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### Original article

# ANATOMICAL STUDY OF SCIATIC NERVE AND ITS VARIATIONS – A CADAVERIC STUDY IN NORTH KARNATAKA REGION

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### ABSTRACT

**Aims :** In many conditions like trauma, inflammation, intramuscular injections and entrapment sciatic nerve is involved. Considering these it is essential to know the course and variations of sciatic nerve. **Methods:** Dissection was done on 21 formalin embalmed cadavers. According to Cunningham's manual dissection was done and piriformis and sciatic nerve were exposed. **Results :** Sciatic nerve existed the pelvis through the greater sciatic foramen below piriformis as a single nerve without division in 33 specimens out of 42 gluteal regions. Most common site of division of sciatic nerve is at popliteal fossa in both sexes. **Conclusion :** The main essence of this study is to get information on variations of the sciatic nerve anatomy. It emphasizes proper clinical implications, for the surgeons to practice efficient surgical recombination and avoid errors. Treatment aimed at maximizing the mobility of the lower limbs.

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### Introduction

Sciatic nerve is the broadest nerve in the body having the width of 2 cms at its origin. It is the continuation of the upper band of the sacral plexus. It is largest branch of the lumbosacral plexus and root value of this nerve is L4 5 S123 spinal segments. It leaves the pelvis through the greater sciatic foramen below the piriformis and enters the gluteal region. In the Gluteal region it passes in between the greater trochanter and ischial tuberosity and is overlapped by the biceps femoris posteriorly. It lies on the quadratus femoris, gamellus superior, obturator internus and gamellus inferior anteriorly. Then it descends in the posterior compartment of the thigh. In the thigh region it lies on the adductor magnus and overlapped by the biceps femoris laterally and semitendinosus, semimembranosus medially. At the junction of middle and lower third of the thigh it divides into tibial and common peroneal nerves, proximal to back of the knee. [1]

The word sciatic is taken from Greek literature (Sciatic = Ischiadicus). The sciatic nerve is also called as ischiadic or ischiatic nerve. It is the thickest and widest nerve in body almost 0.5 cm thick and 2 cm wide respectively at its origin near the sacral plexus. The sciatic nerve is comprised of five nerves (L4,5 S1 2 3) spinal segments. It is largest branch of lumbosacral plexus. The nerve leaves the pelvis through the greater sciatic foramen below the piriformis muscle. It enters deep in the gluteal region, back of thigh and connects the foot via its branches. It supplies entire back of the

thigh, back of the leg and sole of the foot. In 85 to 90% it divides into tibial and common peroneal components at the apex of the popliteal fossa. Pain caused by a compression or irritation of sciatic nerve is called Sciatica. The symptoms are pain along the nerve, tingling, numbness and weakness. Injury of sciatic nerve leads to entire lower limb paralysis which leads to inability to walk. CT scan, MRI, EMG (electrical activity of muscle) and nerve conduction test can be carried out to know the nerve pathology.[2]

The sciatic nerve is the most frequently injured nerve in the lower extremity. It is commonly injured in posterior dislocation of hip and in fracture of hip joint. It is also injured during total hip replacement surgery and in hemiarthroplasty of hip. It is one of the nerves commonly injured due to intramuscular injections. Positioning of individuals during gynaecological surgeries like hysterectomy and dilatation and curettage can affect sciatic nerve.[3] Sciatic nerve may have many variations. Significant number of variations in the bifurcation, course, relation and distribution of its branches were encountered in sciatic nerve by many authors. It may divide before emerging from the greater sciatic notch or it may have separate tibial and common peroneal component from the beginning itself. It may divide in the popliteal fossa either above or below.

Present study was conducted to analyze and describe the variations of sciatic nerve to its statistical analysis. The knowledge of variations of sciatic nerve and its bifurcation are important for clinicians, surgeons and anesthetists. Each variation in division has its specific clinical presentation.[4] Even in the current era, the cadaver is the best means to study anatomy. Hence this study was undertaken on cadavers to study the incidence of sciatic nerve division into tibial and common

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peroneal nerves and its variations.[5] All these variations are important to anatomists, clinicians, anesthetists and surgeons. These variations may lead to entrapment neuropathy (piriformis) syndrome. Considering all these entire scenario an attempt is made to study the variations and course of the sciatic nerve.

#### MATERIALS AND METHODS

40 % formalin fixed 21 cadavers were dissected in the department of Anatomy, KLE University, J. N. Medical College Belagavi. Among them 13 cadavers were male and 8 were female. Total 42 Gluteal regions, back of the thigh and popliteal fosse were dissected. The incision was taken according to the Cunningham's manual. First incision was taken from the posterior superior iliac spine along the iliac crest. Second incision was taken from the iliac crest down wards and medially up to the tip of the coccyx. Flap of the skin and superficial fascia reflected laterally. The deep fascia is removed from gluteus maximus and defined the attachments of the muscle. Gluteus maximus is cut obliquely from above downwards and laterally. The muscle was reflected by passing 2 fingers deep to the lower edge of the muscle, 2 - 3 cm medial to its femoral insertion and cutting upwards between the fingers to the superior to the greater trochanter. The muscle is reflected laterally and medially. The medius and minimus also were exposed. Piriformis muscle was identified and the large sciatic nerve seen below the above said muscle. Fascia surrounding the nerve was cleared. Traced the nerve upwards anterior to the piriformis muscle and downwards to the near the level of the ischial tuberosity. Following the proper exposure the location of the sciatic nerve and its exit from the pelvis and the level of the sciatic nerve division were noted. Normally the sciatic nerve bifurcates at the superior angle of the popliteal fossa in 80-90% of individuals. The sciatic nerve is studied under the following headings.

1. Its exit through greater sciatic foramen with its relation with piriformis muscle.
2. Termination of sciatic nerve into its two divisions.
3. Length of sciatic nerve from lower margin of piriformis to its bifurcation into tibial and common peroneal nerve.
4. Width of sciatic nerve at lower margin of piriformis muscle
5. Any variations in its course and branches.

The variations are divided under following groups

#### A)Exit through the greater sciatic foramen

- E1- Single, undivided sciatic nerve below piriformis.
- E2 - Separate rootlets of tibial nerve along with common peroneal nerve below piriformis.
- E3 - Separate tibial and common peroneal nerve components below piriformis.
- E4 - Separate components, common peroneal nerve piercing piriformis.
- E5 - Separate components, common peroneal nerve passing above piriformis.

#### B)Level of Divisions of sciatic Nerve

- D1 - At gluteal region.
- D2 - At the upper part of the thigh.
- D3 - At the middle of the thigh.
- D4 - At the lower part of thigh (Near superior angle of popliteal fossa)
- D5 - In the popliteal fossa.

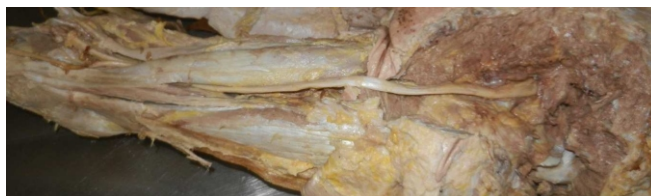
#### C) Length of sciatic nerve from lower margin of piriformis muscle to its bifurcation.

- L1 - Up to Gluteal region
- L2 - Up to upper part of the thigh
- L3 - Up to middle of the thigh
- L4 - Up to lower part of thigh (near superior angle of popliteal fossa)
- L5 - Up to middle level of popliteal fossa.

#### D) Width of sciatic nerve at lower margin of piriformis (Table No.4)

#### OBSERVATIONS AND RRESULTS

In 33 specimens the sciatic nerve emerged through the greater sciatic foramen below the piriformis muscle as a single nerve without division (78.57 %) (E1) (Figure 1).



**Fig. 1. Showing E1 pattern. (Pi - Piriformis Muscle, SN - sciatic nerve)**

No separate rootlets of tibial nerve along with common peroneal nerve below piriformis were seen (E2).

One specimen showed i.e. (2.38 %) both the components of sciatic nerve were separated below piriformis (E3) (Figure no 2).



**Fig. 2. Showing E3 pattern. (Pi - Piriformis, T - Tibial component, CP - Common peroneal component)**

In 7 specimens (16.66 %) the components were separated but the common peroneal nerve was piercing the piriformis muscle.(E4) (Figure no3).



Fig. 3. Showing E4 pattern (Pi - Piriformis, T - Tibial component, CP - Common peroneal component)

One specimen showed i.e. (2.38 %) the common peroneal nerve was passing above the piriformis and tibial nerve below the piriformis muscle (E5). (Figure no 4).



Fig. 4. showing E5 pattern. (Pi - Piriformis, T - Tibial component, CP - Common peroneal component)

It is observed that in males and females E1 pattern is most common and E4 pattern is seen more on right side. While E5 pattern is only seen in males on right side. E3 pattern is also seen only in males but on left side. E2 pattern were not seen either in male or female. (Table. No.1).

It is observed that most common site of division of sciatic nerve is in the popliteal fossa in both sexes (D5) (Figure no. 5).



Fig. 5. showing (D5) pattern, division of SN is in the popliteal fossa.

2nd most common site of division was observed near the superior angle of popliteal fossa in both sexes (D4).( Figure no. 6)

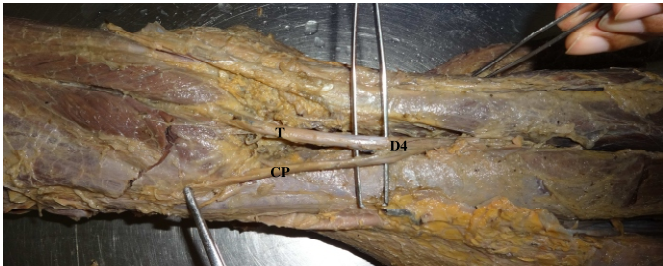


Fig. 6. showing (D4) pattern, observed near the superior angle of popliteal fossa.

In six specimens showed division of the sciatic nerve was at the upper part of the thigh (D2) (Figure no 7).

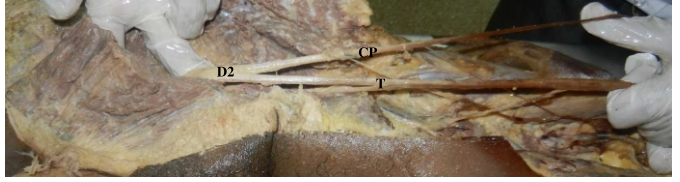


Fig. 7. D2 pattern, showing division at upper part of thigh.

In eight specimens sciatic nerve was divided in the gluteal region (Figure no. 8) D1.



Fig. 8. D1 pattern, showing division at gluteal region.

In six specimens sciatic nerve divided in the middle of the thigh (figure no. 9)(D3) (Table no.2)

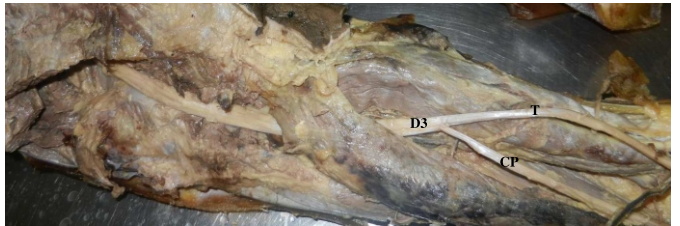


Fig. 9. D3 pattern, showing division at middle of the thigh.

Table 1. Variation in exit pattern of sciatic nerve (Exit through greater sciatic foramen)

	Male (n=13)						Female (n=8)						Total (n=21)	
	Right		Left		Total		Right		Left		Total			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
E1	10	76.92	12	92.30	22	84.61	5	62.5	6	75.0	11	68.75	33	78.57
E2	0	0.00	0	0.00	00	0.00	0	0.00	0	0.00	00	0.00	0	0.00
E3	0	0.00	1	7.69	01	3.84	0	0.00	0	0.00	00	0.00	1	2.38
E4	2	15.38	0	0.00	02	7.69	3	37.5	2	25.0	05	31.25	7	16.66
E5	1	7.69	0	0.00	01	3.84	0	0.00	0	0.00	00	0.00	1	2.38

Table 2. Variation in termination pattern of sciatic nerve (Level of division of sciatic nerve)

	Male (n=13)						Female (n=8)						Total (n=21)	
	Right		Left		Total		Right		Left		Total			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
D1	4	30.76	3	23.07	07	26.91	0	0.00	1	12.5	01	6.25	8	19.04
D2	1	7.69	2	15.38	03	11.53	2	25.0	1	12.5	03	18.75	6	14.28
D3	2	15.38	2	15.38	04	15.38	1	12.5	1	12.5	02	12.5	6	14.28
D4	2	15.38	2	15.38	04	15.38	2	25.0	2	25.0	04	25.0	8	19.04
D5	4	30.76	4	30.76	08	30.76	3	37.5	3	37.5	06	37.5	14	33.33

**Table 3. Length of sciatic nerve from lower margin of piriformis muscle to the bifurcation of sciatic nerve (Up to division of sciatic nerve)**

	Male (n=13)				Female (n=8)				
	Right		Left		Right		Left		
	No.	Length (Cms)	No.	Length (Cms)	No.	Length (Cms)	No.	Length (Cms)	
L1	1	5.5	1	4.5	0	0.0	0	0.0	
L2	3	10.5	3	9.5	1	8.0	1	7.0	
		11.5							11.0
		14.0							17.0
L3	1	24.5	2	28.0	2	19.5	2	15.5	
				29.5		21.5		20.0	
L4	3	32.0	2	32.5	3	29.5	2	34.5	
		32.5		34.0		31.0		30.5	
		34.0		34.0		34.0			
L5	5	42.5	5	42.5	2	38.0	3	36.0	
		39.5		40.0		37.5		37.5	
		39.5		39.5				38.5	
		35.5		36.0					
		35.0		36.0					

From table no.3, It shows that more common length (35 – 42.5 cm) in males whereas (35 – 38.5 cm) in females from lower margin of piriformis to the popliteal fossa. 2nd common length (32 – 34.5 cm) in males whereas (29.5 – 34.5 cm) in female up to near the superior angle of popliteal fossa.

**Table 4. Width of sciatic nerve at lower margin of piriformis**

S.N.	Male (n=13)		Female (n=8)	
	Right 13 mm	Left 13 mm	Right 8 mm	Left 8 mm
1	16.32	17.88	11.12	11.31
2	15.55	12.37	17.33	17.20
3	18.24	14.65	14.32	14.55
4	12.59	14.86	12.45	13.90
5	15.10	13.56	11.50	11.50
6	12.50	13.00	12.35	14.12
7	10.68	16.59	13.00	14.17
8	16.73	18.23	14.12	14.31
9	17.50	16.53		
10	16.67	15.68		
11	15.72	13.89		
12	13.92	15.93		
13	13.22	19.90		
<b>Mean</b>	<b>14.98</b>	<b>15.62</b>	<b>13.27</b>	<b>13.88</b>

From table no.4, it shows the width of sciatic nerve of individual males & females. In male: compare to right side, left side is more width, whereas In female: also compare to right side, left side is more width

## DISCUSSION

Most of the text books of Anatomy, Orthopedics & Surgery state that the sciatic nerve bifurcation levels are important in clinical and surgical procedures. Normally undivided sciatic nerve passes through greater sciatic foramen below the piriformis and divides at apex of popliteal fossa. Interpretation of nerve variation in limbs requires a consideration of phylogeny & development of sacral plexus.[6]

During embryological development at the base of the limb bud, the nerves contributing to the lower limb form two plexuses (lumbar & sacral). Later, as the elements from each of these plexuses grow out into the limb, they are subdivided into dorsal and ventral components for the dorsal and ventral musculatures. [7] The Sciatic nerve is formed when the large dorsal component of sacral plexus (common peroneal nerve) and ventral component (tibial nerve) move downward close together.[7]

It is unclear whether the anatomical variations in relationship between the sciatic nerve and the piriformis muscle.[8] However, it is only through detailed study of regional anatomy that these doubts may one day be clarified.[9] Based on their developmental formation, it is possible that the common peroneal and tibial divisions of the sciatic nerve separate from each other at different levels from their origins like i) in gluteal region ii) posterior compartment of the thigh and popliteal fossa iii) upper part of thigh iv) middle part of thigh. Various studies have reported on the level of sciatic nerve division into tibial and common peroneal nerve.[5] In the study of Prakash et al. (2010) [5] 16.3%, Guvencer et. al (2009) [10] 48.0%, Ugrenovic et. al. (2005) [11] 27.5%, Karambelkar R. R. et. al.(2013) [4] 11.11% of specimens have shown the division in gluteal region.

In our study it is observed that in 19.04% of cases the sciatic nerve has terminated in gluteal region while in male 30.76 % it is terminated on right side and 23.07 % on left side while in females there is only 12.5 % left sided nerves have terminated in the gluteal region.

The level of the sciatic nerve division and its relation to the piriformis muscle was also studied by Ugrenovic et. al.[11] According to them sciatic nerve left the pelvis through the infra piriform foramen in 96% cases, while 4% the variable relations between sciatic nerve and piriformis muscle were detected. (In that 2.5 % common peroneal nerve penetrated the piriformis and left the pelvis and tibial nerve left the pelvis through the infrapiriform foramen. In 1.5 % common peroneal nerve was present above the piriformis and tibial nerve was below the piriformis.[11] When the nerve divides in the pelvis, the common peroneal nerve usually pierces the piriformis muscle. Mouret et. al.[12] has concluded that in case of high division of sciatic nerve the common peroneal nerve passes through the piriformis muscle. Sharma et.al.[13] observed that 2 divisions of sciatic nerve were separate in gluteal region on both the sides with tibial nerve passing below the piriformis and common peroneal nerve piercing the piriformis muscle. Odijama & Kurihara (1963) [14] have found the common peroneal nerve to pierce the piriformis muscle more commonly in males and on left side, it is correlating with our study. The sciatic nerve may get divided into the common peroneal nerve

and tibial nerve in the pelvis and each nerve can leave the pelvis using a separate route. Moore et. al [15] has reported that common peroneal nerve passing through the piriformis and tibial nerve passing below piriformis is in 12.2 % of specimens. Chiba et. al [16] 34.0%, Karambelkar R. R. et. al. [4] 11.11% of specimens.

In our study it has been found that in 16.66% of specimens, common peroneal nerve passing through the piriformis and tibial nerve passing below piriformis.

Beaton & Anson (1937), [17] have classified variations of piriformis and sciatic nerve. Their classification is known as the Beaton and Anson classification. After some time Pokorny et. al.[18] have modified the Beaton and Anson classification and stated that the first variation namely the undivided nerve below the piriformis muscle was the most common type and seen in 79.1% of specimens.

In our study it has been found (E1) 76.92% on right side and 92.30% on left side in male, while in female it has been 62.5% on right and 75.0% on left side. E2 are not found in our study neither in male nor in female. E3 and E5 has been found only in male on left side and right side in 7.69 % of specimen respectively. Where as E4 has been found in male on right side in 15.38 % specimen and in female on right side in 37.5% and left side in 25.0% of specimen.

Table. 3 shows the length of sciatic nerve from lower margin of piriformis muscle to the bifurcation of sciatic nerve into common peroneal and tibial nerve.

Table. 4 shows the width of sciatic nerve at the lower margin of piriformis muscle on the right side and left sides. Showing a significant difference in nerve width between 2 sides. The mean width in male on right side 14.98 mm and left side 15.62 mm. In female on right side 13.27 mm and left side 13.88 mm. So in that we found width of sciatic nerve in male and female, left side is more, compare to right side.

## CONCLUSION

The sciatic nerve is frequently involved in daily medical practice of neurology, orthopedics, rehabilitation & Anesthesia. The knowledge regarding the level of division of sciatic nerve and its mode of exit is of great importance. Abnormal course and division may lead to sciatic neuropathy. Its long course makes it vulnerable to nerve injury. The high division may account for failures in the popliteal block.

Piriformis syndrome is a rare pain generating condition. Anatomical variations in the relationship between the sciatic nerve and the piriformis muscle do not seem to be solely responsible for the piriformis syndrome. Sciatic nerve may rarely be separated within pelvis. In such cases, the tibial nerve and the common peroneal nerve may leave the pelvis through different routes. These variations may cause nerve compressions under other anatomical structures, resulting in non-discogenic sciatica.

The deep gluteal region is often encountered when performing injections and hip replacement surgeries. Diagnosis of nerve anomalies is done by using imaging techniques. The piriformis and SN anomalies have ranged from 1.5 – 35.8% in dissected human specimens as published in literature. Sciatic endometriosis is rare condition detected by MRI, where there is cyclic pain vary with menstrual cycle. It is treated by local excision. In untreated cases there is a cicatricial change in SN which requires radical surgery.

The main essence of this study is to get information on variations of the sciatic nerve anatomy. It emphasizes proper clinical implications, for the surgeons to practice efficient surgical recombination and avoid errors. Treatment aimed at maximizing the mobility of the lower limbs.

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