Section: Anatomy

Original Research Article

# A HUMAN CADAVERIC STUDY ON THE SCIATIC NERVE: VARIATIONS IN BIFURCATION LEVEL IN RELATION TO THE PIRIFORMIS MUSCLE

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*Received* : 20/02/2024
*Received in revised form* : 30/04/2024
*Accepted* : 14/05/2024

*Keywords:*
*Sciatic nerve, Piriformis muscle, Bifurcation, Beaton and Anson classification.*

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DOI: 10.47009/jamp.2024.6.3.5

Source of Support: Nil,
Conflict of Interest: None declared

*Int J Acad Med Pharm*
2024; 6 (3); 17-21

## Abstract

**Background:** Understanding the anatomical variations of the sciatic nerve is essential for clinicians and surgeons due to its implications for sciatic neuropathy, piriformis syndrome, and other surgical procedures. This study aims to investigate the variations of the sciatic nerve's bifurcation level concerning the piriformis muscle using a human cadaveric model. **Materials and Methods:** The study was conducted on 30 formalin-fixed cadavers, evaluating a total of 60 lower limb regions. Each region was assessed for the anatomy of the sciatic nerve using Beaton and Anson's classification. Observations focused on the bifurcation levels of the sciatic nerve and its relationship with the piriformis muscle. **Result:** In 52 of the 60 regions (86.67%), the sciatic nerve displayed a normal pathway, exiting the pelvis via the greater sciatic foramen below the piriformis muscle, and bifurcating at the junction of the middle and lower thirds of the thigh near the apex of the popliteal fossa (Type 1 anatomy). In 8 regions (13.33%), variations were observed. Type 1 variations (6 regions, 10%) showed bifurcation below the piriformis muscle at various distances, from 8 mm to 23.3 cm. In two regions (Type 2, 3.33%), the sciatic nerve was already divided in the pelvic region, with the common peroneal nerve piercing the piriformis muscle and the tibial nerve passing below it. **Conclusion:** The study highlights important anatomical variations in the bifurcation patterns of the sciatic nerve, emphasizing the need for clinicians to be aware of these differences during diagnosis and surgical interventions.

## INTRODUCTION

The sciatic nerve, derived from the Greek word "Ischiadichus," is also known as the ischiadic nerve. It is the largest nerve in the human body and originates as a terminal branch of the sacral plexus, with a diameter of 2 cm at its origin.[1,2] The nerve is formed by the fusion of two components: the tibial and the common peroneal nerves. The tibial component originates from the ventral branches of the ventral rami of L4, L5, S1, S2, and S3, while the common peroneal component originates from the dorsal branches of the ventral rami of L4, L5, S1, and S2.[3,4] These components typically fuse and exit the pelvis via the greater sciatic foramen, below the piriformis muscle. In certain cases, the two components remain separate and pass independently, with the common peroneal nerve piercing the piriformis muscle and the tibial nerve passing beneath it.[5,6] The sciatic nerve descends along the posterior thigh between the greater trochanter and the ischial tuberosity before bifurcating into the tibial and common peroneal (fibular) nerves, proximal to the knee.

Superiorly, the sciatic nerve is positioned deep to the gluteus maximus, initially resting on the posterior ischial surface with the nerve to quadratus femoris positioned between them.[7] The sciatic nerve is particularly vulnerable to injury during posterior hip dislocation, prolonged external compression over the buttock, and in immobile patients lying on hard surfaces. It can also be severely damaged by misplaced therapeutic intramuscular injections into the gluteal region, with iatrogenic causes being the most common source of sciatic nerve injury.[8]


ISSN (O): 2687-5365; ISSN (P): 2753-6556

Compression of the sciatic nerve along its course can lead to conditions like sciatica and piriformis syndrome. Sciatica symptoms include pain, numbness, tingling, and weakness, potentially progressing to difficulty walking, depending on where the pressure occurs. Spinal degenerative disc disorders and radiculopathies can also cause sciatica. The piriformis muscle can sometimes entrap the sciatic nerve in the buttock, leading to piriformis syndrome, a painful condition mimicking sciatica and responsible for up to 6% of low back pain cases. This syndrome is a nondiscogenic cause of sciatica, typically resulting from trauma, inflammation, or degenerative changes in the piriformis muscle, but rare anatomical variations can also contribute.[9]

The sciatic nerve block is frequently used for anesthesia or analgesia in various lower limb surgeries. It can be blocked at any point along its course if sufficient ultrasound guidance is available. However, visualization can be challenging due to the muscle and adipose tissue surrounding the nerve. The sciatic nerve usually bifurcates into the tibial and common peroneal nerves at the junction of the middle and lower thirds of the thigh, near the apex of the popliteal fossa. This bifurcation can vary in location, potentially occurring higher in the thigh or even within the pelvis, leading to incomplete sciatic nerve blocks.

Previous studies have documented numerous variations in sciatic nerve bifurcation. Beaton and Anson's classification of sciatic nerve variations in relation to the piriformis muscle has been widely used and is adopted in this study. The present research aims to raise clinical awareness of the sciatic nerve's course and bifurcation variations with respect to the piriformis muscle. Understanding these anatomical relationships is crucial for clinicians performing invasive procedures in the gluteal region, including hip arthroplasty, ultrasound-guided injections, and sciatic nerve blocks, as well as preventing iatrogenic injuries.

## MATERIALS AND METHODS

**Study Design and Setting:** The study was conducted on 60 formalin-fixed lower limb specimens from 30 embalmed adult human cadavers at Guntur Medical College, Guntur, and Government Siddhartha Medical College, Vijayawada. These specimens were sourced from cadavers used in routine dissection sessions for first-year MBBS students.

**Dissection Procedure**

**Initial Exposure:** The gluteal region of each cadaver was exposed by carefully dissecting the gluteus maximus muscle. The muscle was divided midway and reflected medially and laterally to access the structures beneath.

**Piriformis and Sciatic Nerve Identification:** The piriformis muscle was exposed as the key muscle of the gluteal region. The sciatic nerve emerging through the greater sciatic foramen was identified, and the surrounding sheath was carefully dissected.

**Tracing the Sciatic Nerve:** The sciatic nerve was followed through the posterior thigh and popliteal fossa to its point of division. The connective tissue sheaths around the tibial and common peroneal components were also dissected to trace their paths.

**Observations and Measurements:** Emergence and Bifurcation: The emerging site of the sciatic nerve in relation to the piriformis muscle was noted.

**Level of Bifurcation:** The bifurcation level was documented, including the length from the lower border of the piriformis muscle to the division point of the sciatic nerve, measured in centimeters.

**Inclusion Criteria**

Adult cadavers with no lower limb gross abnormalities or fractures.

**Exclusion Criteria**

Cadavers with lower limbs of unequal length, fractures, or gross abnormalities.

**Data Collection and Analysis:** Following the dissection and observation process, each measurement was systematically recorded and analyzed. The anatomical variations were classified based on the classification system developed by Beaton and Anson. The collected data were organized to highlight the emergence and bifurcation patterns of the sciatic nerve, including:

Type of Emergence: The relationship between the sciatic nerve and the piriformis muscle was categorized according to whether the nerve emerged below, through, or above the piriformis.

**Bifurcation Level:** The sciatic nerve's bifurcation into the tibial and common peroneal nerves was measured in centimeters from the lower border of the piriformis muscle, categorizing each observed variation.

**Ethical Considerations**

The study was conducted with respect to ethical guidelines and institutional regulations for research involving human cadavers. The specimens used in this study were anonymized, and all data were handled in a manner that ensured confidentiality and adherence to ethical standards.

**Statistical Analysis:** Statistical analysis was performed using descriptive statistics to summarize the results. The frequency and percentage of variations were calculated, and data were presented in tables to offer a clear understanding of the anatomical patterns. Where appropriate, differences between types were analyzed to identify significant relationships and implications for clinical and surgical practices.

## RESULTS

The study involved observations of the sciatic nerve bifurcation in 30 formalin-fixed cadavers, providing knowledge into both normal and variant anatomical patterns.


ISSN (O): 2687-5365; ISSN (P): 2753-6556

**Normal Anatomy**

In 52 out of 60 lower limb regions (86.67%), the sciatic nerve displayed a normal anatomical pattern consistent with Type 1 of Beaton and Anson's classification. Here, the sciatic nerve exited the pelvis through the greater sciatic foramen below the piriformis muscle, descending between the greater trochanter and the ischial tuberosity. It bifurcated near the apex of the popliteal fossa, at the junction of the middle and lower thirds of the thigh, into the tibial and common peroneal nerves [Table 1].

**Variations in Sciatic Nerve Bifurcation**

Variations in the bifurcation of the sciatic nerve were observed in 8 out of 60 lower limb regions (13.33%), with six cases classified as Variation Type 1 (10%). In these cases, the sciatic nerve bifurcated below the piriformis muscle. More specifically:

In Specimen 1, it divided into the tibial and common peroneal nerves just 8 mm below the piriformis.

In Specimen 2, it divided similarly 2.7 cm below the piriformis.

In Specimen 3, it bifurcated between the ischial tuberosity and the greater trochanter, 12.5 cm below the piriformis.

In Specimen 4, the bifurcation occurred at the lower border of the gluteus maximus, 15.5 cm below the piriformis.

In Specimen 5, the division occurred in the upper third of the thigh, 18.3 cm below the piriformis.

In Specimen 6, the bifurcation was at the mid-thigh level, 23.3 cm from the piriformis.

Variation Type 2 (3.33%) was noted in two specimens where the sciatic nerve was already divided in the pelvic region. Here, the common peroneal nerve pierced the piriformis muscle while the tibial nerve passed below it [Table 2].

**Table 1: Normal Anatomy of Sciatic Nerve (Type 1 Beaton and Anson's Classification)**

| Characteristic | Observation |
|---|---|
| Number of Lower Limb Regions Observed | 60 |
| Regions Showing Type 1 (Normal Anatomy) | 52 (86.67%) |
| Normal Sciatic Nerve Pathway | Exits pelvis via greater sciatic foramen below the piriformis muscle, descends between greater trochanter and ischial tuberosity, divides at the junction of middle and lower thirds of the thigh |
| Dividing Point | Near apex of popliteal fossa |

**Table 2: Variations in the Sciatic Nerve Bifurcation**

| Variation Type | Frequency (%) | Characteristics |
|---|---|---|
| Variation Type 1 | 6 (10%) | Bifurcates below piriformis muscle |
| Variation Subtypes: | | |
| Specimen 1 | | Divides into tibial and common peroneal nerves 8 mm below piriformis |
| Specimen 2 | | Divides into tibial and common peroneal nerves 2.7 cm below piriformis |
| Specimen 3 | | Bifurcates between ischial tuberosity and greater trochanter, 12.5 cm below piriformis |
| Specimen 4 | | Bifurcates at the lower border of gluteus maximus, 15.5 cm below piriformis |
| Specimen 5 | | Bifurcates in upper third of the thigh, 18.3 cm from piriformis |
| Specimen 6 | | Bifurcates at mid-thigh level, 23.3 cm from piriformis |
| Variation Type 2 | 2 (3.33%) | Divides in pelvic region, remains separate; common peroneal nerve pierces piriformis while tibial nerve passes below it |

**Figure 1: Common Peroneal Nerve Piercing the Piriformis Muscle and Tibial Nerve Passing Below the Piriformis Muscle**

**Figure 2: Bifurcation Immediately Just Below the Piriformis Muscle**


ISSN (O): 2687-5365; ISSN (P): 2753-6556

**Figure 3: Bifurcation in the Gluteal Region Exactly at the Lower Border of Gluteus Maximus**

**Figure 4: Common Peroneal Nerve Piercing the Piriformis Muscle**

**Figure 5: Nerve Dividing in the Gluteal Region**

**Figure 6: Sciatic Nerve Bifurcation in the Region of Mid Thigh**

## DISCUSSION

During embryonic development, the nerves of the lower limb form the lumbar and sacral plexuses at the base of the limb bud, from which the dorsal and ventral components subsequently develop. The sciatic nerve, which is the largest branch of the lumbosacral plexus, is composed of the ventral and dorsal divisions of the ventral rami of the L4, L5, S1, S2, and S3 spinal nerves. It forms through the convergence of the dorsal (common peroneal) and ventral (tibial) components. Due to this structure, the common peroneal and tibial components may separate at various levels.

Several studies have highlighted variations in the sciatic nerve's branching pattern, particularly in relation to the piriformis muscle. Understanding these variations has significant clinical importance in surgical and therapeutic procedures involving the lower limb, such as sciatic nerve blocks, treatments for sciatica and piriformis syndrome, and hip replacement surgeries. Anatomical variations are often linked to specific clinical presentations, underscoring the importance of studying the sciatic nerve.

In this study, among the 60 lower limb specimens examined, 52 (86.67%) showed an undivided sciatic nerve passing below the undivided piriformis muscle. The nerve descends beneath the gluteus maximus, between the ischial tuberosity and greater trochanter, and reaches the posterior thigh. At the superior angle of the popliteal fossa, it divides into the tibial and common peroneal nerves, consistent with Type 1 (or Type A) of Beaton,[10] and Anson's classification.[11] This pattern aligns with prior studies by Beaton and Anson, who observed this type in 84.36% of 120 cadavers and 90% of 240 cadavers, respectively. Similarly, Antoni D et al.[12] found Type 1 in 96% of 100 fetuses, G. Mbaka et al.[13] found it in 76% of 50 extremities in the Nigerian population , and Guvencer et al.[14] observed it in 76% of 50 lower limb specimens.

In the remaining eight specimens (13.33%), variations were observed in the bifurcation level in relation to the piriformis muscle. In two specimens (3.33%), the common peroneal nerve pierced the piriformis muscle while the tibial nerve passed beneath it, resembling Type 2 (or Type B) of Beaton and Anson's classification. Ambumani T.L. et al,[15] observed this pattern in 4% of 50 cadavers, and Antoni D. et al. found it in one of 52 cadavers.

## CONCLUSION

This study provides valuable knowledge into the anatomical variations of the sciatic nerve, particularly in relation to its bifurcation level. Our findings reveal that while the sciatic nerve typically divides at the popliteal fossa (Group F classification), variations can occur at higher levels like the pelvis, gluteal region, and upper or mid-thigh. These differences have significant clinical implications, affecting procedures such as sciatic nerve blocks and hip surgeries. Understanding these variations enhances preoperative assessments, helping prevent injuries and optimize surgical outcomes. Further research on diverse populations is crucial for better therapeutic and surgical planning.


ISSN (O): 2687-5365; ISSN (P): 2753-6556

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ISSN (O): 2687-5365; ISSN (P): 2753-6556