

## TO IDENTIFY THE ANATOMICAL VARIATIONS OF THE SCIATIC NERVE: A CADAVERIC STUDY

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### Abstract

**Background:** The Sciatic nerve is the broadest nerve in the human body. The structure has two elements: the tibia and the common peroneal components, which originate from the ventral rami of the L4 to S3 spinal neurons of the lumbosacral plexus. The nerve leaves the pelvis via the greater sciatic foramen, located below the Piriformis muscle. It then travels downwards between the greater trochanter of the femur and the ischial tuberosity of the pelvis, reaching the knee. **Aim:** To identify the anatomical variations of the sciatic nerve: A Cadaveric Study. **Materials and Methods:** A prospective-descriptive cross-sectional research was conducted to assess the prevalence of anatomical changes in the exit of the SN in connection to the PM in 25 anatomical cadavers of both sexes, with an equal distribution, analysed at the anatomy department. The process of data collecting included dissecting 50 SN from the bodies of both males and females in equal proportions. The inclusion criteria included that the cadavers must have had the gluteal area in an ideal state and well-preserved, enabling the dissection and gathering of data. **Results:** In our investigation, the sciatic nerve (SN) was found to exit inferiorly to the PM in 45 lower limbs (90%); between the fascicles of the PM and inferiorly to the PM in 3 lower limbs (6%); and in 2 thighs, between the fascicles of the PM and superiorly to the PM (4%). The unilateral anatomical changes were more prevalent on the left side (12%) compared to the right side (8%), and were more common in females (12.5%) than in males (7.69%). Our research found that the sciatic nerve branches more often in the upper portion of the popliteal fossa in 54% of instances, in the gluteal area in 38% of cases, and in the middle third of the thigh in 8% of cases. **Conclusion:** The presence of anatomical differences of the SN in relation to the PM poses difficulties in the diagnostic and therapeutic procedures in several clinical and surgical instances. Swift identification of the SN alterations enhances the precision and efficacy of surgical methodologies. Our research has verified that the SN often leaves the pelvis below the PM in 90% of cases, but there may be some anatomical deviations in 10% of cases.

## INTRODUCTION

The term "sciatic nerve" is derived from the Greek word "Ischiadicus" and refers to the largest and longest nerve in the body, which originates from the sacral plexus.<sup>[1,2]</sup> The sacral plexus is created inside the pelvis by joining the anterior divisions of the spinal nerve roots from L4 to S3. The width of the object is around 2 centimetres and it is located in close proximity to the sacral plexus. Typically, it exits via the larger sciatic opening, traverses the pelvis, and reaches the gluteal area by going under the piriformis muscle as a solitary nerve enclosed by a single outer layer called the epi-neural sheath. The sciatic nerve divides into the tibial nerve (TN) and the CPN at the superior angle of the popliteal fossa. The sciatic nerve innervates the hamstrings muscles,

provides sensory input to the hip and knee joints, and its branches have both motor and sensory functions in the leg and foot. The main focus of variation is in the association between SN and the piriformis muscle. Occasionally, the SN undergoes division into its terminal branches while it is still located inside the pelvis, resulting in several pathways exiting the pelvis. The nerve is categorised into several categories based on variations in its natural pathway in the lower leg and its proximity to the piriformis muscle.<sup>[2-7]</sup> The SN is anatomically strongly associated with the internal twin-obturator complex. The link between the SN and passive hip rotation leads to a consistent and repeatable dynamic behaviour. This association may help explain the pathogenic causes behind the internal twin syndrome of the obturator. Magnetic resonance imaging (MRI) is an advanced method that continues to evolve and

is used, along with computed tomography, for the identification of nerve inflammation and assessment of the thickness of the PM. MRI neurography is a significant recent development that serves as a supplementary and non-invasive diagnostic tool for assessing nerves and plexuses. It enables direct visualisation of nerve structures, resulting in higher diagnostic precision compared to alternative study methods.<sup>[9]</sup> Deviation in the anatomical structure of the SN in relation to the PM can result in conditions like piriformis syndrome. This should be taken into account to prevent nerve damage during medical procedures such as pelvic surgeries, hip arthroplasty, intramuscular injections, and cannulation of the spine femoral artery in heart surgery.<sup>[10]</sup> It is crucial to have a comprehensive understanding of the typical structure and interconnections of the human body when carrying out therapeutic or surgical procedures. Therefore, it is essential to identify the possible anatomical variations that can occur in this area and to specify the standard distribution of each anatomical component, as well as the variations and common relationships that may be encountered. The SN develops during the sixth week of embryonic development, whereas the PM forms by the eighth week. This implies that anatomical differences may be formed gradually before to the establishment of the final muscle attachment, which becomes apparent at around 15 weeks of development.<sup>[11]</sup> The abnormal arrangement of the branches of the SN is significant as it can lead to potential injury when administering intramuscular injections, resulting in ineffective nerve anaesthesia, complications during gluteal surgeries, and the onset of piriformis syndrome. It is further proposed that the presence of anatomical variations in the sciatic nerve increases the likelihood of injury during hip arthroplasties. This may occur due to direct physical damage or as a result of the tension and manipulation exerted on the nerve during the surgical procedure.<sup>[12]</sup> Sciatica refers to the discomfort resulting from the compression or irritation of the SN. Symptoms of sciatica include nerve pain, numbness, tingling, and paralysis. Piriformis syndrome is caused by unilateral or bilateral higher break of the SN, which leads to compression of the nerve. This compression results in paralysis of the muscles supplied by the nerve and sensory abnormalities. In this condition, the individual is unable to bend the knee joint and has

impairment in both outward rotation and downward movement of the limb.<sup>[13]</sup>

## MATERIALS AND METHODS

A prospective-descriptive cross-sectional research was conducted to assess the prevalence of anatomical changes in the exit of the SN in connection to the PM in 25 anatomical cadavers of both sexes, with an equal distribution, analysed at the anatomy department.

### Methodology

The process of data collecting included dissecting 50 SN from the bodies of both males and females in equal proportions. The inclusion criteria included that the cadavers must have had the gluteal area in an ideal state and well-preserved, enabling the dissection and gathering of data. The data collection began with the objective of processing this information, which was acquired and gathered in a prearranged and verified manner. The data were organised and visualised using Microsoft Word and Microsoft Excel while documenting the findings, conclusions, and recommendations of this research.

## RESULTS

To analyse and discover differences in SN in connection to the PM, we dissected 50 SN from corpses of both sexes in equal numbers. We examined the frequency, pattern, and course of these variations. [Table 1]

In our investigation, the SN was found to exit inferiorly to the PM in 45 lower limbs (90%); between the fascicles of the PM and inferiorly to the PM in 3 lower limbs (6%); and in 2 thighs, between the fascicles of the PM and superiorly to the PM (4%). The unilateral anatomical changes were more prevalent on the left side (12%) compared to the right side (8%), and were more common in females (12.5%) than in males (7.69%). However, it is important to note that these findings lack statistical significance owing to the limited sample size of cadavers. [Table 2]

Our research found that the sciatic nerve branches more often in the upper portion of the popliteal fossa in 54% of instances, in the gluteal area in 38% of cases, and in the middle third of the thigh in 8% of cases. [Table 3]

**Table 1: Anatomical variations of the SN**

Parameter	Number	Percentage
Number of anatomical bodies	25	100
Sciatic nerve	50	100
Sex		
Male	13	52
Female	12	48

**Table 2: Anatomical variations**

Anatomical variations	Number	Percentage
Inferior to the PM	45	90
Between the fascicles of the PM and inferior to the PM	3	6
Between the fascicles of the PM and superior to the PM	2	4

Anatomical variations of the SN exit from the pelvis among gender		
Male	2/26	7.69
Female	3/24	12.5
Anatomical variation of the SN according to the side of the body		
Unilateral	5	100
Bilateral	5	0
Side of anatomical variation of the SN		
Right	2/25	8
Left	3/25	12

**Table 3: Region of division**

Region of division	Number	Percentage
Gluteal region	19	38
Middle third of the thigh	4	8
Proximal part of the popliteal fossa	27	54

## DISCUSSION

The largest division of the lumbo-sacral plexus is known as the SN. The division level is crucial for both clinical and therapy purposes. The anatomical textbooks and periodicals did not find any major differences in the organisation or division of the sciatic nerve between males and females, hence it was not noticed. The sacral plexus forms as the large dorsal and ventral components move downwards in unison. The occurrence of this high division is seen following posterior hip surgeries and is associated with conditions such as sciatica, nerve damage from deep intramuscular injections, piriformis syndrome, unsuccessful sciatic nerve block during anaesthesia, and injury. Varying clinical presentations might be seen in cases of compression of the SN, CPN and TN.<sup>[14,15]</sup> In 1937, Beaton and Anson identified different variants of the PM and SN in 120 specimens.<sup>[16]</sup> The following year, they expanded their study to include 240 specimens.<sup>[17]</sup> The categorization devised by Beaton and Anson,<sup>[16]</sup> was as follows: The classification includes six types: Type 1 (nerve and muscle are undivided), Type 2 (nerve is divided between and below undivided muscle), Type 3 (nerve is divided above and below undivided muscle), Type 4 (nerve is undivided between heads), Type 5 (nerve is divided between and above heads), and Type 6 (nerve is undivided above undivided muscle). Pooja et al,<sup>[18]</sup> state that understanding the typical anatomy of the SN's emergence from the pelvic cavity, as well as the potential variations in its relationship with the PM, is beneficial for surgical procedures involving the gluteal region and the SN territory. In their study, Güleç et al,<sup>[19]</sup> presented four clinical cases of piriformis syndrome. They found that diagnostic ultrasound evaluation of the gluteal region in each patient revealed anatomical variations of the sciatic nerve (SN). This suggests that using ultrasound could enhance the precision of injection and surgical procedures, as well as reduce associated complications, particularly in cases where there are anatomical variations of the sciatic nerve and PM. Our investigation found that in 45 lower limbs (90%), the SN exited below the PM, with anatomical abnormalities occurring in 10% of instances. In their

study, Berihu et al,<sup>[20]</sup> examined 56 lower limbs to investigate the correlation between the SN and the PM. They found that 75% of the lower limbs had a normal SN architecture, while 25% of the cases revealed abnormalities in the SN's association with the PM. In 5% of the instances, the SN was seen to have trifurcation. According to Monte De Oca's research,<sup>[21]</sup> the occurrence rate of anatomical differences in the departure of the SN in relation to the PM was 10%. The most frequent location where the SN separated into its terminal branches was in the proximal section of the popliteal fossa, accounting for 75% of cases. Budhiraja et al. did a research on 60 lower limbs and found that 31.7% of the SN showed anatomical abnormalities in its connection with the PM. Specifically, the SN was found to emerge between and below the undivided PM in 13.3% of instances. Additionally, in 18.3% of cases, the common peroneal nerve emerged above the PM together with the tibial nerve, which erupted below the PM,<sup>[22]</sup> In a similar Atoni et al,<sup>[23]</sup> examined 56 lower limbs and found that 92.9% of the cases had the typical structure of the SN, while four instances (7.1%) showed morphological changes in the SN. Natsis and colleagues,<sup>[24]</sup> conducted the largest study, including 294 lower limbs. According to their research paper, the relationship between the SN and the PM followed the typical anatomical pattern in 93.6% of the 275 limbs studied. In 4.1% of cases, the common peroneal nerve passed through the PM and the tibial nerve below it. In 0.3% of cases, the common peroneal nerve coursed superior to the PM and the tibial nerve below it. In another 0.3% of cases, both nerves penetrated the PM. In one case (0.3%), both nerves passed above the PM. Finally, in four cases (1.4%), non-classified anatomical variations were observed.<sup>[24]</sup> Ogeng'o et al,<sup>[25]</sup> examined the variations of the SN in 82 deceased individuals of black Kenyan descent. They found that in 20.1% of instances, the SN divided in the pelvis, whereas in 79.9% of cases, the split happened outside the pelvis. In these cases, the SN exited below the piriformis muscle as a single trunk. Barbosa et al,<sup>[26]</sup> performed a comprehensive evaluation and found that the most frequent anatomical difference was the passage of the common fibular nerve through the fibres of the piriformis muscle (33.3%). They also

suggested a potential link between this condition and piriformis syndrome. In a comprehensive systematic review, Poutoglidou et al,<sup>[27]</sup> conducted a meta-analysis to compare the prevalence of SN variants relative to PM among different geographical populations, taking into account gender and laterality. The study found that SN variants were more prevalent among East Asians, with a pooled prevalence of total variants at 31%. However, there were no statistically significant differences in prevalence based on gender and laterality. It is important to take into account all of these differences while studying the signs and symptoms of illnesses affecting the lower extremities. Considering these disparities, we advocate for doing further study on a larger multiethnic population to validate the connections between this structural variation and the PM. This would also provide more insights into the prevalence of these variants. Despite the advancements in neurosurgical procedures and 3D technologies, surgeons still need genuine laboratory anatomical dissections to ensure the safe execution of operations.<sup>[28]</sup> Precise localization of the sciatic nerve (SN) during hip surgeries, together with the documented variability, might help minimise the potential for inadvertent damage. Prior to doing nerve blocks, it is advisable to use ultrasonography to accurately locate the location and bifurcation point of the SN, since its course and bifurcation might vary significantly. Utilising ultrasound may enhance the efficacy and minimise the occurrence of problems related to sciatic or popliteal blocks. The primary constraint of this research is the limited sample size of cadavers. Another constraint is that our anatomical investigation is based on data from a single institution, resulting in consistent use of a uniform dissection method. Consequently, there is a minimal likelihood of overlooking some anatomical variances. This may provide challenges in assessing the quality and danger of bias. However, we were able to reduce this bias by progressively analysing the 25 anatomical entities that matched the inclusion criteria. Further prospective investigations should be carried out in a global, multicenter environment, with a substantial sample size to evaluate the existence and frequency of these anatomical differences in the SN.

## CONCLUSION

The presence of anatomical differences of the SN in relation to the PM poses difficulties in the diagnostic and therapeutic procedures in several clinical and surgical instances. Swift identification of the SN alterations enhances the precision and efficacy of surgical methodologies. Our research has verified that the SN often leaves the pelvis below the PM in 90% of cases, but there may be some anatomical deviations in 10% of cases. Furthermore, we have observed that the SN tends to split into its terminal branches more frequently in the proximal section of the popliteal fossa (54%) and in the gluteal area

(38%). Highlighting the potential anatomical differences of the SN nerve and its significance for various clinical and surgical treatments connected to the SN might enhance the understanding of health science research and its practical application.

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