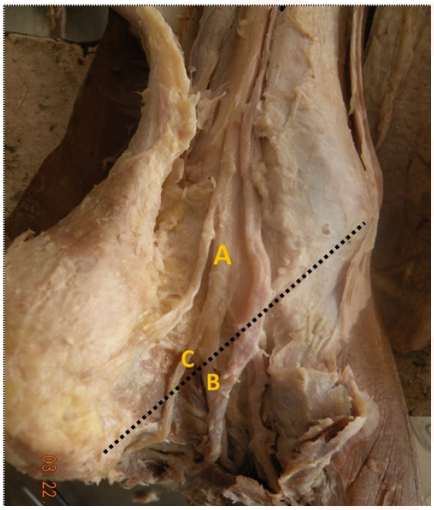


Fig. 6: Terminal division of tibial nerve into medial plantar nerve and lateral plantar nerve 4.2cms above the MMC axis, A:Tibial nerve, B:Medial plantar nerve, C: Lateral plantar nerve,……..Line represents MMC axis

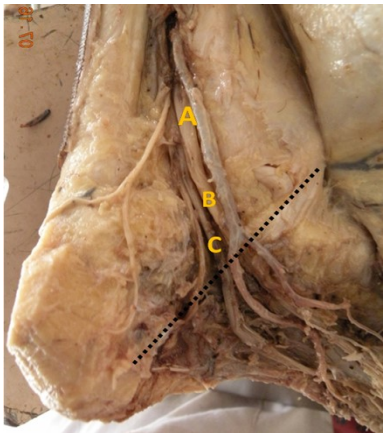


Fig. 7: Terminal division of tibial nerve (N)(yellow dot) is proximal to terminal division of posterior tibial artery(A)(red dot), tibial nerve flattening is seen just before bifurcation.

Pie chart 2: Percentage of feet falling under various categories for the distance between point of terminal division of TN and PTA.

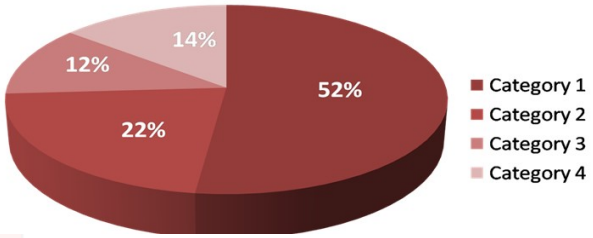


Table 1: Types of division and levels of division of tibial nerve in the posterior tarsal tunnel with percentage of cadaveric feet showing the same (figure no.2,3)

Level of terminal division of TN	Location of terminal division of TN in millimeters (mm) in relation with MMCA	Percentage of cadaveric feet showing various levels of division	Type of division	Percentage of feet showing type of division
1	Distal to the MMCA	0%	III (distal to the PTT)	0%
2	At the MMCA	0%	II (within the PTT)	0%
3	1mm to 5mm above MMCA	12%	I (within the PTT)	84%
4	6mm -10mm above MMCA	32%		
5	11mm-15mm above MMCA	18%		
6	16mm-20mm above MMCA	22%		
7	More than 20mm above MMCA	16%	IV(proximal to the PTT)	16%

Table 2: Categorization of the distance between terminal division point of tibial nerve and terminal division point of posterior tibial artery and percentage of cadaveric feet showing the same (in cases where tibial nerve was dividing at higher level than the posterior tibial artery) (figure 4)

Category	Distance between terminal division point of TN and terminal division point of PTA in milimeters (mm)	Percentage of cadaveric feet falling under various categories
1	0 to 5mm	52%
2	6mm to 10mm	22%
3	11mm to 15mm	12%
4	16mm and above	14%

Table 3: Comparison of percentage of feet showing various types of division of tibial nerve in posterior tarsal tunnel amongst various studies.

Authors	Bifurcation in PTT	Bifurcation distal to PTT	Bifurcation proximal to PTT
	Type I and II	Type III	Type IV
Horwitz et al cited by André Leal Gonçalves Torres, [19]	96%	-	4%
Dellon et al [4]	94%	-	6%
Davis et al cited by André Leal Gonçalves Torres, [19]	90%	-	10%
Louisia et al cited by André Leal Gonçalves Torres, [19]	73%	-	26%
Heimkes et al cited by André Leal Gonçalves Torres, [19]	100%	-	-
Havel et al. cited by André Leal Gonçalves Torres, [19]	93%	-	7%
Ndiaye et al. cited by André Leal Gonçalves Torres, [19]	90%	-	10%
Bilge et al cited by André Leal Gonçalves Torres, [19]	96%	4%	-
Joshi et al [17]	99.90%	0.89%	-
Fernandes at al cited by André Leal Gonçalves Torres, [19]	86.70%	3.30%	10%
A Torres at al cited by André Leal Gonçalves Torres, [19]	88%	-	12%
Alvaro Iborra et al [2]	91.70%	-	8.30%
Present study	**(Type I) 84%**	**0%**	**16%**

DISCUSSION

The authors were able to appreciate the flexor retinaculum but it was thinner than the flexor retinaculum in the hand. The tibial nerve fattening was seen at the point of terminal division in all 50 feet. Posterior tibial blood vessels were superficial to it in all dissected specimens. This might be the most common factor for the compression of the tibial nerve. The same findings were described by Michihiro Kohnoat al[15], Tamang *et a [16]*, SS Joshi et al [17].

In 92% cases tibial nerve was dividing higher than the PTA. SS Joshi et al [17] found the same in 98% of cases. O Bilge et al [11] and Yang et al [18] have also described a higher level of bifurcation of tibial nerve.

Thick strands of fibrous tissue extending from under surface of flexor retinaculum to the bones forming medial wall of the tunnel were dividing the PTT in individual compartments for tendons and neurovascular bundle. The tibial nerve and the blood vessel were in a same compartment separated from the flexor tendons. These findings match with the findings of Joshi et al [17], Dellon et al [5], Havel et al [19].

Because of the unyielding nature of this fibrous tissue surrounding the neurovascular bundle; the tibial nerve becomes immobile and prone to traction injuries or compression by space occupying lesions [5,19].

From table number three; it can be observed that the most common type for terminal division of tibial nerve is within the tarsal tunnel.

Authors are the first to divide the location of terminal division of TN into seven levels. For the same reason it was not possible to compare the results of the same with any other study. In 32% of feet the division of TN was taking place in a range of 6mm-10mm above the MMCA falling under level 4. In 16% of cases division was taking place above the PTT falling under level 7. Knowledge about common and rare levels of terminal division of TN may help the surgeons to localize tibial nerve and its branches precisely in nerve entrapment cases for endoscopic release with minimal handling of surrounding structures.

In 52% of feet the distance between point of terminal division of TN and point of terminal division of PTA was falling in a range between 0-5mm above the MMCA i.e. category 1. This kind of categorization may help the anesthetists to find safe zone to give ankle block without puncturing the posterior tibial artery [13].

Authors hope that anatomical details discussed in this study can fill the gaps in the knowledge regarding the topographic anatomy of terminal branching of tibial nerve up to certain degree. Parameters studied may be added as one of the factor assisting surgeons for endoscopic release of PTT syndrome with minimal tissue handling. Same can be one of the factor helping anesthetists in giving ankle block without damaging PTA.

CONCLUSION

The tibial nerve divides relatively higher than

the posterior tibial artery in the PTT. The tibial nerve and posterior tibial vessels lie in the same compartment in the tarsal tunnel. The tibial nerve lie deep to posterior tibial blood vessels which could be one of the reasons for the compression of the tibial nerve in tunnel. The neurovascular bundle lie in an unyielding fibrous tissue which could be another reason for the entrapment neuropathy.

Most common level of division of tibial nerve is in the tarsal tunnel was level 4 which means the division was located in the range of 6mm to 10mm above the MMCA.

In 52% of feet the distance between point of terminal division of TN and point of terminal division of PTA was in a range between 0-5mm above the MMCA falling under category 1.

In the era of minimal invasive surgeries and regional blocks the precise knowledge of topographic anatomy of tibial nerve in relation with the posterior tarsal tunnel can help the anaesthetists and surgeons to reduce the time duration of the hospital stay for the patient by optimum handling of the region to be operated.

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Conflicts of Interests: **None**

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