Section: Anatomy

Original Research Article

A STUDY OF NEUROVASCULAR STRUCTURES IN TARSAL TUNNEL

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ABSTRACT

Background: Tarsal tunnel is the region beneath the flexor retinaculum on the medial side of the ankle. It transmits the tendons of Tibialis posterior, Flexor digitorum longus,Posterior tibial vessels, Tibial nerve and Flexor hallucis longus tendon.The purpose of the study is to localize the level of bifurcation of tibial nerve,posterior tibial artery with reference to medio malleolar calcaneal axis.

Materials and Methods: The present study was performed on 50 lower limbs from 25 embalmed adult human cadavers from the Institute of Anatomy, Madras Medical College by conventional dissection method. Flexor retinaculum will be dissected along the tarsal tunnel. A reference axis (Medial Malleolar Calcaneal axis) of 1 cm width is derived. The tibial nerve and posteriortibial artery level of bifurcation was classified into Type I, II and III with reference to medio malleolar calcaneal axis.

Results: In present study tibial nerve bifurcation was commonly found to be type I (82%) and posterior tibial artery bifurcation was type II (64%). There is no safe zone on the medial aspect of calcaneus along the MMC axis for blind external fixation of calcaneal fractures.

Conclusion: The proper anatomical knowledge of tibial nerve, its branching pattern becomes a prerequisite for the surgeons to understand the pathogenesis of tarsal tunnel syndrome. Knowledge of variations in the level of bifurcation of neurovascular structures is mandatory in orthopedic surgeries, podiatric medicine and in designing neural cuff electrode implants.

Keywords: Tibial nerve, posterior tibial artery, medial plantar nerve, tarsal tunnel syndrome.

INTRODUCTION

Flexor retinaculum is a strong fibrous band, extending from the medial malleolus of tibia above to the medial tubercle of the calcaneus below. Proximally there is no clear demarcation between its border and the deep fascia of the leg. Distally its border is continuous with the plantar aponeurosis.[1-8] Tarsal tunnel is the region beneath the flexor retinaculum. It is bounded by the flexor retinaculum medially, posterior aspect of talus and calcaneus laterally and medial malleolus anteriorly. the septae arising from the flexor retinaculam divides the tarsal tunnel into four compartments. structures passing through tarsal tunnel.[9-15]

Medial to Lateral: Tendon of Tibialis Posterior, Tendon of Flexor Digitorum Longus, Posterior Tibial artery and Tibial nerve, Tendon of Flexor Hallucis Longus.

Tibial Nerve

Tibial nerve (L4,L5,S1,S2,S3) is the largest terminal branch of Sciatic nerve. It descends along the back of the thigh and popliteal fossa to the distal border of popliteus, passing anterior to the arch of soleus with the Popliteal artery and continuing into the leg. In the leg, Tibial nerve is medial to Posterior tibial artery initially, then it crosses behind them and descends lateral to them until its bifurcation. Tibial nerve ends by dividing into Medial and Lateral plantar nerves.[16-18]

Posterior Tibial Artery

Posterior tibial artery, is the largest terminal branch of popliteal artery. Begins at the distal border of popliteus, enters into the posterior compartment of

leg under cover of tendinous arch of soleus. Posterior tibial artery is at first lateral to Tibial nerve but in the lower part it is crossed by nerve behind it and subsequently becomes medial to it. It ends by dividing into Medial and Lateral plantar arteries.[19-25] The present study was undertaken to localize the level of bifurcation point of tibial nerve, posterior tibial artery. Knowledge of variations in the location of bifurcation level of tibial nerve and posterior tibial artery may prevent the damage to neurovascular structures during various surgical procedures like fixation of fractures with external nailing of tarsal bones, medial displacement osteotomies.[26-37]

MATERIALS AND METHODS

The present study was performed on 50 lower limbs from 25 embalmed adult human cadavers by conventional dissection method. Flexor retinaculum will be dissected along the tarsal tunnel. A reference axis (Medial Malleolar Calcaneal axis) of 1 cm width is derived. This will be represented by two threads, 1cm apart, extending from two points which are 0.5cm on either side of the tip of medial malleolus of tibia to two points which are 0.5cm on either side of the medial tubercle of calcaneum. The tibial nerve and posteriortibial artery level of bifurcation was classified into Type I, II and III with reference to medio malleolar calcaneal axis. Type I, II, III represented the bifurcations proximal to,deep to and distal to the axis respectively.

RESULTS

1. Type of bifurcation of tibial nerve in relation to medial malleolar calcaneal axis

Out of 50 dissected limbs 41(82%) showed the bifurcation of tibial nerve proximal to the medial malleolar calcaneal axis. In 18% bifurcation was noted behind the axis. None of the specimen showed the bifurcation distal to the axis.

Table 1: Distribution of types of tibial nerve in percentages

Bifurcation of tibial nerve	No of specimens	Percentage
TYPE I	41	82
TYPE II	9	18
TYPE III	NIL	-

Table 2: Distribution of types of posterior tibial artery in percentages

Type of bifurcation of posterior tibial artery	No of specimens	Percentage
TYPE I	1	2
TYPE II	32	64
TYPE III	17	34

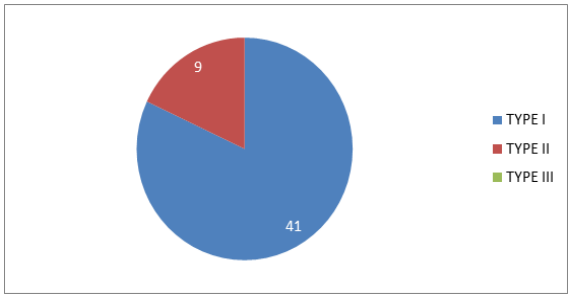

Chart 1: Distribution of Posterior Tibial Nerve Type (N=50).

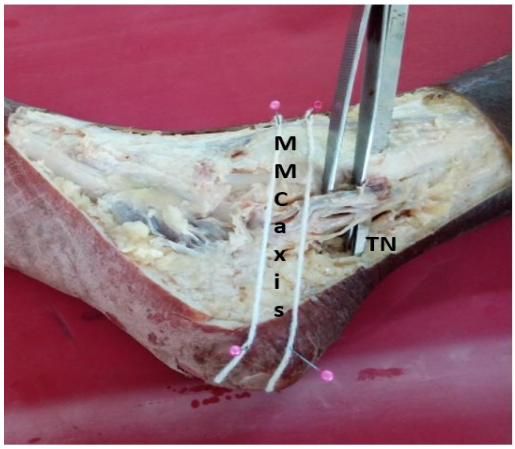

Figure 1: Tibial nerve type I (bifurcation proximal to the MMC axis)

Type of Bifurcation of Posterior Tibial Artery

Out of 50 dissected limbs 2% showed the bifurcation of tibial artery proximal to the medial malleolar calcaneal axis. In 64% bifurcation was noted behind the axis. In 34% of the specimen showed the bifurcation distal to the axis.

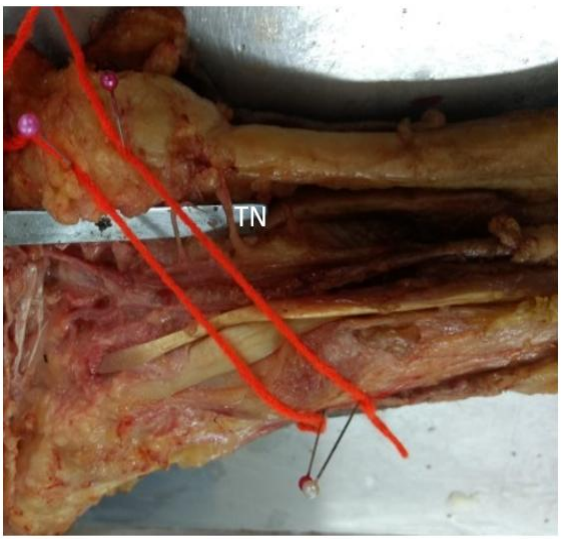

Figure 2: Tibial nerve type II (bifurcation deep to the MMC axis)

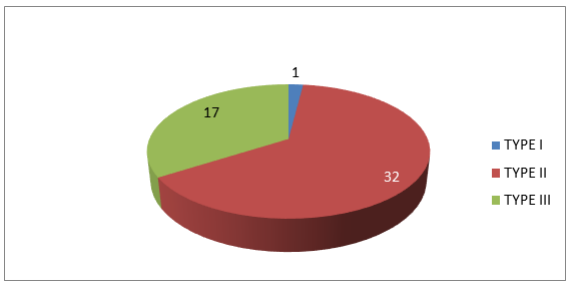

Chart 2: Distribution of Posterior Tibial Artery Type (N=50)

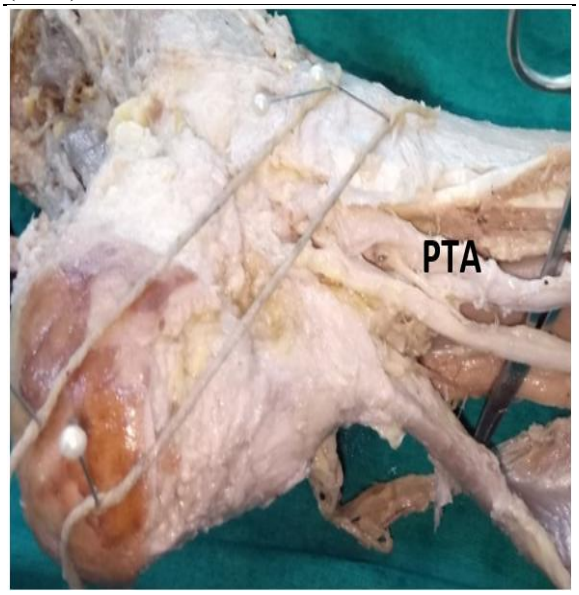

Figure 3: Posterior tibial artery type I (bifurcation proximal to the MMC axis)

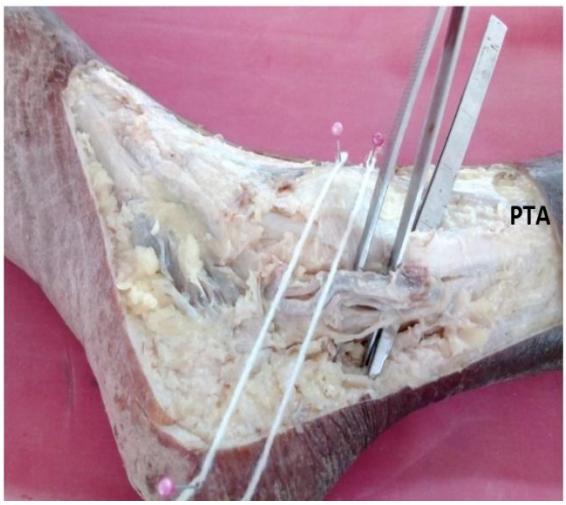

Figure 4: Posterior tibial artery type II (bifurcation deep to the MMC axis).

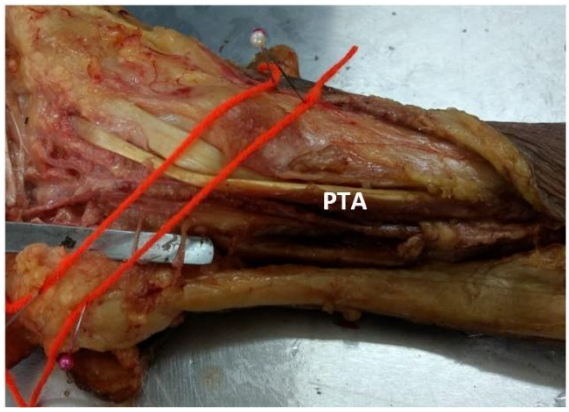

Figure 5: Posterior tibial artery type III (bifurcation distal to the MMC axis)

DISCUSSION

Tibial nerve is the medial, larger terminal branch of sciatic nerve. It gives off articular, muscular, cutaneous and vascular branches and terminates by bifurcating into medial and lateral plantar nerves. Posterior tibial artery is one of the larger terminal branches of the popliteal artery. It gives off circumflex fibular artery, peroneal artery, nutrient branch, muscular branches, communicating branch, medial malleolar branches, calcaneal branches and terminates by bifurcating into medial and lateral plantar arteries. The present study was undertaken to localize the level of bifurcation point of tibial nerve and posterior tibial artery.[37]

During fixation of fractures with external nailing of tarsal bones, other traumatic lesions of the ankle joint and osteochondritis dissecans of the talus, ankle is approached from the medial aspect. Despite of utmost care there are possibilities of injury to tibial nerve and posterior tibial artery. The present study serves as an anatomical guide to prevent damage to the neurovascular structures on the medial aspect of ankle.[4]

Table 3: Comparison of Level of bifurcation of tibial nerve in present study with that of other anatomical studies where they have classified the tibial nerve bifurcation into type I, II, III with reference to MMC axis.

Author	Year Of Study	No.Of Specimens	Type of Bifurcation of Posterior Tibial Nerve		
			Type I %	Type II %	Type III %
Okan Bilge et al	2003	50	84	12	04
Joshi S S et al	2006	112	85	14	01
Torres ALG et al	2012	26	66	22	12
Kalpana.R et al	2014	50	92	6	02
Malar.D et al	2016	20	85	10	05
Binod Kumar Tamang et al	2016	30	90	10	Nil
Present Study	2020	50	82	18	Nil

Table 4: Comparison of level of bifurcation of posterior tibial artery with that of other anatomical studies where they have classified the posterior tibial artery bifurcation into type I, II, III with reference to MMC axis

Author	Year of study	No of specimens	Type of bifurcation of posterior tibial artery		
			Type I %	Type II %	Type III %
Okan Bilge et al	2003	50	10	44	46
Joshi s s et al	2006	112	16.17	72.04	11.76
Kalpana.R et al	2014	50	4	76	20
BinodKumar Tamang et al	2016	30	87	3	10
Present study	2020	50	2	64	34

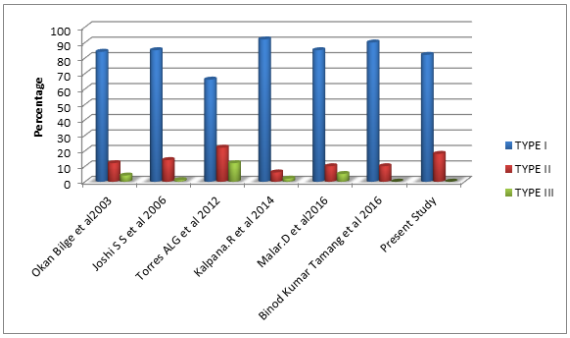

Chart 3: Level of bifurcation of tibial nerve in present study with that of other anatomical studies where they have classified the tibial nerve bifurcation into type I, II, III with reference to MMC axis.

In the present study tibial nerve bifurcation was found to be type I in 82% of specimens, type II in 18%, of specimens which coincides with study done by Okan bilge et al, Joshi et al, Malar et al, lesser than Kalpana et al, Binod kumar et al, and greater than Torres et al.

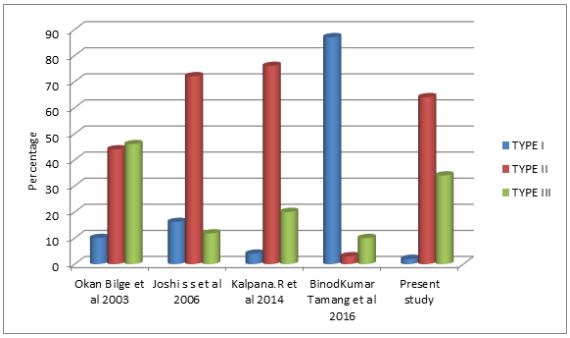

Chart 4: Level of bifurcation of posterior tibial artery with that of other anatomical studies where they have classified the posterior tibial artery bifurcation into type I, II, III with reference to MMC axis

In current study posterior tibial artery bifurcation was found to be type I in 2%, type II in 64%, type III in 34 % of cases which coincides with study done by Kalpana et al, greater than Binod kumar et al, Okan bildge et al, and lesser than Joshi et al.

Deep to flexor retinaculum there is an independent compartment (tarsal tunnel) which lodges the neurovascular bundle. Vascular plane is superficial to the plane of nerves. Bifurcation of tibial nerve is at a higher level (proximal) to that of posterior tibial artery. There is no safe zone on the medial aspect of calcaneus along the MMC axis for blind external fixation of calcaneal fractures.

CONCLUSION

Tarsal tunnel is the space which is located beneath the flexor retinaculum on the medial side of ankle region and transmits the neurovascular structures and tendons of the muscles.

Present study highlighted the bifurcation level of tibial nerve and posterior tibial artery with reference to MMC axis. Tibial nerve bifurcation was found to be type I (proximal to the axis) in 82% of cases, type II (deep to the axis) in 18%, type III (distal to the axis) in Nil cases.

Posterior tibial artery bifurcation was found to be type I (proximal to the axis) in 2%, type II (deep to the axis) in 64%, type III (distal to the axis) in 34 % of cases

So tibial nerve bifurcation was commonly found to be type I and posterior tibial artery bifurcation was found to be type II.

In this study, 50lower limb were used. A horizontal line crossed with the tip of the medial malleolus was selected as a reference mark. The advantage was that this bony structure is relatively stable, and can easily be palpated. We described the branch pattern of the posterior tibial nerve and the posterior tibial artery and their corresponding positions on the basis of the reference line. These positions can provide an anatomic basis to prevent iatrogenic injury when performing a clinical operation, such as the external nailing of the tarsal bones, posterior tibial nerve block and surgery for tarsal tunnel syndrome.

The proper understanding of branching pattern of Tibial nerve becomes necessary for the surgeons to achieve higher success rate in tarsal tunnel release surgeries and avoid iatrogenic injury to the neurovascular structures in orthopaedic surgeries

Knowledge of variations of the level of bifurcation of Tibial nerve is helpful in designing neural cuff electrode implants which are used in functional electrical stimulation (FES) systems to activate nerves that are paralysed due to trauma or other neurological conditions

The anatomy of Tibial nerve and branching pattern plays a significant role in Tibial nerve blocks.

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