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CADAVERIC STUDY OF ANATOMICAL VARIATION OF SCIATIC NERVE IN POPULATION OF BIHAR AND ITS CLINICAL APPLICATION: A CROSS-SECTIONAL STUDY.

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ABSTRACT

Background
The sciatic nerve is the largest in the body. It has peroneal and tibial components. The sciatic nerve (SN) leaves the pelvis through the larger sciatic foramen under the Piriformis muscle (PM) to become the tibial nerve. After that, the sciatic nerve crosses between the pelvic ischial tuberosity and the bigger femur trochanter, ending at the popliteal fossa.
Aim- Cadaveric research was undertaken to ascertain the differences in the anatomy of the sciatic nerve.

Methods
A cross-sectional investigation was done in 50 equally divided anatomical cadavers of both genders to determine the occurrence of anatomical variations in the SN exit associated with the PM. One of the methods used to acquire the data from the bodies of equal males and females involved dissecting 100 SN. The gluteal regions of the cadavers had to be in ideal condition and have been kept adequately to enable data collection and dissection, which was one criterion for inclusion.

Results
The study included 52% males and 48% females. The sciatic nerve exited inferior to the PM in 90% of limbs, inferiorly and between the PM's fascicles in 6%, and superiorly and between the fascicles in 4%. Unilateral abnormalities were 12% more common on the left side and 12.5% more frequent in females than males. The SN most often branched in the popliteal fossa (54%), followed by the gluteal region (38%) and the middle third of the thigh (8%).

Conclusion
This study highlights the anatomical variations between the SN and PM, which are crucial for clinical and surgical procedures. Awareness of these variations can enhance diagnostic accuracy and surgical outcomes, particularly in the context of SN-related conditions and interventions.

Recommendation
Further large-scale, multicenter studies are recommended to confirm these findings and provide more comprehensive insights into SN anatomical variations' prevalence and clinical implications.

Keywords: *Sciatic nerve, Piriformis muscle, Anatomical variation, Cadavers*
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INTRODUCTION

The Greek word "Ischiadicus" is the source of the name of the sciatic nerve, which is the largest and longest nerve in the human body. The sacral plexus is the source of it [1,2]. From L4 to S3, the anterior segments of the pelvic branches of the spinal nerve are connected to form the sacral plexus within. The width of the item, approximately 2 cm, is quite near the sacral plexus. The largest sciatic aperture is often where it exits and passes through the pelvis before descending to the gluteal region. The epi-

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neural sheath, which encloses the solitary nerve that powers the piriformis muscle, is the outermost layer.

Near the top nerve of the popliteal fossa, the sciatic nerve splits into the tibial nerve (TN) and the CPN. It innervates the hamstring muscles and supplies sensory information to the hip and knee joints, performing dual sensory and motor functions in the leg and foot. Variation primarily focuses on how the SN and the piriformis muscle are related. Sometimes, when the SN is still inside the pelvis, it divides into its terminal branches, creating many exit routes from the pelvis. Based on variations in the nerve's natural lower leg route and proximity to the piriformis muscle, it is classified into several varieties [2–7]. The internal twin-obturator complex and the SN are closely related anatomically. The relationship between passive hip rotation and the SN results in reliable and repeatable dynamic behavior. This correlation could provide insight into the pathologic mechanisms underlying the obturator's internal twin syndrome [8].

Together with computed tomography, Magnetic Resonance Imaging (MRI) is a sophisticated procedure continually improving. It is utilized to find out nerve inflammation and evaluate the PM's thickness. A noteworthy advancement in recent years is MRI neurography, which provides an additional non-invasive diagnostic means of evaluating nerves and plexuses. Compared to other study methods, it allows for the direct visualization of nerve structures, leading to higher diagnostic precision [9].

Conditions such as piriformis syndrome may arise from deviations in the anatomic framework of the SN concerning the PM. This must be considered to avoid nerve damage after receiving medical processes, including hip arthroplasty and pelvic surgery. Spinal cannulation and intramuscular injections of the femoral artery during cardiac surgery [10]. It is essential to possess a thorough comprehension of the usual composition and relationships throughout the human body when doing medical or surgical operations. Consequently, it's critical to determine the potential anatomical changes that may transpire in this region and to detail each individual's standard distribution anatomical component, in addition to the differences and typical connections that could be made. In the sixth week of embryonic development, the SN develops, and nearing the eighth week, the PM forms. This suggests that anatomical variations could arise progressively before creating the ultimate muscle connection, manifesting at approximately 15 weeks of the developmental process [11].

The aberrant branching SN pattern is essential because it may cause damage during intramuscular injections, which could lead to poor nerve anesthesia, problems during gluteal procedures, or piriformis syndrome formation. It is also advised that anatomical anomalies in the sciatic nerve heighten the risk of damage during hip replacement procedures. This could happen as a direct result of physical harm or as a result of the nerve being compressed and moved during the surgical process [12].

This ailment affects the person's ability to bend their knee joint and impairs their ability to rotate their limb downward and outward [13].
The present cadaveric research was undertaken to ascertain the differences in the anatomy of the sciatic nerve.

MATERIALS & METHOD

Study Design

A prospective-descriptive cross-sectional survey

Study Setting

The study was carried out at Sadar Hospital, Jehanabad, Bihar, India, spanning from June 2023 to July 2024.

Participants

50 physical cadavers of both genders, to find out how common it was for the SN to exit the body around the PM.

Inclusion Criteria

Cadavers included had equal gender representation, well-preserved gluteal regions, intact lower limbs, and no prior hip or pelvic surgery.

Exclusion Criteria

This study does not include cadavers whose gluteal areas were not in excellent condition or well-preserved.

Procedure

Equal amounts of male and female bodies were dissected to extract 100 SN as part of the data collection procedure. The gluteal regions of the cadavers are required to be in perfect health and be conserved for them to be used for dissection and data gathering. The data collection aimed to process this information, gather it, and obtain it in a predetermined and verified manner.

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Statistical Analyses

Microsoft Word and Microsoft Excel were used to organize and visualize the data and record the research's results, conclusions, and recommendations.

Ethical considerations

The study protocol was approved by the Sadar Hospital Ethics Committee and written informed consent was received from all the participants.

RESULTS

Table 1- Anatomical Variations of the SN

Parameter	**Number**	**Percentage**
Number of anatomical bodies	50	100
Sciatic Nerve	100	100
Sex		
Male	26	52
Female	24	48

To detect and identify variations in SN with the PM, 100 SN were excised from equal numbers of male and female corpses. The study examined these variants' frequency, pattern, and evolution (Table 1).

Table 2- Anatomical variations.

Anatomical variations	**Number**	**Percentage**
Inferior to the PM	90	180
Between the fascicles of the PM and inferior to the PM	6	12
Between the fascicles of the PM and superior to the PM	4	8
Anatomical variations of the SN exit from the pelvis among gender		
Male	4/52	15.38
Female	6/48	25
Anatomical variation of the SN according to the side of the body		
Unilateral	10	200
Bilateral	10	0

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Side of anatomical variation of the SN		
Right	4/50	16
Left	6/50	24

According to the analysis, the SN exits 90 lower limbs (90%), between the PM's fascicles and inferior to the PM in 6 lower limbs (6%), and between the PM's fascicles and superior to the PM in 4 thighs (4%). The left side of the body experienced unilateral anatomical changes more frequently (12%) than the right side (8%), and females had them more frequently (12.5%) than males (7.69%). It's crucial to remember, nevertheless, that the small sample size of cadavers used in this study means that these results lack statistical significance (Table 2).

Table 3- Region of Division

Region of Division	**Number**	**Percentage**
Gluteal region	38	38%
The middle third of the thigh	8	8%
Proximal part of the popliteal fossa	54	54%

According to the research, the sciatic nerve branches more frequently in the gluteal region in 38% of cases, in the upper part of the popliteal fossa in 54%, and the middle part of the thigh in 8% of instances (Table 3).

DISCUSSION

The study analyzed 50 cadavers, equally distributed between males and females, to examine the anatomical variations of the sciatic nerve (SN) about the piriformis muscle (PM). The findings revealed that in 90% of the lower limbs, the SN exited inferior to the PM, while in 6% of the cases, it passed inferiorly but between the fascicles of the PM, and in 4% of the cases, it exited superiorly between the PM's fascicles. This indicates that the vast majority of the SN follows a predictable path inferior to the PM, but a significant minority exhibit variation that could have clinical implications, especially during surgical interventions.

The study also observed that unilateral anatomical abnormalities were more common on the left side (12%) compared to the right side (8%), and were more frequently found in females (12.5%) than in males (7.7%). These findings suggest a potential predisposition based on side and gender, which could be important for clinicians to consider when diagnosing or treating conditions related to SN, such as piriformis syndrome.

Furthermore, the research identified that the SN branches most frequently in the proximal part of the popliteal fossa (54%), followed by the gluteal region (38%), and less commonly in the middle third of the thigh (8%). This distribution highlights the importance of understanding the typical branching patterns of the SN for surgical planning, nerve block procedures, and the management of nerve-related pain, as variations in these regions could increase the risk of complications.

Overall, the study underscores the need for healthcare professionals to be aware of the potential anatomical variations of the SN to enhance diagnostic accuracy and surgical precision, particularly in procedures involving the lower limbs and the pelvis.
Different clinical manifestations may occur when the SN, CPN, or TN are compressed [14,15]; a study distinguished between several PM and SN forms in 240 instances [16]. They added 480 specimens to their analysis the following year [17] Beaton and Anson's classification, which they developed [16], was as follows: Six types make up the classification: Type 1 is an undivided muscle and nerve; Type 4 muscles are split between heads; Type 5 muscles are split nerve between and above heads; Type 6 muscles are divided above the undivided muscle; Type 2 muscles are divided within and below the undivided muscle; and Type 3 muscles are divided between and beneath the undivided muscle.

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For surgical treatments that affect the SN territory and the gluteal area, it is helpful to know how the SN normally exits the abdominal cavity and whether there are any abnormalities in its connection with the PM [18]. Four cases of piriformis syndrome were documented clinically throughout their study. The gluteal region of each patient was assessed by diagnostic ultrasonography, which they found revealed anatomical alterations of the sciatic nerve (SN) [19].

This implies that ultrasonography could improve the accuracy of injections and surgical treatments while lowering related problems, especially when PM and the sciatic nerve have structural variances. The study revealed that the SN placed below the PM in 90 lower limbs (90%), with structural anomalies occurring in 10% of cases.

A study looked at 112 lower limbs to examine the relationship between the SN and the PM. A normal SN architecture was detected in 75% of the lower limbs [20]. However, in 25% of the patients, abnormalities in the SN-PM connection were noted. In 5% of the patients, trifurcation was observed in the SN. According to research, 10% of anatomical changes in the SN's departure from the PM were found to occur [21].

A study's findings showed that the incidence rate of anatomical changes in the SN's departure concerning the PM was ten percent [21]. The most common place where the supernova divided into its terminal branches occurred in the popliteal fossa's proximal region, accounting for 75% of instances. Budhiraja and colleagues studied 31.7% of the SN discovered in 60 lower limbs, revealing anatomical irregularities related to the PM. In particular, the SN was discovered to appear in between and beneath the single PM in 13.39% of cases.

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The tibial nerve emerged below the PM, while the common peroneal nerve erupted above it in 18.3% of cases [22]. In a similar investigation, researchers examined 56 people with disorders of the lower limbs [23]. They found that 92.90% of the cases had normal SN architecture and that the remaining four instances (7.1%) exhibited SN morphological changes. The largest study, comprising 294 lower limbs [24]. In 93.6% of the 275 limbs analyzed, the PM and the SN connection matched the traditional anatomical pattern, according to their research article.

The tibial nerve, which is located below the PM, was crossed by the major peroneal nerve in 4.1% of instances. The common peroneal nerve crossed the PM in 0.3% of cases and went under the tibial nerve in others. Both nerves pierced the PM in 0.3% of the cases. Two nerves reached the PM in one instance (0.3%). Finally, in four cases (1.4%) nonclassified anatomical alterations were seen [24].

Eighty-two dead black Kenyans were studied for differences in their SN. The SN broke outside the pelvis in 79.9% of instances, whereas it split inside the pelvis in 20.1% of cases, according to their findings [25]. Under the piriformis muscle in these situations, the SN persists as a single branch. Following a thorough examination, [26] discovered that the transmission of the common fibular nerve through the piriformis muscle fibers accounted for the bulk of morphological abnormalities (33.3%).

They also proposed a possible connection between this illness and the sickness known as Piriformis. A meta-analysis [27] was carried out in a thorough systematic review to examine the prevalence of SN variations in PM across several geographic groups, accounting for laterality and gender. The study discovered that, with a pooled prevalence of all variations at 31%, SN variants were more common among East Asians. Nevertheless, there were no statistically significant variations in the prevalence according to laterality or gender. When examining the telltale signs and symptoms of diseases affecting the lower limbs, it is crucial to consider these variations.

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Given these discrepancies, the study supports conducting additional research on a more diverse region to confirm the associations between this PM and the structural variation. Additionally, this would indicate additional light on how common these mutations are. To ensure the safe execution of operations, surgeons still require authentic laboratory anatomical dissections, even with the developments in neurosurgery and 3D technologies [28]. The exact localization and documented variety of the sciatic nerve (SN) following hip surgeries may serve to mitigate the risk of inadvertent injury. Since the SN's path and bifurcation can vary greatly, it is best to use ultrasonography to precisely pinpoint the SN's position and bifurcation point before doing nerve blocks.

Applying ultrasound technology can potentially improve outcomes and reduce the incidence of sciatic or popliteal block issues. The small number of cadavers in the sample is the main limitation of this study. The anatomical study's reliance on data from a single place, which leads to the constant application of a uniform dissection technique, is another limitation. As such, there is very little chance of missing some anatomical differences. This could make it challenging to evaluate the degree and risk of bias. By

gradually examining the 50 anatomical entities that met the inclusion criteria, this bias was lessened.

To evaluate if certain structural anomalies are present and how frequently they occur in the SN, further prospective studies involving a sizable sample size should be conducted in a worldwide, multicenter setting.

GENERALIZABILITY

The generalizability of this study is limited by its relatively small sample size and the focus on a specific population from Bihar. While the findings provide valuable insights into anatomical variations of the sciatic nerve, broader studies with larger and more diverse populations are necessary to confirm these results and enhance their applicability to different demographic groups.

CONCLUSION

The study highlights significant anatomical variations in the sciatic nerve's relationship with the piriformis muscle, with the majority exiting inferior to the muscle but notable deviations observed. These variations, more common on the left side and in females, underscore the importance of considering individual anatomical differences in clinical and surgical practices to enhance accuracy and reduce the risk of complications. According to the research, the SN leaves the pelvis beneath the PM in 90% of cases, with anatomic variations occurring in 10% of cases.

In addition, the findings indicate that the SN typically splits into its terminal branches, with the gluteal region (38%) and the proximal part of the popliteal fossa (54%) being the most prevalent locations. Highlighting the possible anatomical variations of the SN nerve and its importance for different clinical and surgical therapies related to the SN may improve awareness of health science research and its applications.

LIMITATION

The small number of cadavers in the sample is the leading study limitation. The anatomical analysis's reliance only on data from one institution, which leads to the ongoing use of the same dissection method, is a further limitation.

RECOMMENDATION

Large-scale research must confirm these findings, and additional prognostic markers should be considered. A multicenter study could provide more comprehensive insights into the prevalence.

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LIST OF ABBREVIATIONS

SN - Sciatic Nerve
PM - Piriformis Muscle
TN - Tibial Nerve
CPN - Common Peroneal Nerve
MRI - Magnetic Resonance Imaging

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No funding was received.

CONFLICT OF INTEREST

The authors have no conflicting interests to declare.

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