

## Original Research Article

# A study of sciatic nerve in relation to piriformis muscle in South Indian population

Roshni Bajpe, Ashray N. S.\*, Anagha Sheshachalam Bharadwaj

Department of Anatomy, Kempegowda Institute of Medical Sciences, Bangalore, Karnataka, India

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### \*Correspondence:

Dr. Ashray N. S.,

E-mail: nsashray@gamil.com

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### ABSTRACT

**Background:** The sciatic nerve (SN) is the largest nerve in the body, emerging from the pelvis beneath the piriformis muscle (PM) and dividing into the tibial nerve (TN) and common peroneal nerve (CPN). The long course and proximity to the PM make the SN susceptible to multiple injuries and compression, especially in the gluteal area and posterior thigh.

**Methods:** This study aimed to assess the anatomical variations of the SN course by analysing 68 lower limb specimens. The dissection focused on the gluteal region and back of the thigh, with special attention to the level and nature of the SN's bifurcation. The SN and PM were exposed by retracting the gluteus maximus muscle. The level of SN division and its relation to PM were recorded, photographed and classified into five groups.

**Results:** The findings showed a wide range of variations in SN bifurcation, with the most common type of SN bifurcation occurring at the lower end of the posterior thigh, found in 72.05% of specimens. The least common was the pelvic bifurcation before exiting the gluteal region in 2.94% of specimens. The study also revealed rare variations, such as the reunion of split divisions in 8.82% of specimens.

**Conclusions:** The variations in the division of the SN are crucial for clinical and surgical procedures involving the gluteal and posterior thigh regions. Such anatomical insights can reduce iatrogenic injuries and improve procedural outcomes.

**Keywords:** Anatomical variation, Common peroneal nerve, Piriformis muscle, Sciatic nerve, Tibial nerve

## INTRODUCTION

The SN, also known as the ischiatic nerve, is the longest and widest nerve in the human body. It originates from the ventral rami of the fourth lumbar to the third sacral spinal nerves and is typically about 2 cm wide at its origin. SN enters the lower limb through the greater sciatic foramen, usually below the PM. The SN provides motor nerve supply to all muscles of the posterior compartment of the thigh, all compartments of the leg and the dorsum and the sole of the foot. It also provides sensory supply to the leg and foot. The long course of the SN makes it susceptible to various injuries around the hip and back of the thigh.<sup>1</sup> The SN is enclosed by a common neural sheath, which contains the tibial and common peroneal components,

which are separated by the septum of Compton-Cruveilhier.<sup>1,2</sup> SN terminates into two main branches, the TN and CPN, at the upper angle of the popliteal fossa. The SN can divide into its terminal branches at variable levels starting from the sacral plexus till the popliteal fossa.<sup>1</sup> The two terminal branches, despite coursing independently, had revealed neural intercommunication in 75% of SN examined, which emphasizes the importance of understanding the variations of the terminal branches.<sup>3</sup> The PM is the key muscle in the gluteal region, it arises from the anterior surface of the sacrum as three digitations and exits the pelvis through the greater sciatic foramen, which substantially fills it and attaches to the medial side of the upper border of the greater trochanter of the femur.<sup>1</sup> The variations of SN in relation to PM have been well

documented and classified.<sup>4</sup> The identification of the point of division of SN can help clinicians in various diagnostic and therapeutic interventions, improving the quality of patient care. The anatomical variations should be considered to avoid nerve injury while performing procedures such as pelvic surgeries, hip arthroplasty and intramuscular injections.<sup>3,5</sup>

There have been significant variations in the level of SN bifurcation documented across different regions of the world, including within the Indian population.<sup>5,6</sup> In regard to the variations of SN termination, this study was performed to assess the site of anatomical division to provide more information in the study population. The objective is to study the lower limbs to assess the site of division and comparison with previous work.

## METHODS

This prospective descriptive study was conducted on 68 formalin-fixed lower limb cadaveric specimens (one limb per cadaver) at the Department of Anatomy, Kempegowda Institute of Medical Sciences, Bangalore. Ethical clearance was obtained from the Institutional Ethics Committee.

The gluteal region of each lower limb was dissected by retraction of the gluteus maximus muscle to expose the PM and SN, which descends in the inferolateral direction. The variations in division of the SN and its relationship to PM in all specimens were carefully observed, noted by both the authors. The SN was marked with yellow acrylic paint to enhance visualization in photographs, without altering its anatomical structure. The structural variations were identified and classified into five groups, noting the level of division of SN through its course. All dissections were performed by two independent anatomists and observations were cross-verified for inter-observer reliability; discrepancies were resolved by consensus.

### Inclusion criteria

Lower limb cadavers without gross pathology, trauma or surgeries in the gluteal regions were studied.

### Exclusion criteria

Any injuries, trauma, surgeries in the gluteal region and posterior aspect of the thigh are not taken. The data were analysed manually using frequencies and percentages.

## RESULTS

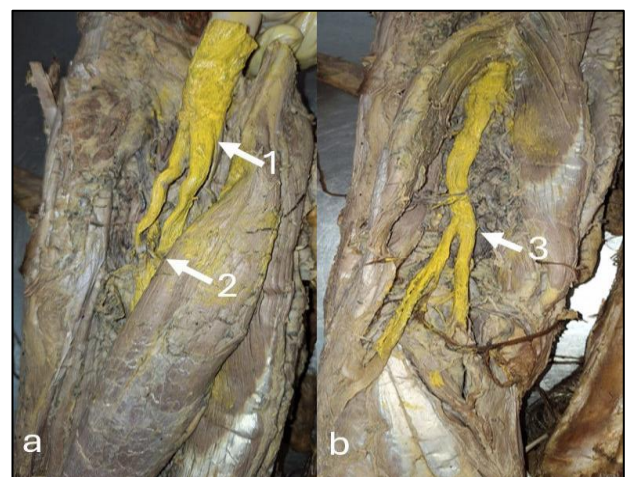
In the present study of 68 specimens, 39 were right lower limbs and 29 were left lower limbs. Two specimens showed a Group A type of division, in which the SN bifurcated within the pelvis before exiting into the gluteal region. In this variation, the TN and CPN coursed separately below the PM; this was the least common type of SN bifurcation. No specimens showed a Group B division. Five specimens showed a Group C type of

division, with bifurcation of the SN in the upper one-third of the thigh. Twelve specimens showed a Group D type of division, with bifurcation in the middle one-third of the thigh.

Forty-nine specimens showed a Group E type of division, in which the SN divided at the superior angle of the popliteal fossa; this was the most common type of bifurcation. The distribution of each group is summarized in Table 1.



**Figure 1 (a, b): Division of SN within the pelvis. arrow 1 represents CPN piercing PM and TN passing below the muscle. Arrow 2 represents rejoining of two divisions at the gluteal region. Close-up photography of specimen (a) showing the reunion of split divisions and arrow 3 represents SN terminal bifurcation into two divisions.**



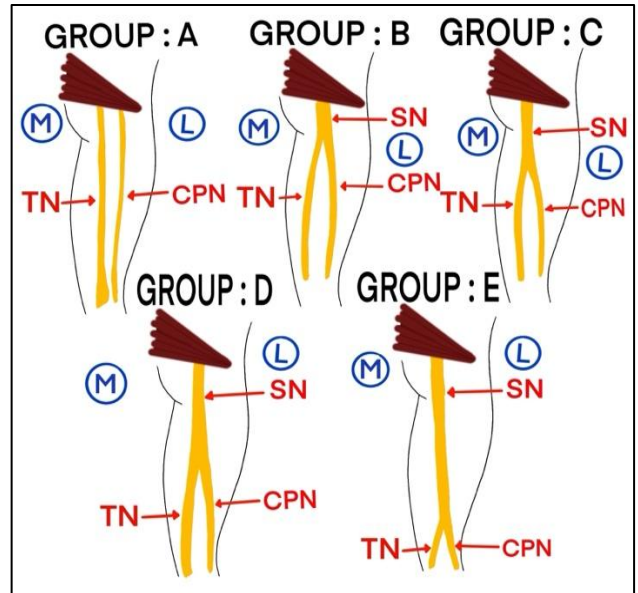
**Figure 2 (a, b): The upper part of the SN division, with arrow 1 indicating the bifurcation of the SN at the upper one-third of the thigh and arrow 2 depicting the rejoining following a short course forming a loop. The lower part of the SN division, with arrow 3 indicating the bifurcation at the apex of the superior angle of popliteal fossa.**



**Figure 3:** Varied course of the SN seen, with arrow 1 showing the reunification of the initial split divisions of the SN in the gluteal region, arrow 2 showing the reunification of the nerve after a short course in the upper one-third of the thigh and arrow 3 showing the terminal division of the SN at the level of the popliteal fossa.



**Figure 4 (a, b):** Close-up photograph of specimen depicting the varied course of the SN. Arrow 1 indicates the rejoining of the split divisions of the SN and arrow 2 indicates the division of the SN after a short course in the upper one-third of the thigh.



**Figure 5:** Digital illustration depicting the five major anatomical variants (Groups A–E) of SN division as classified in the present study.

While documenting the termination of SN, four uncommon variations were noted, which are listed as follows.

Bifurcation of the SN within the pelvis before its exit into the CPN and TN, with the CPN component piercing the PM and the two components rejoining to form the SN bundle, which then coursed downward to divide again at the popliteal fossa, as shown in Figure 1. The SN passing below the pelvis and splitting at the upper one-third of the posterior thigh, then reuniting after a short course to form a loop before terminating at the popliteal fossa, as shown in Figure 2.

The SN dividing into two divisions that reunite after a short course in the gluteal region, then re-split and reunite again at the upper one-third of the posterior thigh, continuing as a single trunk before finally terminating at the popliteal fossa, as shown in Figure 3.

The SN dividing into two divisions that unite in the gluteal region to form the main trunk for a short course before terminating at the upper one-third of the posterior thigh; this variation was observed in two specimens, as shown in Figure 4.

**Table 1: Number and percentage of anatomical variants in the final termination SN division in the present study.**

Group	Number (%)
A	2 (2.94)
B	0 (0)
C	5 (7.35)
D	12 (17.21)
E	49 (72.05)

**Table 2: Level of SN division reported in various studies.**

S. no.	Name of the Researcher	Number of lower limbs used for the study	Year of publication	Before exiting pelvis in percentage	After exiting pelvis in percentage
1	Beaton et al <sup>4</sup>	120	1937	15	85
2	Guvencer et al <sup>11</sup>	50	2009	48	52
3	Ogeng'o et al <sup>22</sup>	164	2011	20.1	79.9
4	Patel et al <sup>9</sup>	86	2011	8.2	91.8
5	Sawant et al <sup>20</sup>	100	2013	22	78
6	Adibatti et al <sup>29</sup>	50	2014	8	92
7	Berihu et al <sup>25</sup>	56	2015	25	75
8	Javia et al <sup>23</sup>	102	2019	23.53	76.47
9	Pitta et al <sup>6</sup>	100	2023	17.5	82.5
10	Present study	68	2025	10.29	89.71

**Table 3: Comparison of percentages showing the level of SN bifurcation categorized into five groups (A–E) in the present and previous studies.**

S. no.	Name of the Researcher	Year of Publication	Group A	Group B	Group C	Group D	Group E
1	Prakash et al <sup>21</sup>	2010	16.3%	2.3%	3.5%	2.3%	75.6%
2	Sawant et al <sup>20</sup>	2013	22%	2%	3%	12%	61%
3	Javia et al <sup>23</sup>	2019	23.53%	3.92%	1.96%	2.95%	67.64%
4	Pitta et al <sup>6</sup>	2023	28.75%	8.75%	6.25%	3.75%	52.5%
5	Present study	2025	2.94%	0%	7.35%	17.21%	72.05%

## DISCUSSION

The long course of SN makes it one of the most frequently injured nerves in the lower limb.<sup>7</sup> The variations in SN have been well documented in various geographical regions of the world and have been classified into several categories; the first documented and the most accepted classification of SN in relation to PM has been described by Beaton and Anson.<sup>4</sup> Table 2 summarizes the percentage of SN bifurcation occurring before and after exiting the pelvis across various studies.

In the present study, the percentage of SN divided before exiting the pelvis is 10.29% and after exiting the pelvis it is 89.71%. Beaton et al, has described the SN divided before exiting the pelvis in 15% and after exiting the pelvis in 85%.<sup>4</sup> The present study results are similar to studies done on the Indian population by Grewal et al (10% before and 90% after exiting the pelvis) and Patel et al (8.2% and 91.8%, respectively).<sup>8,9</sup> Gabrielli et al have documented comparable findings among the Brazilian population (13.7% and 86.3%, respectively).<sup>10</sup>

In a study by Guvencer et al on the Turkish population, 48% of SNs bifurcated before exiting the pelvis, while 52% bifurcated after exiting the pelvis.<sup>11</sup> These high-division variations are clinically relevant, as they may predispose the SN to entrapment and contribute to piriformis syndrome.<sup>12,13</sup> The term sciatic derives from the Greek word "Ischiadikos," referring to pain or trouble arising from the hip region.<sup>14</sup> SN compression in the fibro-

osseous tunnel of the greater sciatic foramen can lead to entrapment syndrome, clinically presenting as lower back pain radiating to the leg.<sup>12,14</sup> The Beaton and Anson type B variant, in which the CPN is piercing the PM and the TN is passing below the PM, is one of the recognized anatomical causes of piriformis syndrome and was observed in two specimens in the present study.<sup>12</sup> A rare variant observed in the present study involved the intrapelvic division of the SN followed by reunion into a single trunk, which continued through the posterior thigh until bifurcating again in the popliteal fossa. There were similar variants described in literature, including those where the divided components reunite at variable levels in the thigh or popliteal fossa.<sup>15,16</sup>

The SN bifurcation levels are important in clinical and treatment aspects in the gluteal region. In the thigh, penetrating wounds and fractures of the acetabulum injure the SN. Identification of variations in the level of bifurcation makes surgical procedures more effective and accurate.<sup>17</sup> Brooks et al classified the terminal division of the SN into six major groups. The classification is listed below.<sup>18</sup>

### Group A

Division of SN in the pelvis.

### Group B

Division of SN in the gluteal region.

#### Group C

Division of SN in the upper region of the thigh.

#### Group D

Division of SN in the middle region of the thigh.

#### Group E

Division of SN in the lower region of the thigh.

#### Group F

Division of SN in the popliteal fossa.

In the present study, Groups E and F were combined as one group (Group E) because divisions occurring at or below the lower one-third of the thigh are regarded as normal anatomical variants, without distinct visual differentiation in cadaveric specimens or notable clinical or surgical distinction, as shown in Figure 5.<sup>1,18</sup> The present study did not document SN bifurcation in the gluteal region. This is consistent with the findings of Grewal et al, who also reported 0% division at this level.<sup>8</sup> Similarly, the Polish study did not identify a distinct gluteal-level division.<sup>19</sup> The upper and middle one-thirds of the posterior thigh SN bifurcation were observed in 7.35% and 17.21%, respectively, in the current study. This result was higher than observations in other similar studies on the Indian population, which documented around 2-4%.<sup>20,21</sup> This result is consistent with the 10.4% division observed in the middle one-third of the posterior thigh in the Kenyan population.<sup>22</sup> The findings of this study revealed terminal division of the SN in the pelvic region in 2.94% of specimens. This result was different from other similar Indian studies, where on an average around 16 to 24% showed terminal pelvic division of the SN.<sup>20,23</sup> Other similar international studies conducted in Kenya and Turkey showed terminal division of the SN in about 20.1% and 48% of cadavers respectively.<sup>11,22</sup> These percentage variations across different studies are summarized in table 3.

Regional anaesthesia of the lower limb increasingly utilizes SN blocks due to improved postoperative pain control.<sup>24,25</sup> SN blocks can be given at any site based on the particular case from proximal (sacral plexus or trans-gluteal approach) to distal (popliteal approach).<sup>5</sup> The anatomical variations of the SN terminal division are important to bear in mind when SN block is performed in the popliteal fossa. The high division of the nerve leads to complete failure of the SN block or an incomplete block of the SN.<sup>24,25</sup> Ultrasound visualization is therefore recommended to observe the anatomical variations before nerve block administration.<sup>24</sup> In the present study, the reunion of split divisions of SN bifurcations has been documented in 8.82% of specimens. The splitting and reunification variants have been documented in 4.9% of the Kenyan population.<sup>22</sup> The peculiar division of the SN

and its relationship to surrounding structures can be explained on an embryological basis. The nerves of the lower limb develop from the lumbar and sacral plexuses at the base of the limb bud. The SN forms by the approximation of its ventral (TN) and dorsal (CPN) components, which are enclosed within a connective tissue sheath known as the epineurium. Variations in the level of SN division in relation to the PM and along the posterior thigh may result from incomplete formation of the epineurium.<sup>8,12</sup>

By the sixth week of development, the SN is already formed and the PM becomes identifiable by the eighth week. These findings suggest that anatomical variations may arise before the establishment of the definitive muscular insertion, which occurs around the fifteenth week of development.<sup>26</sup> There are various parts in the human body where the reunification of nerves has been documented. Femoral nerve dividing and reuniting has been documented in relation to iliacus muscle entrapment.<sup>27</sup> Kubwimana et al report a case of a SN loop in the mid-thigh that passes the three perforator artery branches of the profunda femoris artery. These findings can have clinical importance if the perforator arteries develop an aneurysm or pseudoaneurysm, which can lead to SN-like compression features.<sup>28</sup> The present study provides no evidence of blood vessel or muscle pathologies in relation to the nerve. The presence SN reunion may reduce the severity of sciatic neuropathies but may complicate nerve block procedures.<sup>29</sup> Documentation of such anatomical variations improves clinical awareness and procedural outcomes.

This study has certain limitations. The sample size was limited to 68 cadavers from a single South Indian institution, which may not represent the broader population variability. The macroscopic anatomy was assessed, but the microscopic correlation of neural sheath formation was not performed to provide a greater understanding of the abnormal reunion of SN. Future research can overcome these limitations by including larger, multicentric cadaveric samples, complemented by radiological correlation to visualize in vivo variations.

## CONCLUSION

The location, course and division of SN in regard to PM play a paramount role in the diagnosis and treatment of various etiological conditions in the gluteal and back of thigh regions. The various anatomical variations in the study population possess clinical significance while evaluating the sciatic entrapments or neuropathies, the severity of which depends on the level of division. The level of SN compression would alter the diagnosis and treatment protocol. The documentation of rare variations with the reunion of split divisions and formation of nerve loops can pose a significant challenge while performing surgical procedures in the region. Hence, understanding anatomical abnormalities could enhance patient outcomes and direct further research, which helps physicians in

various disciplines like anatomy, anaesthesiology, orthopaedics, neurology and physiotherapy.

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