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Anatomical Variations of the Sciatic Nerve: High Division and Trifurcation and its Clinical Implications

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Abstract

Background: The sciatic nerve, the widest nerve in the body, plays a crucial role in lower limb sensory and motor functions. It consists of two components—the tibial nerve and common peroneal nerve - originating from the lumbosacral plexus, specifically the ventral rami of L4 to S3 spinal nerves. While anatomical variations such as high division and trifurcation are relatively rare, they have significant clinical implications.

Materials and Methods: This study assessed the incidence of high division and trifurcation of the sciatic nerve using 64 lower limb specimens from 32 formalin-fixed cadavers, provided by the Department of Anatomy at our institution. The sample included 16 males and 16 females. Dissections involved exposing the gluteus maximus to observe the sciatic nerve's relationship with the piriformis muscle and examining the nerve's course and branching variations in the posterior thigh.

Results: Out of the 64 lower limbs, 51 (79.6%) exhibited normal sciatic nerve anatomy. Variations were observed in 13 lower limbs (20.1%). Of these, 11 limbs (17.1%) showed high division of the sciatic nerve, predominantly in males (8 limbs, 12.5%) compared to females (3 limbs, 4.6%). Additionally, 2 lower limbs (3.1%) exhibited trifurcation, both in females.

Conclusion: Understanding these anatomical variations is essential for addressing challenges in medical and surgical contexts, helping to reduce complications and improve patient outcomes.

Keywords: Common Peroneal Nerve, High Division, Piriformis, Sciatic Nerve, Tibial Nerve, Trifurcation

Introduction

Sciatic nerve is a broad, thickest and the largest nerve of body, consisting of two components namely the tibial and common peroneal component, both of which initially form a common trunk from the lumbosacral plexus. The tibial component is from the ventral branches of ventral rami of L4 to S3 spinal nerves. The common peroneal component is from the dorsal branches of ventral rami of L4 to S2 spinal nerves [1] [2]. Sciatic is a Greek word derived from "Ischiadichus" and hence it is called as ischiadic nerve [3].

Normally it emerges through the greater sciatic foramen, leaves pelvis and enters into gluteal region by passing below piriformis as a single nerve encompassed by a single epineural sheath. It divides subsequently into two terminal branches i.e., tibial nerve and common peroneal nerve, usually at superior

angle of popliteal fossa. There are both motor and sensory fibers in it. The motor branches of the nerve supply the posterior group of thigh muscles as well as two joints of the lower limb: femoral and knee joint. Its sensory branches supply the whole tibial and foot areas with the exception of the anteromedial tibial region and the medial margin of the foot [4].

The point of division of the sciatic nerve into the tibial and the common peroneal nerve is variable. The common site is at the junction of the middle and lower thirds of the thigh, near the apex of the popliteal fossa. The division may occur at any level from the pelvis to the superior angle of the popliteal fossa [3 – 8]. Variations in the exit of sciatic nerve in relation to piriformis muscle may lead to nerve compression, which may result in piriformis syndrome.

High division of the sciatic nerve, where it branches into the tibial and common fibular nerves higher in the thigh, occurs in 10-20% of people. This variation can cause compression-related issues like piriformis syndrome and incomplete nerve blocks during anesthesia, leading to muscle paralysis, impaired knee flexion, and affected plantar flexion. It increases the risk of nerve injury during hip and thigh surgeries, necessitating careful preoperative planning and surgical technique, and may also complicate nerve block effectiveness and diagnosis [9 – 13].

Trifurcation, where the sciatic nerve divides into three branches, which may include the tibial nerve, common fibular nerve, and an additional nerve such as the medial or lateral cutaneous nerve of the thigh, is less common, occurring in under 5% of people. This variation complicates surgeries and regional anesthesia due to the presence of extra branches. Detailed preoperative imaging and precise technique are crucial to avoid functional impairments. Accurate neurological assessment is also essential, as trifurcation can lead to atypical presentations of nerve injuries or neuropathies. [9 – 13].

Hence, the present study aimed to assess the incidence of high division and trifurcation of the sciatic nerve in cadavers during routine dissections. These anatomical variations can present challenges in medical and surgical contexts, making it essential to understand them to reduce complications and improve patient outcomes.

Materials & Methods:

Sixty-four lower limb specimens from thirty-two formalin-fixed cadavers, all without gross pathology, were used for this study. The cadavers belong to the Department of Anatomy at our institution, included 16 males and 16 females. This study was conducted during routine dissection classes for medical undergraduates over an 18-month period. Each cadaver was numbered sequentially. Dissection of the gluteal region involved exposing and cleaning the Gluteus maximus muscle to reveal the structures underneath. The Piriformis muscle and its relationship to the sciatic nerve and its branches were observed and recorded. Additionally, the posterior compartment of the thigh was dissected to examine the sciatic nerve's course, branching variations, and points of bifurcation and trifurcation.

Results:

Thirty two formalin fixed cadavers comprising of 64 lower limbs were used for this study. Among them 51 lower limbs (79.6 %) showed a normal anatomy of the sciatic nerve. Thirteen lower limbs (20.1 %) showed variations in the sciatic nerve. Of the thirteen lower limbs (20.1 %), the eleven lower limbs (17.1 %) show variations of the higher division of sciatic nerve in relation to piriformis muscle, of which eight lower limbs (12.5 %) are male, and three lower limbs (4.6%) are of female. The rest two lower limbs (3.1 %), showed trifurcation of sciatic nerve are of females.

Moreover, the rest two female lower limbs (3.1 %), shows variations of the sciatic nerve in relation to popliteal region of the thigh. One specimen showed trifurcation of sciatic nerve on right side lower limb which is divided into three major divisions (tibial nerve, Superficial & deep peroneal nerves) in the middle of the popliteal fossa. Another lower limb specimen showed trifurcation of sciatic nerve into tibial, superficial and deep peroneal nerves on the left side at the superior angle of the popliteal fossa.

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Figures 1, 2, 3 Illustrates the sciatic nerve variations observed in this study

Figure.1: Right Gluteal region showing high division of Sciatic nerve into Tibial Nerve (TN) and Common Peroneal Nerve (CPN) under the piriformis muscle.

Figure.2: dissection of Right Popliteal fossa showing trifurcation of the Sciatic nerve (SN) divided in the middle of the popliteal fossa into Tibial Nerve (TN), Superficial Peroneal Nerve (SPN) and Deep Peroneal Nerve (DPN).

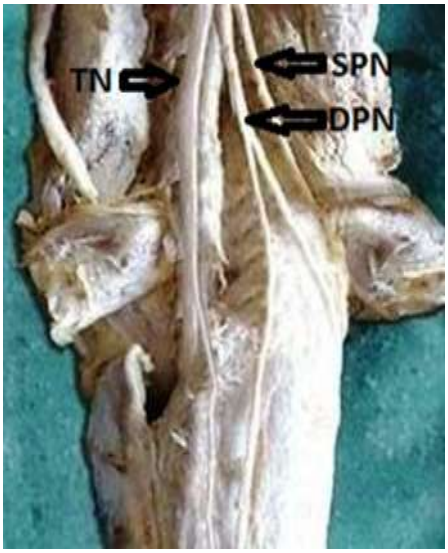

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Figure.3: Dissection of Left Popliteal fossa showing trifurcation of the Sciatic nerve (SN) divided in the middle of the popliteal fossa into Tibial Nerve (TN), Superficial Peroneal Nerve (SPN) and Deep Peroneal Nerve (DPN).

Discussion:

The sciatic nerve, the largest branch of lumbosacral plexus is composed of ventral and dorsal divisions of ventral rami of L4 to S3 spinal nerves. The sciatic nerve is formed when the large dorsal component of the sacral plexus (common fibular nerve) and the ventral component (tibial nerve) move downward close together and hence the common peroneal and tibial components can separate from each other at various levels from their origin [14, 15, 16]. A number of variations in the course and distribution of the sciatic nerve have been reported.

The present study shows eleven lower limbs (17.1%) with two terminal branches of sciatic nerve emerging below the Piriformis muscle directly and descends separately throughout their course. In a study by Shewale et al., 2 % of the specimens showed the common peroneal and the tibial nerve emerge separately below the Piriformis muscle [17]. 15–30 % of the sciatic nerve variations in relation to Piriformis muscle are reported in the previous studies [18]. Beaton and Anson have classified the relationship of sciatic nerve to the Piriformis muscle in 120 specimens in 1937 and 240 specimens in 1948 into six types [19, 20]. Their classification is as follows:

Type 1: Undivided nerve below undivided muscle.

Type 2: Divisions of nerve between and below undivided muscle.

Type 3: Divisions above and below undivided muscle.

Type 4: Undivided nerve between heads.

Type 5: Divisions between and above heads.

Type 6: Undivided nerve above undivided muscle.

In our study, according to Beaton and Anson's classification of the relation of sciatic nerve variation to Piriformis muscle, 79.6 % (51 specimens) belongs to type 1, 17.8% (11 specimens) belongs to type 2. Specimens of type 3, type 4, type 5 and type 6 category of Beaton and Anson's classification are not found in our study.

Zhon L [21] reported that the sciatic nerve divided at a range of 40-120mm above the popliteal crease. In the Rajendran et al., [22] division was noted about 24mm above popliteal crease. This shows that the nerve is divided in the low level of the popliteal fossa.

Nayak S [23] reported a trifurcation of Sciatic nerve in the middle of the popliteal fossa into the tibial nerve, common peroneal nerve and an abnormal trunk. The abnormal trunk was divided into lateral cutaneous nerve of the calf and peroneal communicating nerve. Another case report by Sawant S.P [24] reported bilateral trifurcation of the sciatic nerve in the middle of the popliteal fossa into the tibial superficial, deep peroneal nerves. Birhane Alem Berihu [25] study also reported, the Sciatic nerve was trifurcated in the low level of the popliteal fossa into the tibial, common peroneal nerve, peroneal communicating nerve and lateral sural nerve was absent. In the present study, two (3.1%) female lower limb specimens showed the trifurcation of sciatic nerve is divided in the middle of

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the popliteal fossa into tibial nerve (TN), Superficial Peroneal nerve (SPN) and Deep Peroneal nerve (DPN).

Conclusion:

Understanding sciatic nerve variations, such as high division and trifurcation, is crucial for effective clinical practice, influencing surgical procedures, anesthesia, and neurological assessments. Proper preoperative imaging, including high-resolution ultrasound and MRI, is essential for mapping nerve anatomy to minimize injury risks. Surgeons and anesthesiologists should adapt their techniques based on these variations to ensure successful interventions. Postoperative monitoring of nerve function is also critical for promptly addressing complications, with ongoing research and advancements in imaging potentially enhancing our ability to manage these variations effectively.

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