

# Cadaveric Study on Variations in the Level of Bifurcation of Sciatic Nerve and its Clinical Implications

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## ABSTRACT

**Introduction:** Sciatic nerve is the thickest nerve of the human body arising from the sacral plexus. It bifurcates into tibial nerve and common fibular nerve at any level from the pelvis to the popliteal fossa. Variations in the level of bifurcation of sciatic nerve is having correlation with many clinical conditions like piriformis syndrome, sciatica, sleeping foot, foot drop, etc.

**Aim:** To observe the variations in the level of bifurcation of sciatic nerve into tibial nerve and common fibular nerve, to correlate the variations with their clinical implications and to discuss the findings of the present study with the available literature regarding the same.

**Materials and Methods:** A total of 102 lower extremities from 51 formalin fixed cadaver were used in the present study. All these 102 lower extremities were divided into six groups (Group A to F), according to the level of bifurcation of sciatic nerve into tibial nerve and common fibular nerve; in the pelvis (Group A), in the gluteal region (Group B), in the upper (Group C), middle (Group D) and lower (Group E) part of posterior compartment of thigh,

in the popliteal fossa (Group F). Numbers and percentages of the lower extremities falling in particular group were calculated and table was formed accordingly.

**Results:** In the present study, we found 24 (23.53%) lower extremities in Group A, 4 (3.92%) in Group B, 2 (1.96%) in Group C, 3(2.95%) in Group D, 48(47.06%) in Group E and 21(20.59%) in Group F. The lower part of posterior compartment of thigh was the most common (47.06%), within the pelvis prior to exit into the gluteal region is the second most common (23.53%) and the upper part of posterior compartment of thigh was the least common (1.96%) level of bifurcation of sciatic nerve into tibial nerve and common fibular nerve in the present study.

**Conclusion:** Variations in the level of bifurcation of sciatic nerve into tibial nerve and common fibular nerve is not so rare. The knowledge of variations in the level of bifurcations of sciatic nerve will help in early diagnosis and treatment of sciatic nerve entrapment or neuropathies and simultaneously reducing the associated morbidities.

**Keywords:** Common fibular nerve, Pelvis, Piriformis, Popliteal fossa, Tibial nerve

## INTRODUCTION

The sciatic nerve is 2 cm wide at its origin and is the thickest nerve in the body. Sciatic nerve leaves the pelvis enters into the gluteal region via the greater sciatic foramen below piriformis. Afterwards, it passes between the greater trochanter and ischial tuberosity and descends into the posterior compartment of thigh and divides into the tibial nerve and common fibular nerve at a varying level proximal to the knee [1]. The tibial nerve is medial and consists of ventral divisions of anterior primary rami of L4,L5,S1,S2,S3, while common fibular nerve is lateral and consists of dorsal divisions of anterior primary rami of L4,L5,S1,S2. The sciatic nerve supplies the muscles of back of thigh, muscles of leg and foot and mostly whole of the skin of leg. It divides mostly at the apex of the popliteal fossa in the lower part of the posterior compartment of thigh. Various authors and researchers have found the variations in the level of bifurcation of sciatic nerve into tibial nerve and common fibular nerve from the sacral plexus to the popliteal fossa [2-4]. Unilateral or bilateral congenital higher divisions of sciatic nerve may lead to compression of sciatic nerve resulting in various clinical conditions during the lifespan of a person like sciatica, piriformis syndrome, sleeping foot, failure/sparing of sciatic nerve block in lower limb surgeries etc. Sciatica is the pain caused by a compression or irritation of the sciatic nerve. Symptoms of sciatica include pain, numbness, tingling and weakness. Piriformis syndrome is one of the causes of sciatica which occur secondary to compression of sciatic nerve due to abnormal form and position of the piriformis muscle [5-8].

Many researchers studied the complex relations between the piriformis and the sciatic nerve or its branches [6,8-12]. But the studies showing the variations in the level of bifurcation of sciatic

nerve from the pelvis to the popliteal fossa with their clinical correlation are relatively less [13,14]. The present study was done to observe the variations in the level of bifurcation of sciatic nerve into tibial nerve and common fibular nerve and to correlate the variations with their clinical implications.

## MATERIALS AND METHODS

The present cross-sectional study was carried out on 102 lower extremities from 51 formalin fixed cadavers of different medical colleges of Gujarat (Banas Medical College and Research Institute, Palanpur; Gujarat Adani Institute of Medical Sciences, Bhuj; GMERS Medical College, Dharpur, Patan, Gujarat). Prior approvals of institutional ethics committee of these institutions were taken for the study. The study was done during the routine dissection sessions for the 1<sup>st</sup> year MBBS students over the period of three years from March 2016 to March 2019. Layer wise dissection of gluteal region was done, during which skin, superficial fascia and deep fascia were reflected and gluteus maximus was exposed. Afterwards gluteus maximus was reflected from its origin to expose the structures covered by it. Area nearby the piriformis muscle and sciatic nerve were cleared. Further, the posterior compartment of thigh as well as popliteal fossa were also dissected and cleared to find out the variations in the level of bifurcation of sciatic nerve [15]. The levels of bifurcation of sciatic nerve into tibial nerve and common fibular nerve in all 102 lower extremities were photographed and documented. The findings were analysed statistically by using Microsoft Office Excel 2016.

We divided 102 lower extremities into total six groups (A to F) according to the level of bifurcation of sciatic nerve into tibial nerve and common fibular nerve as mentioned below [13]:

**Group A:** Sciatic nerve bifurcates into tibial nerve and common fibular nerve prior to its exit in the gluteal region i.e. sciatic nerve bifurcates into tibial nerve and common fibular nerve in the pelvic region only

**Group B:** Sciatic nerve bifurcates into tibial nerve and common fibular nerve in the gluteal region.

**Group C:** Sciatic nerve bifurcates into tibial nerve and common fibular nerve in upper part of the posterior compartment of thigh.

**Group D:** Sciatic nerve bifurcates into tibial nerve and common fibular nerve in middle part of the posterior compartment of thigh.

**Group E:** Sciatic nerve bifurcates into tibial nerve and common fibular nerve in lower part of the posterior compartment of thigh.

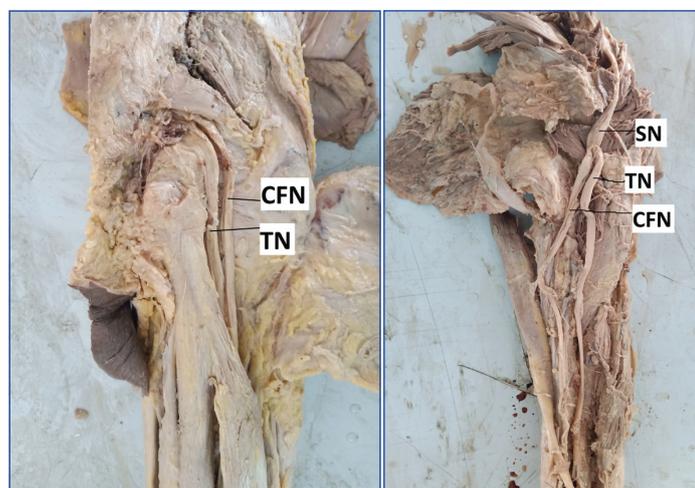
**Group F:** Sciatic nerve bifurcates into tibial nerve and common fibular nerve in the popliteal fossa.

## RESULTS

As shown in [Table/Fig-1], 24 lower extremities out of total 102 lower extremities taken in the present study (23.53%) falls in Group A. In these 24 lower extremities falling in Group A, the sciatic nerve bifurcates into tibial nerve and common fibular nerve within pelvis prior to its exit in the gluteal region [Table/Fig-2]. Four lower extremities out of total 102 lower extremities taken in the present study (3.92%) falls in Group B. In these four lower extremities, the sciatic nerve bifurcates in the gluteal region [Table/Fig-3]. Two lower extremities out of total 102 lower extremities taken in the present study (1.96%) falls in Group C where, the sciatic nerve bifurcates in the upper part of the posterior compartment of thigh [Table/Fig-4]. Three (2.95%) of total falls in Group D the sciatic nerve bifurcates in the middle part of the posterior compartment of thigh [Table/Fig-5]. Forty eight lower extremities out of total 102 lower extremities taken in the present study (47.06%) falls in Group E where, the sciatic nerve bifurcates

Serial No	Group according to the level of bifurcation of sciatic nerve	Number of lower extremities falling in particular group	Percentage (%)
1	Group A	24	23.53
2	Group B	4	3.92
3	Group C	2	1.96
4	Group D	3	2.95
5	Group E	48	47.06
6	Group F	21	20.59
TOTAL		102	

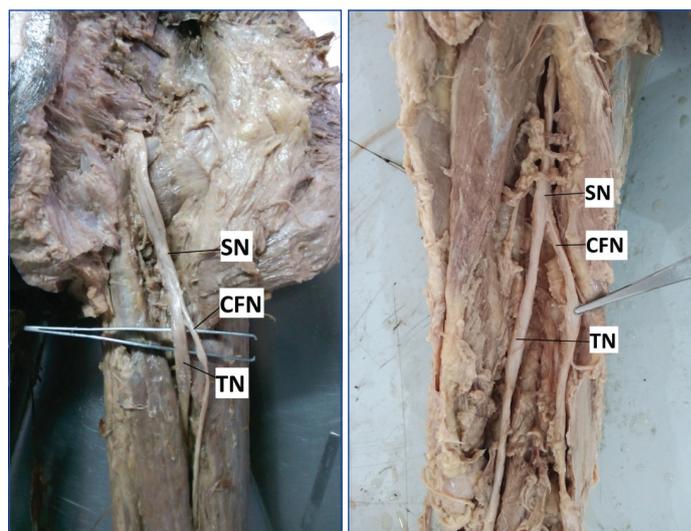
[Table/Fig-1]: Showing the various groups (A to F) of lower extremities according to the level of bifurcation of sciatic nerve, number of extremities falling in the particular group and percentages of the same.



[Table/Fig-2]: Showing the two branches of sciatic nerve; Tibial Nerve (TN) and Common Fibular Nerve (CFN). Sciatic nerve bifurcated into tibial nerve and common fibular nerve within pelvis prior to its exit in the gluteal region.

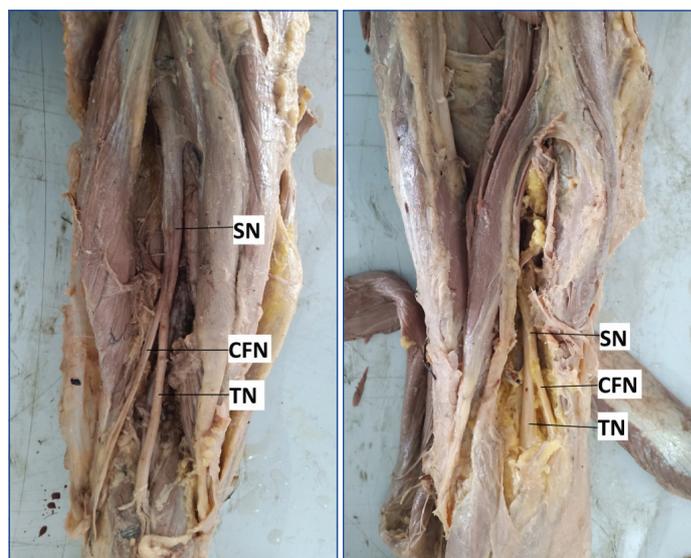
[Table/Fig-3]: Showing the Sciatic Nerve (SN) bifurcates into Tibial Nerve (TN) and Common Fibular Nerve (CFN) in the gluteal region.

in the lower part of the posterior compartment of thigh [Table/Fig-6]. Twenty one lower extremities out of total 102 lower extremities taken in the present study (20.59%) falls in Group F in which the sciatic nerve bifurcates in the popliteal fossa [Table/Fig-7].



[Table/Fig-4]: Showing the Sciatic Nerve (SN) bifurcates into Tibial Nerve (TN) and Common Fibular Nerve (CFN) in upper part of the posterior compartment of thigh.

[Table/Fig-5]: Showing the Sciatic Nerve (SN) bifurcates into Tibial Nerve (TN) and Common Fibular Nerve (CFN) in middle part of the posterior compartment of thigh.



[Table/Fig-6]: Showing the Sciatic Nerve (SN) bifurcates into Tibial Nerve (TN) and Common Fibular Nerve (CFN) in lower part of the posterior compartment of thigh.

[Table/Fig-7]: Showing the Sciatic Nerve (SN) bifurcates into Tibial Nerve (TN) and Common Fibular Nerve (CFN) in the popliteal fossa.

The lower part of posterior compartment of thigh was the most common (47.06%) level of bifurcation of sciatic nerve into tibial nerve and common fibular nerve in the present study. Within pelvis prior to its exit in the gluteal region is the 2<sup>nd</sup> most common (23.53%) level of bifurcation of sciatic nerve into tibial nerve and common fibular nerve in the present study. The upper part of posterior compartment of thigh is the least common (1.96%) level of bifurcation of sciatic nerve into tibial nerve and common fibular nerve in the present study.

## DISCUSSION

As shown in [Table/Fig-8], Prakash et al., studied the variations in the level of bifurcation of sciatic nerve in 86 lower extremities from 43 properly embalmed and formalin fixed cadavers [13]. They found 16.3% lower extremities in Group A, 2.3% in Group B, 3.5% in Group C, 2.3% in Group D, 40.7% in Group E and 34.9% in Group F. In their study (40.7%) as well as in the present study (47.06%), the most common level of bifurcation of sciatic nerve is in the lower part of posterior compartment of thigh. Second most common level of bifurcation of sciatic nerve in their study is in the popliteal

fossa (34.9%), while in the present study 2<sup>nd</sup> most common level of bifurcation of sciatic nerve (23.53%) is in the pelvic region prior to its exit in the gluteal. Least common level of bifurcation of sciatic nerve in their study is in the gluteal region as well as in the middle part of posterior compartment of thigh (2.3% in each), while in the present study least common level of bifurcation of sciatic nerve (1.96%) is in the upper part of posterior compartment of thigh. Sawant SP has also classified the lower extremities into Group A to F according to the level of bifurcation of sciatic nerve [14]. In his study also, the most common level of bifurcation of sciatic nerve is in the lower part of posterior compartment of thigh. Incidences of intrapelvic bifurcations of sciatic nerve in these three studies (as shown in [Table/Fig-8]) vary from 16% to 24%. In these cases of higher divisions of sciatic nerve, the chances of failure of popliteal block anaesthesia is there. Due to long course, more thickness and variable level of bifurcation of sciatic nerve, it can be involved in entrapment neuropathies. Further, the highly variable relations of sciatic nerve and piriformis muscle will increase the chances of occurrence of piriformis syndrome [6,8-10].

Sr No	Groups (A to F)	Prakash et al., [13] (2010)	Sawant SP [14] (2013)	Present study (2019)
1	Group A	16.3 %	22 %	23.53 %
2	Group B	2.3 %	2 %	3.92 %
3	Group C	3.5 %	3 %	1.96 %
4	Group D	2.3 %	12 %	2.95 %
5	Group E	40.7 %	53 %	47.06 %
6	Group F	34.9 %	8 %	20.59 %

**[Table/Fig-8]:** Comparison of findings of present study (Group A to F) with the findings of other researchers [13,14].

As shown in [Table/Fig-9], Beaton LE et al., studied the variations in the level of bifurcation of sciatic nerve as well as variable relations of sciatic nerve exit with the piriformis muscle [9]. They found 15%

Sr No	Name of the researcher	Number of lower extremities involved in the study	Level of division of sciatic nerve (in percentage)	
			Before exiting pelvis	After exiting pelvis
1	Beaton LE et al., [9]	120	15	85
2	Beaton LE [10]	240	9.2	90.8
3	Gabrielli C et al., [11]	80	13.7	86.3
4	Ugrenovic S et al., [12]	200	4	96
5	Pokorný D et al., [16]	182	20.9	79.1
6	Guvencer M et al., [17]	50	48	52
7	Prakash et al., [13]	86	16.3	83.7
8	Ogeng'o JA et al., [18]	164	20.1	79.9
9	Patel S et al., [19]	86	8.2	91.8
10	Sawant SP [14]	100	22	78
11	Adibatti M et al., [20]	50	8	92
12	Dhivya S et al., [21]	64	1.56	98.44
13	Patel Z et al., [22]	60	1.7	98.3
14	Present study (2019)	102	23.53	76.47

**[Table/Fig-9]:** Comparison of findings of present study with the findings of other researchers [9-14,16-22].

cases of higher (intrapelvic) divisions of sciatic nerve. Further, Beaton LE [10] (1938) found 9.2%, Gabrielli C et al., [11] (1997) found 13.7%, Ugrenovic S et al., found 4%, Prakash et al., found 16.3%, Sawant SP found 22%, Pokorný D et al., found 20.9%, Guvencer M et al., found 48%, Ogeng'o JA et al., found 20.1%, Patel S et al., found 8.2%, Adibatti M et al., found 8%, Dhivya S et al., found 1.56%, Patel Z et al., found 1.7 % and in the present study (2019) we found 23.53% cases of intrapelvic divisions of sciatic nerve [11-14,16-22]. Divisions of sciatic nerve in the pelvis, in the gluteal region or in the upper part of the posterior compartment of thigh may result in involvement of only one of the two divisions during popliteal fossa injury. This can also explain the reduced severity of presentation of the sciatic neuropathy.

Acute sciatic neuropathies develop as a result of injury during hip arthroplasty, posterior hip dislocation, posterior hip fracture, misplaced therapeutic injections in the gluteus maximus etc., [23]. Sciatic nerve palsy occurs after total hip replacement surgery in about 1% of cases. Chronic sciatic neuropathies due to prolonged external compression over the hard surfaces in cases of bedridden patients are less common. Sleeping foot can occur due to compression of the sciatic nerve in persons with bad sitting position over the edge of the table or chair. Person will feel the numbness, pain, difficulty in walking. The severity of symptoms occurs according to the involvement of sciatic nerve or tibial nerve or common fibular nerve. In higher divisions of sciatic nerve, chances of involvement of only one branch are there. Bergman RA et al., found that the height of a person and the level of the divisions of sciatic nerve are not related with each other [24].

According to Vloka JD et al., sciatic nerve is bifurcating into its terminal branches at a mean distance ranging from 0-115 mm above the popliteal fossa [25]. An ideal site of the popliteal block is by insertion of the needle at 100 mm above the popliteal crease i.e., proximal to the bifurcation of sciatic nerve. Saleh HA et al., concluded in their study that the sciatic nerve bifurcates at a variable level about 50-180 mm above the knee and this may account for frequent failures with popliteal blocks [26]. Early recognition of variations in the level of bifurcation of sciatic nerve makes surgical procedures more accurate and effective. Nerve grafting and other surgical procedures done in the popliteal fossa will require the precise knowledge of level of bifurcation of sciatic nerve. Further various structures in the intimate relations to the tibial nerve and common fibular nerve, manipulated in many surgical procedures, may be different with the variations in the level of bifurcation of sciatic nerve.

Babinski MA et al., found the intrapelvic division of sciatic nerve in which common fibular nerve passed superior and tibial nerve passed inferior to the superior gemellus muscle [27]. This type of variation may lead to sciatica, piriformis syndrome, coccygodynia, muscle atrophy. Other causes of sciatica like prolapsed inter vertebral disc, posterior dislocation of hip joint, pressure from uterus during pregnancy should be carefully excluded while dealing with these cases.

According to Stuart L et al., common fibular nerve is more prone to mechanical injury than the tibial nerve because the common fibular nerve has larger and more tightly packed funiculi with less protective connective tissue and because of its more lateral position and tethering in sciatic notch and the head of fibula [28]. If the division of sciatic nerve is higher, the chances of mechanical injury to common fibular nerve will be more.

Brooks JBB et al., Saritha S et al., Sabnis AS, Shewale AD et al., Kathe DP et al., Khan AA et al., Berihu BA et al., found higher bifurcations of sciatic nerve in their study [29-35]. Khan K et al., Raj RP et al., Khan B et al., Banoo S et al., Goshi RC, Amrutha KV et al., Stoyanov J et al., and Huq E et al., also found a case of higher division of sciatic nerve in each of their study [36-43]. In the present study also, we found the higher divisions of sciatic nerve within the pelvis in 23.53% of lower extremities and within the gluteal region in 3.92% of lower extremities.

## LIMITATION

Age and gender wise distribution of the cadavers was not done in the present study.

## CONCLUSION

In the present study, we observed the variations in the level of bifurcation of sciatic nerve. Lower part of the posterior compartment of thigh is the most common (47.06%) and within the pelvis prior to its exit in the gluteal region is the 2<sup>nd</sup> most common (23.53%) level of bifurcation of sciatic nerve in the present study. In the sciatic nerve entrapment or neuropathies, the severity of symptoms may depend on the level of involvement of sciatic nerve; whether whole sciatic nerve is involved or its tibial branch is involved or its common fibular branch is involved. In higher bifurcation of sciatic nerve, the chances of involvement of only one out of the two branches of sciatic nerve are more. Diagnosis and treatment will vary with the compression of one of the branch of sciatic nerve (tibial/common fibular) versus the compression of whole sciatic nerve. In these cases, chances of failure/sparing of sciatic nerve block are also there. Further, the knowledge of variations in the level of bifurcations of sciatic nerve will help in diagnostic and therapeutic medical practices of orthopedics, anaesthesia, radiology, neurology, physiotherapy, etc.

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Date of Submission: **Mar 18, 2019**

Date of Peer Review: **Mar 22, 2019**

Date of Acceptance: **Mar 28, 2019**

Date of Publishing: **Apr 01, 2019**

FINANCIAL OR OTHER COMPETING INTERESTS: None.