



## *Cadaveric Study on the Anatomical Variations of the Sciatic Nerve*

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### ABSTRACT

*A cadaveric study on the anatomical variations of the sciatic nerve involves the examination and analysis of the sciatic nerve in human cadavers to understand the variations in its anatomical structure and distribution. The sciatic nerve is the longest and thickest nerve in the human body, arising from the lumbosacral plexus in the lower back and extending down through the buttocks and the back of the thigh, eventually branching out into the tibial and common fibular nerves.*

*Cadaveric studies are an essential part of medical research, especially in anatomy and surgical disciplines. These studies provide detailed insights into the human body's structures and variations that might not be adequately represented in textbooks or imaging studies. By examining cadavers, researchers can observe the sciatic nerve's different courses, branching patterns, and relationships to surrounding anatomical structures. The current work aims to study the anatomical variations in branching pattern and division of sciatic nerve, to know the variations of sciatic nerve by observing and dissecting the formalin fixed lower limbs and to document the different variations of the division of the sciatic nerve for any surgical and diagnostic inventions.*

**Keywords:** *Anatomical Variations; Sciatic Nerve; Cadaveric Study; Motor innervation; Sensory innervation.*

### **Introduction**

The sciatic nerve is the largest roots (L4-S3) arising from the lumbo sacral plexus. It carries two nerve components, namely: the tibial component (L4,L5,S1,S2,andS3) and the common peroneal component(L4,L5,S1,and S2).This nerve in normal anatomy ,enters the gluteal region from the pelvis through the greater sciatic foramen ,passing inferior to the piriformis muscle. It follows a descending path along the posterior thigh, up to the proximal region of the popliteal fossa, where it divides into its terminal branches: the tibial nerve and the common peroneal nerve. The tibial division innervates the hamstring muscle of the posterior thigh, the muscle of the posterior compartments of the leg, and the muscles of the sole of the foot. The common peroneal division innervates the short head of biceps femoris, and the

muscle of the lateral and anterior compartments of the leg and the dorsum of the foot [1].

The sciatic nerve is large and round at its origin in the buttock, the sciatic nerve is shaped like a flattened band that is about 5 mm high and 10 mm to 15 mm wide. As it continues down into the leg, the nerve forms into a more rounded shape.<sup>3</sup> At its thickest portion, the nerve measures about 2 cm in diameter,<sup>1</sup> about the same circumference of a US penny. The sciatic nerve is the longest nerve in the body. In the pelvis, the sciatic nerve and a few other surrounding nerves and blood vessels exit through an opening called the greater sciatic foramen (sciatic notch) [2]. This opening is located deep in the buttock, just below the piriformis muscle. The nerve then rests on the back portion of the ischium, the curved bone at the base of

the pelvis. It then courses down and runs below and along the side of the large gluteus maximus muscle in the buttock. The nerve descends by crossing behind a combination of muscles located deep in the hip joint. At the lower edge of the gluteus maximus muscle of the buttock, the nerve reaches the back portion of the upper thigh. The nerve lies deep within the thigh, covered by the large thigh muscle, called the biceps femoris [3]. The sciatic nerve is a terminal branch of the sacral plexus. It is formed from both anterior and posterior divisions of the anterior (ventral) rami of spinal nerves L4 through S3. The anterior branches of these five spinal nerves meet and converge in the posterior pelvic region to form a single large nerve. The sciatic nerve then descends posteriorly and leaves the pelvis through the greater sciatic foramen. It passes inferior to the piriformis muscle, accompanied by the posterior femoral cutaneous nerve, pudendal nerve, internal pudendal artery and vein, inferior gluteal nerve, inferior gluteal artery and vein [4]. The sciatic nerve then progresses downward between the interconnected muscles of the thigh. It is surrounded by a single long fatty sheath from the pelvis to the knee. At the knee, the nerve divides into two branches. At the popliteal fossa: The tibial nerve continues down the back of the calf to the heel and sole of the foot. The common peroneal nerve (common fibular nerve) travels sideways along the outer part of the knee to the outer border of the lower leg and foot. Both these nerves finally terminate into small sensory nerves in the calf that innervate the outer side of each foot. These sensory nerves are called the sural nerves. Smaller branches: Along its course, the sciatic nerve gives off smaller branches, called collaterals, which include the: Muscle branches of the sciatic nerve that supply the muscles in the thigh—including the hamstring group at the back of the thigh, and the adductor magnus muscles along the inner thigh. Other small branches supply the leg and foot muscles. Articular branches of the sciatic nerve that supply the back of the hip joint and the back and side of the knee joint. While the sciatic nerve does not supply any structure in the buttock, pain may be referred to this area when the sciatic nerve is impaired. The sciatic nerve then continues its course through the posterior thigh. It runs between the long head of the biceps femoris muscle and the adductor magnus muscle, and laterally to the semitendinosus and semimembranosus muscles [5].

On its course through the posterior thigh, the sciatic nerve gives off several small motor muscular branches that innervate the several muscles of the thigh. At the apex of the popliteal fossa, the sciatic nerve terminates

by dividing into two terminal branches: The tibial nerve, the common fibular (peroneal) nerve.

The tibial nerve continues the course of the sciatic nerve and descends down through the posterior aspect of the leg as far as the heel of the foot. More specifically, the tibial nerve passes through the center of the popliteal fossa and runs below the tendinous arch of the soleus muscle [6].

It continues its course in a neurovascular bundle through the posterior leg compartment and passes through the tarsal tunnel [5]. When it reaches the foot, the tibial nerve divides into two terminal branches: medial and lateral plantar nerves that innervate the majority of the foot muscles. In contrast to the tibial nerve, the common fibular (peroneal) nerve courses laterally towards the head of the fibula. When it reaches the anterior compartment of the leg, the nerve divides underneath the fibularis longus muscle into the superficial fibular (peroneal) nerve and deep fibular (peroneal) nerve. The superficial branch supplies the lateral compartment of the leg, while the deep branch supplies the anterior compartment of the leg and medial aspect of the foot [7].

### **Motor innervation**

The sciatic nerve provides a direct motor supply for the muscles of the posterior thigh via small muscular branches. These muscles include biceps femoris, semimembranosus, semitendinosus, and the ischial portion of the adductor magnus. The tibial nerve provides motor supply for the muscles in the posterior portion of the leg and foot. These muscles include the gastrocnemius, soleus, plantaris, popliteus, flexor hallucis longus, flexor digitorum longus, and tibialis posterior. The common peroneal nerve supplies the muscles of the anterior and lateral sections of the leg and foot. The muscles of the anterior aspect include: tibialis anterior, extensor hallucis longus, extensor digitorum longus, and peroneus tertius. The lateral leg muscles include peroneus longus and peroneus brevis [8].

### **Sensory innervation**

The sciatic nerve gives off sensory branches that provide sensory supply for the largest portion of the lower limb. First, on its course, the sciatic nerve innervates the skin of the posterior thigh. Then the sensory supply continues through its terminal branches; The tibial nerve innervates the sole of the foot. The branches of the common peroneal nerve innervate the lateral aspect of the leg and dorsum of the foot, as well as the skin between the first two toes. The tibial nerve and common peroneal nerve make up

the medial and lateral sural nerves. These nerves provide sensation to the calf and a small lateral portion of the foot [9].

Sciatica refers to pain that radiates along the path of the sciatic nerve, which branches from your lower back through your hips and buttocks and down each leg. Typically, sciatica affects only one side of your body. Sciatica most commonly occurs when a herniated disk, bone spur on the spine or narrowing of the spine (spinal stenosis) compresses part of the nerve. This causes inflammation, pain and often some numbness in the affected leg.

Sleeping or compression of the sciatic nerve against the femur or unusual stretching after sitting for a long time, may give rise to a "sleeping foot" [10].

### ***Histology of Sciatic Nerve***

Sciatic nerve is the largest peripheral nerve of the human body. It gives motor and sensory innervation for most of the lower limb. A nerve is a cord-like structure that contains a bundle of axons. These axons are often referred to as fibers. Each axon is surrounded by a layer of connective tissue called Endoneurium [9]. Each axon is bundled together to form Fasciculi which is also surrounded by the Epineurium. Finally all the structures are entirely covered with a connective tissue layer called Perineurium.

### ***Literature Review***

The variations of sciatic nerve at different levels were emphasized in many studies. Some of such studies have been reviewed here for this current study and briefly described below.

David Fahoda, David Viegl et al (2006), studied the variation in the division of the sciatic nerve. The authors studied 91 cadavers and found an atypical relationship in 19 cases. In this study individual variation were found with the following frequency (1) The sciatic nerve exists below the piriformis muscle in 79.1% of cases (2) The sciatic nerve separates into two divisions above the piriformis, one branch passing through the muscle the other below it(14.3%).(3) An unsplit nerve passes through the piriformis muscle 2.2%. The nerve separates into 2 divisions within PM and one branch exiting above the muscle and passing along its dorsal aspect the second exiting distally below the muscle in 4.4%.

Ewa Okrazewka (2002) conducted a statistical scan of the sciatic nerve variations in the Polish population. In this study he had found some variations (a)the sciatic nerve passes under piriformis muscle as one nervous trunk, however the trunk do not gather and play the role of terminal branches of the nerves .(c) another

variation they found that the sciatic nerve divided into 2 components within the popliteal fossa.

Krzysztof A.tomaszewski(2016) conducted a study on the surgical anatomy of SN. They analysed 768 lower limbs.85.2% shows normal course of SN ,in the remaining specimens the SN bifurcated in the pelvis and the CPN piercing the piriformis muscle and the TN coursing below the piriformis.

Maria alaxandra thiago furtado(2013) found that the high division of the SN in the gluteal region. They found the SN divided bilaterally in its terminal branches, the TN and CPN in the interior portion of the gluteal region. Inside the pelvis the CPN and TN just before crossing the greater sciatic notch. In 15 another specimen the SN divided on both sides in its terminal branches. Another variation is the CPN exit through the pelvis above the piriformis and TN below the piriformis.

Prakash, A.K Devi et al (2010) found that SN divides into CPN and TN prior to its exit in the gluteal region. In it 2.3% specimen shows division of SN in the gluteal region 3.3% of the specimen that SN divided at the upper part of the posterior compartment of thigh. In their study they also found (37.3%) cases divided into CPN and TN within the popliteal fossa.

M.A Babursk, F.A Machadoln(2003),found another variation which the CPN was observed under the inferior margin of the superior gemellus muscle and over obturator internus instead of its normal portion on the superior margin of the gemellus

Trefon Totlis George A.et al(2013),examined 294 limbs to study the variations in the division of sciatic nerve. They found that the sciatic nerve and piriformis muscle relationship followed the typical un formal pattern in 275 limbs (93.6%). In 12 limbs(4.1%) the common peroneal nerve passed through and the tibial nerve below a double piriformis. In one limb(3%). The common peroneal nerve passed through and the tibial nerve passed above the piriformis in the limbs(1.4%).

Sailesh patel (2013) found three types of sciatic nerve when it comes out of the lesser pelvis to the gluteal region and in relation with piriformis muscle. Type 1- sciatic nerve as a single trunk comes out below the piriformis. Type 2 - The sciatic nerve is already divided in the pelvis and its two divisions come out below the piriformis. Type 3- The sciatic nerve is already in the pelvis and its two divisions come out differently from the pelvis,one (CPN) comes out after piercing the piriformis and the other (TN) comes out below the piriformis.

Birhane alem berihesyared godeta (2015) found that the CPN and TN arise and separate below the piriformis and region posterior to quadratus femoris 16 muscle and bifurcate at the superior angle of popliteal

fossa. Another variation is the CPN emerges above the piriformis and TN emerges below the piriformis and descends separately along their courses. Another variation is that the SN trifurcates into CPN, TN and an unusual trunk divides into the lateral cutaneous nerve of the calf and peroneal communicating nerve.

Samara Lewis, Fade Furak (2011) had studied the anatomical variation of the SN in relation to piriformis muscle. In this study they found that out of 102 lower limb (89%) specimens exhibit the normal pattern of the SN course, the rest of the specimen shows variation that is CPN passing through the piriformis muscle and TN passes below the piriformis muscle. They also found another variation that is the CPN passes over the piriformis muscle and TN passes below the muscle.

Graham Drpont, Hotence unno (2018) conducted a study on the variation of the SN and its clinical implications. They found that the right and left gluteal region and upper posterior thigh of an adult male cadaver (74yrs and dead), the SN was found to have an unusual configuration. Specifically the nerve exit the pelvis as a united SN but just inferior to the piriformis it fully split into TN and CPN, and it passes downwards as separate nerve.

Muslafa Gervencer et al (2008) conducted a study on the topic of variations in the high division of sciatic nerve and relationship between the sciatic nerve and the piriformis muscle. In this study they found that in 52% of cases the sciatic nerve exited the pelvis as whole nerve without any division whereas in 48% a high division was observed. Branches of sciatic nerves left the pelvis below the PM as separate nerves. In 24% one branch of the SN left the pelvis through the piriformis and other branch passes above the piriformis muscle.

H.A.M. Salch M.M.O El fark, et al (2009), studied the level of divisions of the sciatic nerve in the popliteal fossa and its relationship to the common epineural sheath of the sciatic nerve. The level of division of sciatic nerve 17 sheath into tibial nerve and common peroneal nerve above the knee was measured in 30 cadaver's specimens. The SN was invariably formed of independent trunk (FN, CPN). The SN division at a distance range of 50- 180 mm above the popliteal fossa crease. The present findings suggest the tibial and common peroneal nerve leaves the common sciatic nerve sheath at variable distances from the popliteal crease these findings and the relationship of the tibial and peroneal nerve sheath may have significant implications for popliteal nerve block.

Amelic M Lutz et al (2017) studied SN variation based on the scanning report of 755 cases. Conventional anatomy (type I) in which an undivided sciatic nerve passes below the piriformis muscle was identified in

87% of cases the remaining 13% of cases demonstrated a type II pattern in which one division of the sciatic nerve passes below. Only two other instances of variant anatomy were identified (both type III). Most variant cases were associated with a split sciatic nerve at the level of the ischial tuberosity (65.8%). By contrast only 6% of cases demonstrated a split sciatic nerve at this level in the context of otherwise conventional anatomy.

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Saritha S., Praveen Kumar et al (2012) conducted a study on the anatomical variation in bifurcation of the sciatic nerve. The present study showed that 85-89% of the specimen showed normal pattern but in 10-11% the sciatic nerve divided in the pelvis into a component and one (TN) passes through the piriformis muscle and another case (CPN) passes above the piriformis.

International journal of anatomy and research (2017) published a study on sciatic nerve and its variations in this study they found that 41 gluteal regions and posterior compartment of thigh (82%) showed normal anatomy of SN and also piriformis muscle but in 18% shows variations in the sciatic nerve of which 10% the sciatic nerve passes through the piriformis muscle and in the rest of the specimen the 2 component of the SN, the TN passes above the piriformis muscle and CPN passes below the piriformis muscle.

Konstantinos Natsis et al (2013), found that in the pelvis the SN division and the CPN passed between the two heads of a double PM while the TN passed below the PM they also found another variation is that the SN divides into 2 components in which the CPN passes superior to the PM and it just with TN which passes below the piriformis muscle after it until it passes downward and again divided into CPN and TN above the popliteal fossa.

Journal of clinical diagnostic research (JCDR) published a study on the variant anatomy of the sciatic nerve. In their study they were examined 50 gluteal regions. Among them 46 specimens the SN had a normal course after it exit below the piriformis and

divided into TN and CPN above the popliteal fossae. While in 4 specimens thus was high division of sciatic nerve within the pelvis the TN passed below the piriformis and CPN passed above the piriformis to enter into the gluteal region. Both the nerve had in depended on course in upper one third of the thigh later both components fused in the middle one third of the back of thigh and subsequently re-split normally at the superior angle of the popliteal fossa. Another important variation also found that is the SN trifurcates in the back of thigh as TN CPN and additional muscular branch to soleus.

A.D. Shewaler R Karambellar (2013) had studies on the variation in course and termination of SN. The sciatic nerve exhibits normal course in 73.3%. 19 In 2 specimens (2.22) both the nerve was separated, and the tibial nerve was in separate rootlet form. In 10 specimen (11.11%) the component were in the intrapiriform compartment but separately emerging while in 10 specimens (11.11%) the component were separate, but the common perineal nerve was piercing the piriformis muscle. Only in 2 specimens (2.23%) the CPN was passing above the piriformis and TN below the Muscle.

**Materials and Methods**

Here the study was focused on the variations in the branching pattern of sciatic nerve in their course. For this a study was performed in 25 disarticulated lower limbs of unknown age and sex. The study was conducted by placing the disarticulated and dissected lower limb on the dissection table and observing for the variations. To complete the accuracy of the study, the observed variations were counterchecked with anatomy atlas, research guide and my previous knowledge.

**Sample**

The present study was carried in out on 25 disarticulated lower limbs allotted for the medical students at School of Medical Education, Centre for Professional and Advanced Studies, Gandhinagar, Kottayam, Travancore Medical College, Kollam

**Sample Technique**

In this study the sample technique was random.

**Sample Size**

The size of the present study was 25 disarticulated dissected lower limbs.

**Ethical Aspect**

Written permission from the college authority and a formal permission was obtained from various institutions for the present study.

**Observation**

In the present study of twenty-five formalin fixed lower limbs, 12 left leg and 13 right legs are observed sciatic nerve variations are observed in the type of branching and variations in relation to piriformis muscle.

**Variations**

About fourteen specimens the sciatic nerve had a normal course after its exit below the piriformis and divided into tibial and common peroneal nerve at the superior angle of popliteal fossa.

In four specimens there was high division of the sciatic nerve within the pelvis.

In three specimen’s trifurcation of sciatic nerve was observed with an additional branch (sural nerve). In one lower limb sciatic nerve divided into common peroneal and tibial nerves in the popliteal fossa, in this case the tibial nerve is very thin.

In one lower limb sciatic nerve divides into two from the origin as tibial and common peroneal nerves. Common peroneal nerve pierces the piriformis and tibial nerve runs under the piriformis.

In two lower limb, the sciatic nerve divides into two in the upper part of the thigh then it fuses in the middle and again splits into two in the upper part of the popliteal fossa (Table 1).

**Result**

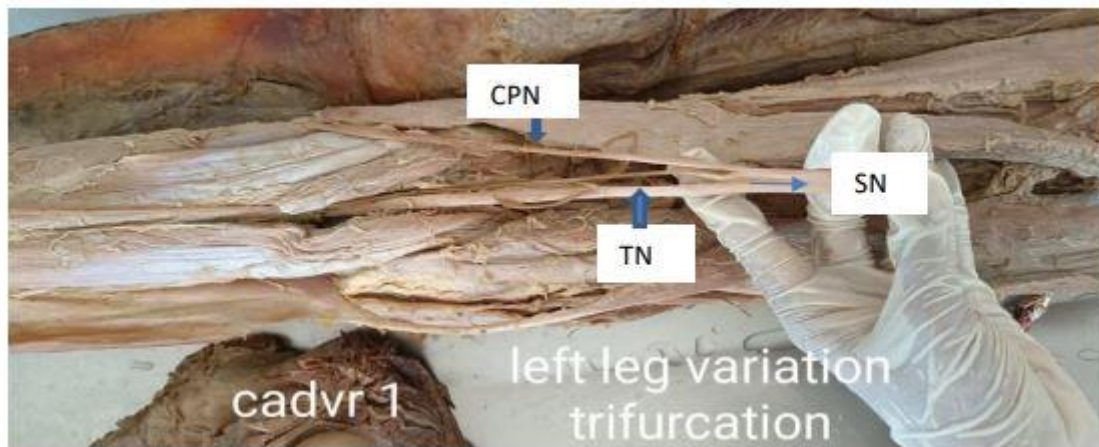
Variation of the division of sciatic nerve.

Total no.of lower limb specimen :25

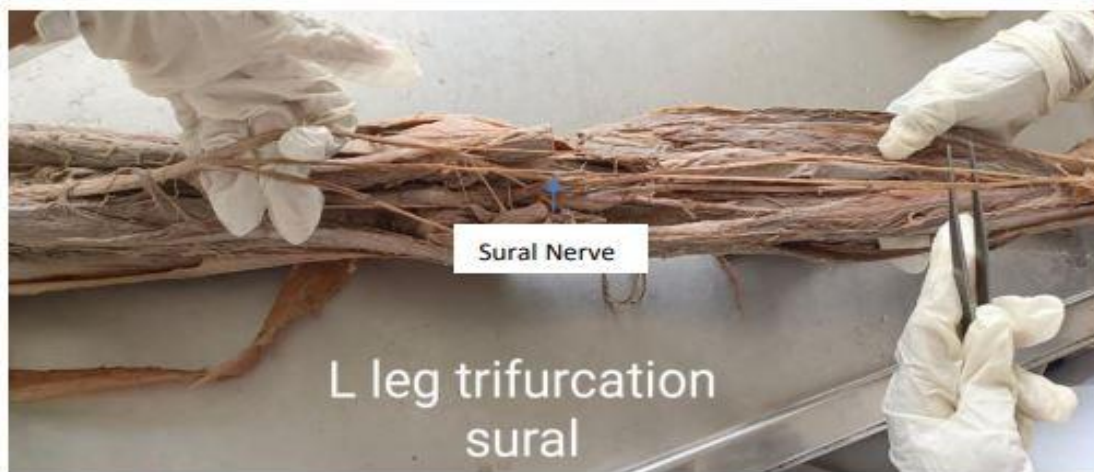
Total no.of normal specimen. :14

**Table 1:** Percentage of different types of branching of sciatic nerve.

Type of branching of sciatic nerve	Number of specimens showing branching pattern	Percentage
High division of SN	4	16
Trifurcation of SN	3	12
Bifurcation of SN	4	16



**Figure 1:** Left lower limb showing trifurcation in the upper part of popliteal fossa.



**Figure 2:** Left lower limb showing trifurcation as TN, CPN and Sural nerve.

### Discussion

Sciatic nerve is the largest branch of lumbosacral plexus. Sciatic nerve is formed by the close downward movement of large dorsal and ventral components during development and hence the common peroneal and tibial component can separate from each other at various levels from their origin. In the present study of 25 formalin fixed lower limb were examined for the variation in the course and division of the sciatic nerve (Figures 1-4). The classification of sciatic nerve division as follows:

- Type 1 : Undivided nerve below undivided muscle
- Type 2 : Division of nerve between and below undivided muscle.
- Type 3 :Division above and below the muscle.
- Type 4 : Undivided nerve between muscle.
- Type 5 : Division between and above the heads.

In the present study we have encountered type1 and type3. In one case common peroneal nerve passed through the piriformis while tibial nerve passed beneath the muscle. In the present study 2 left lower limb show high division of sciatic nerve. High division of sciatic nerve has been reported earlier with an incidence of 47%. The probable basis for the pelvic division is the separate existence of nerve during embryonic development. Various studies have been reported about high division of sciatic nerve in the gluteal region. Shewale et al, has reported 11% of sciatic nerve division in the gluteal region [11]. Prakash et al, has also reported 16.3% sciatic nerve division in the gluteal region [12]. Guvencer et al, has also reported sciatic nerve in the gluteal region in 46% [13].



**Figure 3:** Bifurcation showing thin tibial nerve.



**Figure 4:** Right leg showing high division of sciatic nerve.

In the present study in one leg sciatic nerve divide into two from the origin as tibial and common peroneal nerves. Common peroneal nerve pierces the piriformis muscle and tibial nerve run under the piriformis. Moore et al, has been reported that common peroneal nerve passing through the piriformis in 34% of cases [14]. Previous anatomical studies have demonstrated 15% variation in relationship between the piriformis and sciatic nerve.

Trifurcation of sciatic nerve is observed in three legs, in the present study. Trifurcation of sciatic nerve is rarely cited in the literatures. In the present study, trifurcation of sciatic nerve into tibial, sural, and common peroneal at the superior angle of popliteal fossa. Such cases of trifurcation have been earlier reported with different branches by Sawant and Nayak [15,16].

In the present study two lower limb sciatic nerve divide into two in the upper part of thigh, then it fuses in the middle and again divide into two in the upper part of popliteal fossa. Here there is a trifurcation of common peroneal nerve, tibial and sural nerve arises.

sural nerve has two components, one from tibial and one from sciatic nerve directly.

In this study, in one formalin fixed lower limb sciatic nerve divided into two from the origin as tibial nerve and common peroneal. Common peroneal nerve pierces the piriformis and tibial nerve run under the piriformis muscle. This variation has also been described as type 2 according to Beaton's and Anson's classification [17].

Variations such as high division and trifurcation of nerve can lead to nerve injury during deep intramuscular injection, failure of sciatic nerve block anaesthesia during various surgical procedure piriformis syndrome / inadvertent damage to sciatic nerve during varicose vein stripping. Variations in the course of sciatic nerve may complicate surgery and in the interpretation of sciatic neuropathy.

### **Conclusion**

The variant anatomy of sciatic nerve may cause piriformis syndrome and failure of sciatic nerve block. Hence present study is undertaken to know the level of division, exit, course, relationship to piriformis and

variations in the branching pattern of sciatic nerve. In this study,

- High division of sciatic nerve is observed in 16% lower limbs.
- Trifurcation of the sciatic nerve is observed in 12% lower limbs.
- Bifurcation of the sciatic nerve is observed in 16% lower limbs.

This study documents trifurcation of sciatic nerve in 3 lower limbs, it is rarely cited in the literature. The knowledge regarding the level of division & distribution of sciatic nerve & its location is of clinical importance. The long course of sciatic nerve makes it vulnerable to injury as it is commonly involved in regular medical practices such as anaesthesia, rehabilitation, orthopaedics and neurology.

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No funding was received for this study.

### **Conflict of Interest**

The authors declare that he has no conflict of interest.

### **Ethical approval**

The study was approved by the S.M.S Medical College, Jaipur, India

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