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Original research article

A Study of Tibial Nerve - Origin, Course and Motor Branching Pattern to Deep Muscles of the Posterior Leg

Dr. Amrita Kumari[1], Dr. Nafees Fatima[2], Dr. Vivekanand[3], Dr. Birendra Kumar Sinha[4]

[1]Assistant Prof. Department of Anatomy, PMCH, Patna,Bihar, India

[2]Assistant Prof. Department of Anatomy, PMCH, Patna, Bihar, India

[3]Assistant Prof. Department of Anatomy, PMCH, Patna, Bihar, India

[4]Associate Prof. Department of Anatomy, PMCH, Patna, Bihar, India

Corresponding Author: Dr. Vivekanand

Abstract

Background: Tibial nerve which is the largest component of the sciatic nerve is derived from the ventral branches of ventral rami of L4, L5, S1, S2, and S3. It originates from the sciatic nerve and runs through the back of thigh, popliteal fossa and back of leg to endat the junction between the medial malleolus and the medial tubercle of calcaneus.The study was done to find the level of origin termination, and the motor branching pattern of the tibial nerve to the deep muscles of the posterior Leg.

Material and Methods: This Study was Carried out, total 60 adult lower limbs were dissected from the back of the thigh to the ankle. The level of origin of tibial nerve from sciatic nerve above the apex of head of fibula was measured in cms. The range, mean and standard deviation were calculated. Themuscular branching pattern and the number of muscular branches to each muscle werenoted. The level of termination of Tibial nerve in relation to malleolar calcaneal axis was observed. Percentage for all the variables was calculated.

Conclusion: The anatomy of the tibial nerve in the posterior Leg was found to be complexand variable. Such high variability in the origin, termination, and motor branching pattern puts the nerve under high risk for iatrogenic injuries while performing procedures like popliteal block anaesthesia, motor nerve block, neurotomies, free fibular graft and decompression techniques in compartment syndrome.

Keywords: Tibial nerve, Sciatic nerve, Motor branching pattern, FHL, FDL.

Introduction

The posterior compartment of the leg (Plantarflexor compartment, posterior Leg[3]) is the largest of the three compartments. The muscles are divided into superficial and deep groups by the transverse intermuscular septum. The TN, posterior tibial and fibular vessels supply both parts of the posterior compartment but they run in the deep compartment, anterior to the transverse intermuscular septum. The TN supplies all the muscles of the posterior Leg. As the TN is in close relation to the tightly packed deep compartment any swelling here may lead to a serious condition called compartment syndrome.[2] In this condition there will be hypesthesia over the distribution of the TN, pain and weakness of the flexors of the toes**.** Prompt decompression is

the treatment [4] for which a thorough anatomical knowledge of the TN in the posterior Leg is essential to prevent injury to the nerve and its branches during treatment. The knowledge regarding the level of origin of TN from SN is important becausedevelopmentally it is possible for the tibial and common peroneal components of the SN to separate high up in the gluteal region. These nerves may then take different routes and the piriformis muscle may be divided into 2 parts by one or both the nerves. These anatomical variations must always be borne in mind as they have important clinical implications in anaesthesiology, surgery, neurology and sports medicine. A high origin of TN and CPN from SN can result in involvement of one of the two terminal branches of SN giving rise to atypical sciatic compression syndrome.[5] Sometimes a high origin of TN may lead to escape of the nerve from popliteal block anaesthesia and sciatic neuropathy. Knowledge regarding the variation of origin of TN is important because compression of the nerve may lead to coccygodynia and muscleatrophy. Knowledge regarding the TN and its motor branching pattern may help to reduce iatrogenic injuries and motor loss of the foot during surgical procedures such as high tibial osteotomy and fascial release procedures in the posterior compartment of the leg. TN branches to FHL and FDL are suitable for direct nerve transfer for restoration of motor function of deep peroneal nerve. where FHL muscle is supplied onlyby a single branch of TN, transfer of this nerve for neurotization of the deep peroneal nerve may result in complete denervation of the FHL muscle leading to functionalimpairment of the foot and claw toe deformity of the great toe. Spastic equinovarus foot is a deformity caused by spasticity of soleus, gastrocnemius and TP muscles. TN blocks with anaesthetic or neurolytic agents are done for the management of the disease. Knowledge regarding the precise location of the motorbranches of the TN to the muscles concerned in the development of spastic foot may increase the accuracy of motor blocks and neurotomies in the treatment of the condition. TP spasticity may not always be responsible for varus deformity. If the varus is not caused by spasticity of TP and, if it is inappropriately weakened then an ankle valgusmay occur. Hence precisely localizing the TP nerve and blocking it with an anaesthetic agent may help to determine the role of TP in equinovarus deformity. To provide an anatomical basis for the diagnosis and treatment of the tarsal tunnel syndrome the relationship of the TN to the tarsal tunnel must be understood.[11] Tarsal tunnel syndrome can be caused by systemic causes (diabetes mellitus) and local cause (space occupying lesions). In diabetes mellitus the patients are predisposed to the development of tarsal tunnel syndrome due to water retention in the nerve resulting in increase in cross- sectional volume of the nerve. This knowledge may also increase the accuracy of surgical procedures like external nailing of the tarsal bones, medial displacement osteotomies and fixation of fractures in podiatric medicine. There are some cases reported in literature where in the TN was mistakenlyresected for the plantaris tendon for repair of a ruptured calcaneal tendon. Such inadvertent resection of the TN will lead to devastating surgical complications like loss ofsensation of the sole of foot and neuropathic problems. In these circumstances reconstruction of the TN is also not possible as it has a poor prognosis. Hence the present study has been taken up to study the origin, termination and motor branching pattern of TN to the deep muscles of the posterior Leg.

Objectives

Level of origin of the tibial nerve from sciatic nerve in relation to the apex of head of fibula(AHF), Number of muscular branches given off in the posterior Leg to Flexorhallucis longus(FHL), Flexor digitorum longus(FDL) and Tibialis posterior(TP), Branching pattern of the tibial nerve to the deep muscles of the back of leg.

Review of Literature

Tibial nerve also called as the medial popliteal nerve is the larger terminal branch of sciatic

nerve. It is derived from ventral branches of ventral rami of L4, L5, S1, S2, S3. It begins from the sciatic nerve opposite the junction of middle with lower one third of the thigh and descends along the back of thigh and popliteal fossa to reach the distal border of popliteus muscle where it is accompanied by posterior tibial vessels. Here the nerve lies lateral to the artery later crosses posteriorly to lie medial to the artery. In the back of leg the TN accompanied by the posterior tibial vessels descends deep to thesoleus and gastrocnemius muscles. In the distal third of the leg the nerve is covered only by skin and fascia, sometimes overlapped by FHL muscle. The nerve mostly lies on TP muscle. It initially lies medial to the vessels crosses posteriorly to finally lie lateral to it.[1] On reaching the interval between the medial malleolus and the medial margin of the heel the nerve divides into medial and lateral plantar nerves under cover of the flexor retinaculum.

To determine the bifurcation point of TN and posterior tibial artery and the location of medial and lateral plantar nerves in the tarsal tunnel, the study was done in 50 lower limbs. A reference line 1 cm wide extending from tip of medial malleolus to medial tubercle of calcaneum was taken. This axis represents the inferior edge of flexor retinaculum and tarsal tunnel. A study was done to determine the topographic anatomy of the TN and its branches at theankle in relation to the tarsal tunnel, bilateral dissections of 26 fresh cadavers were performed. It was found out that the TN bifurcation occurred under the tunnel in 88% cases and in 70% of the cases among that the bifurcation occurred in an area between 10mm proximal and distal to the MCA. The TN bifurcation occurred proximal to the tunnel in 12% cases.[12] 100 cadaver lower extremity dissections were done by Horwitz in 1938 and it was found that the TN terminated 1.3cm above and behind the tip of the internal malleolus. Tarsal tunnel syndrome is a clinical condition caused by entrapment of the TN or its branches within the fibro-osseous tunnel under the flexor retinaculum of ankle joint dueto systemic cause (diabetes) or local cause (space occupying lesions). Dissection of medial aspect of ankle of amputated right lower limb and normal left lower limb of a cadaver was done. It was found that the TN showed type II bifurcation bilaterally and also the neurovascular bundle lie in separate compartments making the nerve prone for compression. In diabetic patients increased water content in the TN is due to glucose metabolism to sorbitol which increases the cross-sectional volume of the nerve making it prone for compression under the flexor retinaculum.

Material and Methods

This is Observational, Study will be done on 60 formalin fixed lower limbs of adult human cadavers from the Department of Anatomy, at Patna Medical College and Hospital, Patna Bihar.

Inclusion criteria : Lower limbs of adult human cadavers irrespective of sex andside

Exclusion criteria : Cadaver limbs with deformities, trauma and surgical scars

The study was done by dissecting 60 formalin fixed lower limbs of adult human cadavers irrespective of sex and side following the Cunningham manual of practical anatomy, 15th edition volume 1.

The limbs were placed over a block in prone position with the hip and knee extended.The skin of the back of leg was incised longitudinally along the midline from the back of the thigh through the popliteal fossa to the ankle. After reflection of the skin the deep crural fascia was dissected and removed, the triceps surae was carefully dissected and separated close to their origin by cutting through the muscle. The tibial nerve was dissected out carefully from its origin to its termination. Care was taken not to open the epineurium. The apex of head of fibula

(AHF) was taken as a landmark to determine the level of origin of TN from SN as this bony landmark can be easily palpable and this bony prominence can be used to determine the level of origin of TN prior to surgery.

Results

The study was conducted on 60 formalin fixed lower limbs of adult human cadavers.Each parameter of the objective was observed, noted and tabulated. The level of origin ofthe TN from the SN in relation to AHF was measured in centimeters. The percentage wascalculated for each variable. The range, mean and standard deviation was calculated for the readings obtained for the level of origin of TN from SN in relation to AHF.

Figure 1: Specimen showing the FDL muscle being suppliedthrough its superficial surface. Specimen showing the FHL muscle being supplied by3 nerve branches. Level of origin of tibial nerve from sciatic nerve in relation to AHF

Table 1:

Title	<12 cm	12-24 cm	>24 cm
Number of Specimens	24	30	6
Percentage (%)	40	50	10
Mean	8.1	15.68	34.75
S.D	2.38	2.73	4.81

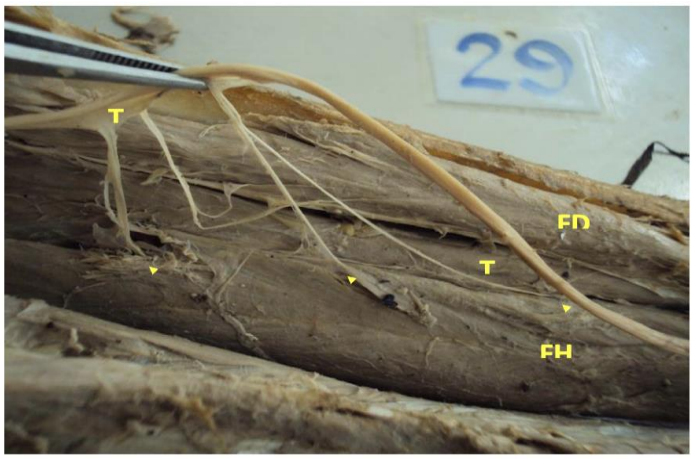

Figure 2: Branching pattern of TN in the posterior Leg

Table 2:

Title	Type I	Type II	Type III
Number of Specimens	42	14	4
Percentage (%)	70	23.33	6.67

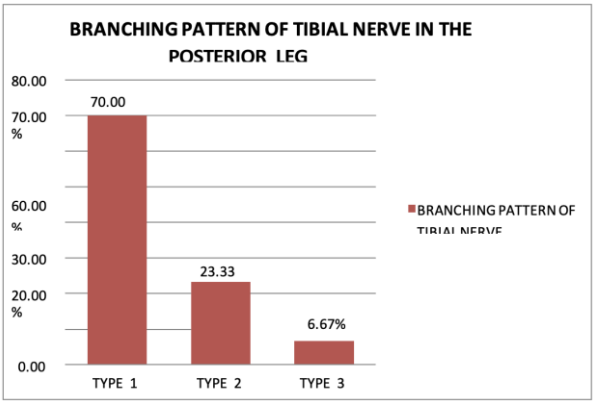

Figure 3: Number of muscular branches- FHL (%)

Table 3:

Title	1 branch	2 branch	3 branch	4 branch
Number of Specimens	44	14	1	1
Percentage (%)	73.33	23.33	1.67	1.67

Table 4: Level of Termination of tibial nerve in relation to Malleolar Calcaneal Axis(MCA)

Title	Above MCA	At MCA	Below MCA
Number ofSpecimens	49	9	2
Percentage (%)	81.67	15	3.33

Discussion

The present study showed that the TN originated from the SN at variable positions in the back of thigh. A study was done by Abdelghany AH et al, on 24 lower limbs. In 95.83% (n=23) of specimens TN originated from the SN at a range of 12-24 cm with a mean of 17.91± 3.80cm above the level of AHF. In 4.17% (n=1) the TN originated from the SN lower down ie, 5 cm above level of AHF. In this study none of the specimens showed the TN originating from the SN very high up in the thigh ie; > 24 cm above level of AHF as seen in our study.[8] According to Keith L Moore in 12% of people, the TN and CPN separate as they leavethe pelvis. In these cases the TN passes inferior to piriformis and CPN pierce this muscle or pass superior to it.[2] In the study by Prathiba K. et el, on 100 lower limbs 3% of the lower limb specimens showed this variation. In 50 gluteal region dissections by Guvencer M et al, 7 gluteal regions showed this variation. It was observed bilaterally on 5 cadavers with 16%. These anatomical variants must always be borne in mind as they have important clinical implications in anaesthesiology, surgery, neurology and sports medicine. A high origin ofTN and CPN from SN can result in involvement of only one of the two terminal branchesof SN giving rise to atypical sciatic compression syndrome.[5] Knowledge of the variations of origin of TN is important because compression of the nerve may lead to coccygodynia, muscle atrophy. Sometimes a high origin may lead to escape of the nerve from popliteal block anaesthesia and sciatic neuropathy. Hip fracture,dislocations of the hip and hip arthroplasty may result in acute

sciatic neuropathies. Tibial nerve is often iatrogenically injured during fibular graft harvest, high tibial osteotomy and fascial release procedures. Neurotomy is frequently done on the motor branches of TN for the treatment of spastic foot**.** Selective nerve blocks are tried before selective neurotomy. A thorough knowledge about the motor branches of TN to the muscles of posterior compartment is needed to perform nerve blocks and neurotomy.[8] There is a limited availability of data in the literature regarding the anatomy of TN branches in the posterior compartment of leg.[7] The presence of 2 branches were found in 23.33% (n= 14) (Photograph 10, specimen 10) specimens. Both the branches innervated the medial border of muscle in 7 specimens, deep surface in 4 and superficial surface in 3 specimens. The nerve to FHL is the last of the muscular branches to arise. It has a long course downwards on the superficial surface of the muscle and sends several branches to the muscle. Occasionally there may be 2 nerves supplying the muscle. The nerve branch accompanies the upper part of peroneal artery and gives twigs to it.[4] Abdelghany AH et al in 24 lower limb specimens found that the TN innervated the FHL muscle by a single branch in 41.67% specimens (n= 10) and it supplied the medial borderof the muscle. The presence of 2 branches was found in 58.33% of specimens (n= 14),the upper branch supplied to the medial border and the lower one to the deep surface of the muscle.[8] Dissections were carried out on 50 lower limbs specimens. Type I- seen in 84 % (n =42) specimens, Type II- seen in 12% (n=6) specimens and Type III- seen in 4% (n=2) specimens.[14] In a dissection study by Joshi SS et al in 112 lower limb specimens the following results were obtained Type I- seen in 85.2% specimens, Type II- seen in 14.7% specimens and Type III- seen in 0.89% specimens.[15]

Conclusion

There is a limited availability of data in the literature in this regard. Hence the present study was done to determine the number of muscular branches given off by the TN to each muscle and the precise location on the muscle where the motor nerve branches entered. The nerve shows three unique motor branching patterns to the deep muscles of the posterior Leg, much unlike what has been stated in the classical textbooks on the subject.

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