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Original Research Article

A STUDY OF TIBIAL NERVE- MOTOR BRANCHING PATTERN TO THE DEEP MUSCLES OF THE POSTERIOR CRURAL REGION

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ABSTRACT

Background: Tibial nerve is the largest branch of the sciatic nerve. From the back of thigh the tibial nerve passes vertically downward along the middle line of popliteal fossa. In the lower part of the fossa it is overlapped by the two heads of gastrocnemius and enters the posterior crural region accompanied by the posterior tibial vessels under cover of the tendinous origin of soleus muscle. The study was done to find the motor branching pattern of the tibial nerve.

Materials and Methods: Study was conducted in 60 formalin fixed lower limbs of adult human cadavers from the Department of Anatomy, JJM Medical college, Davangere, Karnataka. The muscular branching pattern and the number of muscular branches from the tibial nerve to the deep muscles of posterior crural region were noted.

Results: Type I motor branching branching pattern was the most common type observed in 70% of specimens. The Flexor halluces longus and Flexor digitorum longus were mainly supplied by one nerve branch.

Conclusion: The anatomy of the tibial nerve in the posterior crural region was found to be complex and variable. Such high variability in the 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. Hence a thorough anatomical knowledge is indispensible prior to performing an intervention in the posterior crural region.

KEY WORDS: Tibial nerve, Motor branches, Deep muscles of leg.

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INTRODUCTION

The tibial nerve, the larger component of the sciatic nerve, is derived from the ventral branches of the fourth and fifth lumbar and first to third sacral ventral rami. It descends along the back of the thigh and popliteal fossa to the distal border of popliteus. It then passes anterior to the arch of soleus with the popliteal artery and continues into the leg. In the thigh, it is overlapped proximally by the hamstring muscles but it becomes more superficial in the popliteal fossa, where it is lateral to the popliteal vessels. At the level of the knee, the tibial nerve becomes superficial to the popliteal vessels and crosses to the medial side of the artery. In the distal popliteal fossa, it is overlapped by the junction of the two heads of gastrocnemius. In the leg, the tibial nerve descends with the posterior tibial vessels to lie between the heel and the medial malleolus. Proximally, it is deep to soleus and gastrocnemius, but in its distal third is covered only by skin and fasciae, and

overlapped sometimes by flexor hallucis longus. At first medial to the posterior tibial vessels, it crosses behind them and descends lateral to them until it bifurcates. It lies on tibialis posterior for most of its course except distally, where it adjoins the posterior surface of the tibia. The tibial nerve ends under the flexor retinaculum by dividing into the medial and lateral plantar nerves [1].

The tibial nerve supply both parts of the posterior compartment but they run in the deep compartment, anterior to the transverse intermuscular septum. The branches of the tibial nerve are articular, muscular, cutaneous, medial calcaneal and medial and lateral plantar nerves[2]. The tibial nerve supplies all the muscles of the posterior crural region. As the tibial nerve is in close relation to the tightly packed deep compartment any swelling here may lead to a serious condition called compartment syndrome[3]. In this condition there will be hypesthesia over the distribution of the tibial nerve, pain and weakness of the flexors of the toes**.** Prompt decompression is the treatment for which a thorough anatomical knowledge of the tibial nerve in the posterior crural region is essential to prevent injury to the nerve and its branches during treatment[4,5].

Knowledge regarding the Tibial nerve 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[7]. Neurotomy is frequently done on the motor branches of tibial nerve for the treatment of spastic foot. Selective nerve blocks are tried before selective neurotomy. A thorough knowledge about the motor branches of tibial nerve to the muscles of the posterior compartment is needed to perform nerve blocks and neurotomy. There is a limited availability of data in the literature regarding the anatomy of tibial nerve branches to the deep posterior compartment of the leg. Tibial nerve branches to flexor hallucis longus and flexor digitorum longus are suitable for direct nerve transfer for restoration of motor function of deep peroneal nerve. In conditions where flexor hallucis longus muscle is supplied only by a single branch of tibial nerve, transfer of this nerve for neurotization of the deep peroneal nerve may result in complete denervation of the flexor hallucis longus muscle leading to functional impairment of the foot and claw toe deformity of the great toe[5,6].

Articular branches to the knee joint accompany the superior and inferior medial genicular arteries and the middle genicular artery; they form a plexus with a branch from the obturator nerve and also supply the oblique popliteal ligament. The branches accompanying the superior and inferior medial genicular arteries supply the medial part of the capsule. A branch of the nerve to popliteus supplies the posterior portion of the superior tibiofibular joint. Just before the tibial nerve bifurcates, it gives off branches that supply the ankle joint. Proximal muscular branches arise between the heads of gastrocnemius and supply gastrocnemius, plantaris, soleus and popliteus.

The nerve to soleus enters its superficial aspect. The branch to popliteus descends obliquely across the popliteal vessels, curling round the distal border of the muscle to its anterior surface. It also supplies tibialis posterior, the superior tibiofibular joint and the tibia, and gives off an interosseous branch that descends near the fibula to reach the distal tibiofibular joint. Muscular branches in the leg, either independently or by a common trunk, supply soleus, tibialis posterior, flexor digitorum longus and flexor hallucis longus. The branch to flexor halluces longus accompanies the fibular vessels. The sural nerve descends between the heads of gastrocnemius, pierces the deep fascia proximally in the leg, and is joined at a variable level by the sural communicating branch of the common fibular nerve. Some authors term this branch the lateral sural cutaneous nerve, and call the main trunk the medial sural cutaneous nerve. The sural nerve descends lateral to the calcaneal tendon, near the short saphenous vein, to the region between the lateral malleolus and the calcaneus, and supplies the posterior and lateral skin of the distal third of the leg. It then passes distal to the lateral malleolus along the lateral side of the foot and fifth toe, supplying the overlying skin. It connects with the posterior femoral cutaneous nerve in the leg and with the superficial fibular nerve on

the dorsum of the foot. The sural nerve is often used as an autologous peripheral nerve graft on the grounds that it is easily harvested, readily identified and exclusively cutaneous[7,8,9].

MATERIALS AND METHODS

Study was conducted in 60 formalin fixed lower limbs of adult human cadavers from the Department of Anatomy, JJM Medical college, Davangere, Karnataka. The study was done by dissecting 60 formalin fixed lower limbs of adult human cadavers irrespective of sex. 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 first intermuscular septum was incised longitudinally in the middle and reflected to expose the deeper muscle and neurovascular bundles. 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 was taken as a landmark to determine the level of origin of tibial nerve from sciatic nerve as this bony landmark can be easily palpable and this bony prominence can be used to determine the level of origin of tibial nerve prior to surgery. The measurements were taken using a measuring tape in centimeters. The branches of the tibial nerve were carefully dissected and studied regarding the branching pattern. The tibial nerve was traced distally till its division into its terminal branches. Every effort was made not to split artifactually the medial from the lateral plantar nerves.

The point of division of tibial nerve was studied in relation to Malleolar- Calcaneal Axis (MCA) with respect to three levels- above MCA (level I), at MCA (level II), below MCA (level III). The MCA is a reference line extending from tip of medial malleolus to medial tubercle of calcaneus. These two landmarks were taken as, they are prominent, easy to palpate and they represent the inferior edge of flexor retinaculum. Each measurement was taken twice and the average value was computed as the final value so as to reduce the bias errors. Findings were observed, noted and tabulated. Photographs were taken for each specimen. The percentage was calculated for each variable. The range, mean and standard deviation was calculated for the readings obtained for the motor branching pattern of tibial nerve to the deep muscles of the posterior crural region.

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 range, mean and standard deviation was calculated for the readings obtained for motor branching pattern of Tibial nerve from Sciatic nerve in relation to apex of head of fibula. The result thus obtained has been illustrated in the form of tables, charts and photographs.

Graph 1: Branching pattern of tibial nervein the posterior crural region.

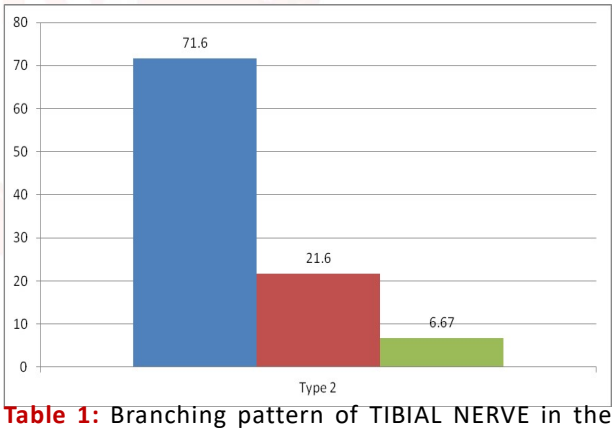


Table 1: Branching pattern of TIBIAL NERVE in the posterior crural region.

Title	Type 1	TYPE 2	Type 3
Number of Specimens	43	13	4
Percentage (%)	71.6	21.6	6.66

DISCUSSION

In the present study tibialis posterior muscle was innervated by a single branch in 98.33% (n= 59) specimens through its superficial surface. Presence of 2 branches was noted in 1.67% (n=1) specimen and it supplied the muscle through its superficial surface. Tibialis posterior is one of the muscles which is affected in spastic equinovarus deformity. An anatomical knowledge of the motor nerve branches to this muscle

will help to relieve temporary spasticity by injection of an anaesthetic locally to the motor branch and permanent relief is obtained by selective neurotomy of the motor branch. In conditions where the tibialis posterior muscle does not cause spasticity inadvertent neurotomy of the nerve branch supplying the muscle will lead to the formation of a valgus deformity instead of varus.

Selective block of the motor nerve branches by anaesthetic agents must be done prior to performing a permanent surgery. This will help to determine the role of the muscle in the formation of spasticity and deformity. So a thorough anatomical knowledge of the precise location of the motor nerve branches of the tibial nerve is important for the operating surgeons, orthopaedicians and anaesthetists doing this procedure[10]. As not many studies are aimed at determining the motor entry point of tibial nerve to tibialis posterior muscle this parameter was taken up in the present study. During fibular osteotomy the motor branch to tibialis posterior along with the branch to flexor hallucis longus is under primary risk to injury as the branch arises from the fibular side of the main nerve[7].

Hence a detailed knowledge of the exact location of the tibial nerve and its motor branches is necessary prior to performing such procedures. To provide an anatomical basis for the diagnosis and treatment of the tarsal tunnel syndrome the relationship of the tibial nerve to the tarsal tunnel must be understood[11].

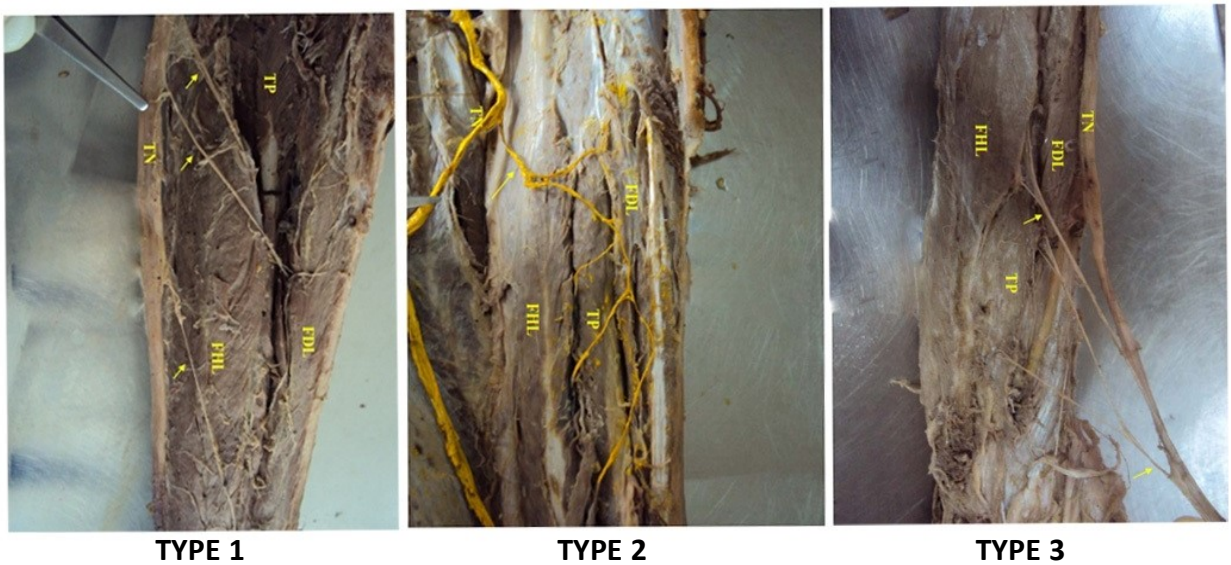
Tarsal tunnel syndrome can be caused by systemic causes and local cause. In diabetes mellitus the patients are predisposed to the development of tarsal tunnel syndrome due to water retention in the nerve resulting in increase in cross- sectional volume of the nerve[12,13]. In such cases a proximal level of termination of the nerve along with increased cross-sectional diameter of the nerve may complicate the condition resulting in diabetic foot.

Hence the knowledge regarding the level of division of the tibial nerve into its terminal branches is essential for the treatment of tarsal tunnel syndrome by decompression. 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[14,15].

There are some cases reported in literature where in the tibial nerve was mistakenly resected for the plantaris tendon for repair of a ruptured calcaneal tendon. Such inadvertent resection of the tibial nerve will lead to devastating surgical complications like loss of sensation of the sole of foot and neuropathic problems. In these circumstances reconstruction of the tibial nerve is also not possible as it has a poor prognosis[16].

Hence a thorough anatomical knowledge of the location of the tibial nerve in the posterior crural region is imperative to avoid such grave mishaps.

Fig. 1: Branching pattern of tibial nerve in posterior crural region.



TYPE 1 **TYPE 2** **TYPE 3**

CONCLUSION

Number of muscular branches given off in the posterior crural region to Flexor hallucis longus, Flexor digitorum longus and Tibialis posterior

Branching pattern of the tibial nerve to the deep muscles of the back of leg.

In the present study 3 particular branching patterns of the tibial nerve were determined similar to the pattern.

Among the 60 specimens dissected, Type I- seen in 71.6 %, n= 43, Type II- seen in 21.6 %, n= 13, Type III- seen in 6.66 %, n= 4.

As per the present study most common branching pattern was Type I and least common was Type II. Type III branching pattern though rare and present only in 6.66% of the specimens in the present study, should be kept in mind by the operating surgeons as damage to this single nerve can result in the paralysis of all the 3 muscles supplied by it. This variation is also important during selective tibial neurotomies. The study of the motor branching pattern of tibial nerve provides a detailed anatomical description of the peripheral course and distribution of the motor branches. This knowledge will 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.

Conflicts of Interests: None

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