

Anatomic Variation of the Sciatic Nerve: A Study on the Prevalence, and Bifurcation Loci in Relation to the Piriformis and Popliteal Fossa

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Abstract

Objective. To examine and identify sciatic nerve variations in relation to the piriformis muscle, its prevalence, pattern and the course of its bifurcation loci. **Materials and Methods.** Twenty-eight formalin fixed male cadavers comprising 56 lower limbs were used for this study. Dissection of the gluteal region and posterior compartment of the thigh was conducted to expose the sciatic nerve. Variations in the sciatic nerve anatomy, their relationship to the piriformis muscle and points of bifurcation, and other observable features were noted and recorded. **Results.** Fifty-two lower limbs (93%) showed normal anatomy of the sciatic nerve. Four regions (7.1%) showed variations in the morphology of the sciatic nerve. Of these, one (1.8%) showed a variation of the sciatic nerve with the piriformis muscle. This single case showed a common peroneal nerve emerging on the left between the heads of a double piriformis muscle - a variant not described in the original Beaton and Anson classification, with the tibial nerve deep to the muscle. In two other limbs, the sciatic nerves showed a normal relationship with the piriformis, but had variations in the bifurcation loci (bilateral). The divisions were in upper third and middle third of the right and left thighs respectively. **Conclusion.** Knowledge of the level of bifurcation and distribution of the sciatic nerve and its location is important. This nerve is commonly encountered by neurologists, orthopaedics, and anaesthesiologists. The uncommon anatomical findings described are relevant to surgeons to enable them to perform efficient surgical procedures and avoid errors.

Key Words: Sciatic Nerve ▪ Bifurcation Loci ▪ Piriformis ▪ Sciatica.

Introduction

The sciatic nerve is the largest nerve in the human body, formed by the union of five nerve roots (L4-S3) arising from the lumbosacral. It carries two nerve components, namely: the tibial component (L4, 5, S1, S2, and S3) and the common-peroneal component (L4, 5, S1, and S2) (1). This nerve, in normal anatomy, enters the gluteal region from the pelvis through the greater sciatic foramen, passing inferior to the piriformis muscle. It follows a descending path along the posterior thigh, up to the proximal region of the popliteal fossa, where it divides into its terminal branches: the tibial nerve and the common peroneal nerve. The detailed anatomy of the sciatic nerve has been described elsewhere (2). However, variations from

the classical descriptions have been observed concerning the location where the nerve divides, as well as its relationship to the piriformis muscle (3).

Reports suggest that certain variations of the sciatic nerve, as it emerges into the gluteal region, may be the cause of sciatica and piriformis syndrome (4, 5). Six per cent of low back pain cases are caused by piriformis syndrome, a painful condition that mimics sciatica and is ancillary to sciatic nerve entrapment (6, 7). It was also suggested that incomplete sciatic nerve block during popliteal block anaesthesia could be caused by the sciatic nerve terminating high-up or in the proximal thigh (8). To avoid iatrogenic injuries caused by clinical procedures, such as hip arthroplasty or pelvic surgery, clinicians need detailed knowledge of the anatomical variations of the sciatic nerve

and piriformis muscle (9, 10). Spinal degenerative disc disorders or spinal radiculopathies can cause sciatica, although piriformis syndrome is responsible for up to 6-8% cases of sciatica (11). Studies suggest that pain in the buttock or posterior hip, arising from non-discogenic or extra-pelvic entrapment of the sciatic nerve, may indicate piriformis syndrome (12).

Hence, the purpose of this present study was to examine sciatic nerve variations with the piriformis muscle, its pattern and course of bifurcation loci, in the black population of sub-Saharan Africa. Beaton and Anson's classification method for sciatic nerve variation with the piriformis (12) was employed in this study, just as it was previously used by several others (13, 14).

Materials and Method

Fifty-six lower limbs from 28 formalin fixed male cadavers, without any clinical data of gross pathology, were examined during routine dissection in the Gross Anatomy Laboratory of the Niger Delta University, Wilberforce Island, Bayelsa State. The gluteal regions of these cadavers were carefully dissected and the gluteus maximus muscle retracted to expose the piriformis muscle and sciatic nerve.

The posterior compartment of the thigh was also dissected, and the long head of the biceps femoris was separated from the semitendinosus muscle, to further expose the course of the sciatic nerve in the posterior compartment of the thigh. The sciatic nerve variation pattern in relation to the piriformis, the frequency and distribution of sciatic nerve bifurcation loci were examined, identified, recorded, and photographed. Data were collected for a period spanning five years. Anatomical variations were identified and classified on the basis of the Beaton and Anson classification system (12), which categorises structural variations of the sciatic nerve with the piriformis muscle in the gluteal region into six (6) types (Figure 1).

- a) Type-1: undivided nerve below undivided muscle
- b) Type-2: divisions of nerve between and below undivided muscle

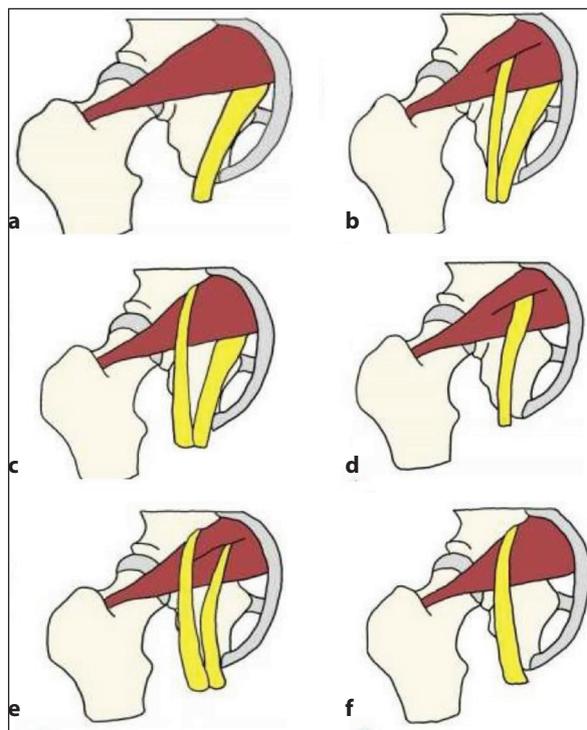


Figure 1. (a – f): Anatomic variations of the relationship between the piriformis muscle and sciatic nerve. Diagrams illustrate the six variants originally described by Beaton and Anson (a) An undivided nerve comes out below the piriformis muscle (normal course); (b) A divided sciatic nerve passing through and below the piriformis muscle; (c) A divided nerve passing above and below an undivided muscle; (d) An undivided sciatic nerve passing through the piriformis muscle; (e) A divided nerve passing through and above the muscle heads; (f) An undivided nerve above undivided muscle (15).

- c) Type-3: divisions above and below undivided muscle
- d) Type-4: undivided nerve between heads
- e) Type-5: divisions between and above heads
- f) Type-6: undivided nerve above undivided muscle

Ethical Statement

In Nigeria, government hospitals and prisons are required to release the corpses of bandits or criminals and unclaimed bodies to medical schools to aid in the training of medical students. At least 80% of all cadavers in Nigerian medical schools are from bandits or criminals that were killed in

conflicts with law enforcement agents; less than 10% are unclaimed corpses (16, 17). Once received by a department of anatomy, such bodies are available for teaching, learning, and research. By convention, cadaveric study within a gross anatomy laboratory does not require special ethical approval. Photography that may reveal identification is strictly prohibited. Respect and courtesy are observed when working with these cadavers.

Results

In this study, 52 (92.9%) out of 56 dissected lower limbs of human cadavers showed normal anatomy of the sciatic nerve, piriformis muscle, and their relationship (Figure 2), which corresponds to type-1 according to Beaton and Anson's classification (Figure 1a). Four (7.1%) limbs showed variations in the anatomy of the sciatic nerve. The most prevalent variation showed the common peroneal nerve passing through the piriformis muscle and the tibial nerve passing below. This variation is type-2 according to Beaton and Anson's classification. The two (3.6%) lower limbs of a particular cadaver showed a bilateral variation of the sciatic nerve in relation to the piriformis muscle: on the right limb, the common peroneal nerve emerged through the piriformis and the tibial nerve below, with both descending distinctly. On the left limb, the common peroneal nerve emerged between the heads of a double piriformis (double head piriformis), while the tibial nerve passed beneath the muscle (Figure 3). In both extremities in another cadaver (3.6%, bilateral), the sciatic nerve bifurcation occurred in the thigh at different locations in the right and left thighs. On the left, it was at the mid-thigh, and on the right at the upper one-third of the thigh, with a rare communicating twig connecting the common peroneal nerve to the tibial nerve (Figure 4).

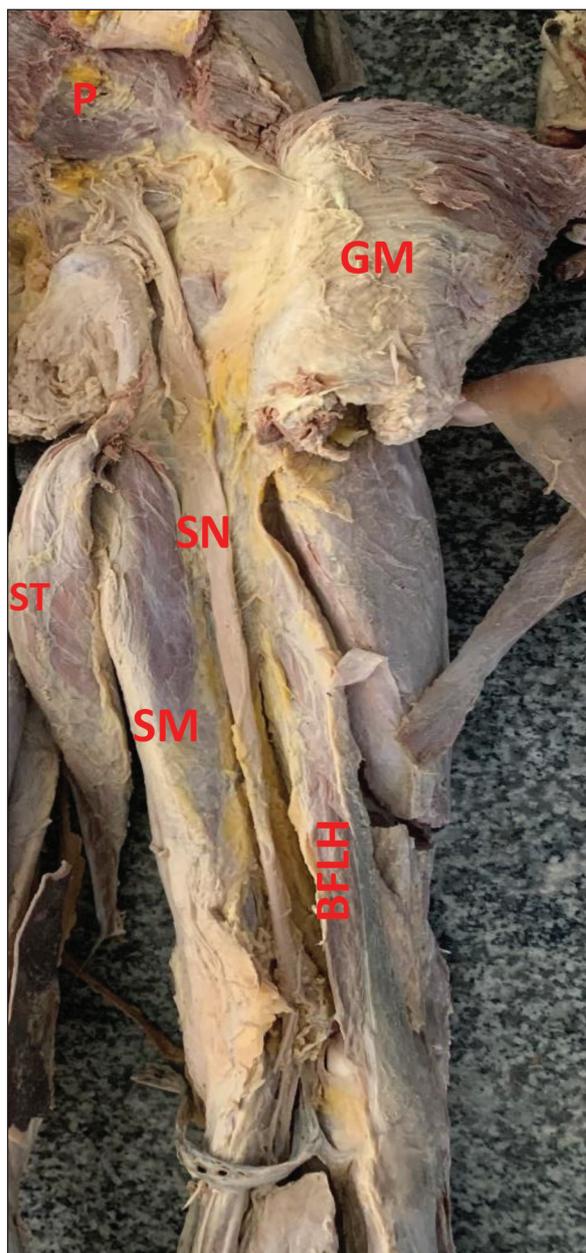


Figure 2. Picture of a dissected right lower limb showing the normal anatomy of the piriformis muscle (P); Gluteus maximus (GM); Sciatic nerve (SN); Semitendinosus (ST); Semi-membranosus (SM); Biceps femoris (long head) (BFLH).

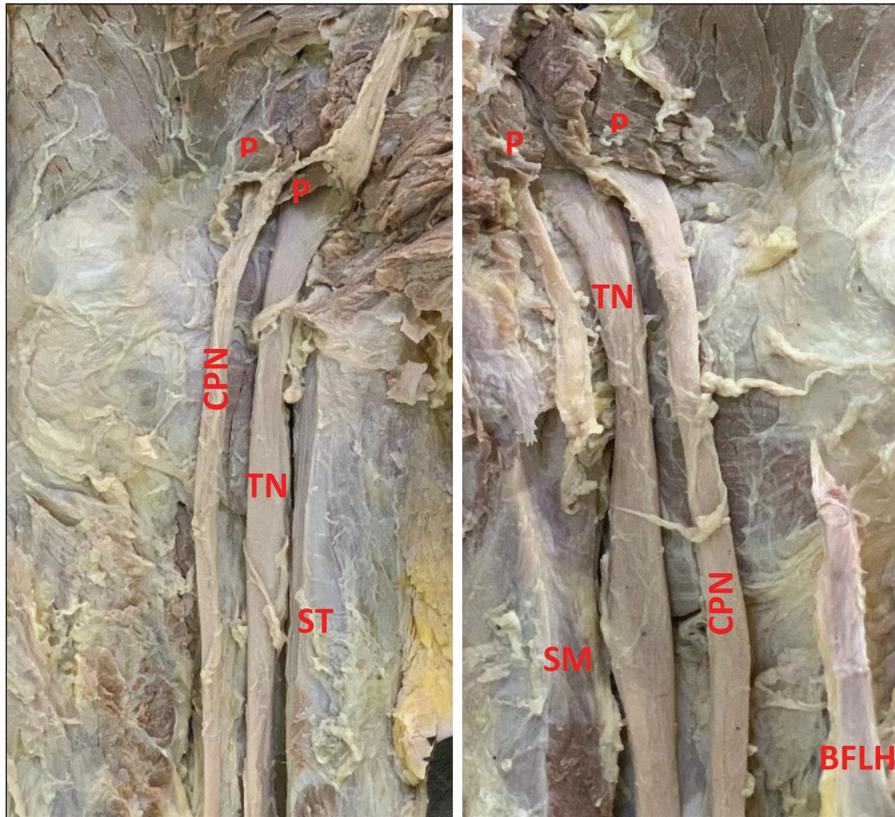


Figure 3. A bilateral variation of the sciatic nerve in relation to the piriformis muscle. A) Left lower limb showing divided piriformis muscle (P), with the common peroneal nerve (CPN) passing through and the tibial nerve (TN) below it, and both nerves descending separately. Semitendinosus (ST). B) Right lower limb showing the piriformis muscle (P), with the common peroneal nerve passing through and the tibial nerve below the muscle. Both nerves descend separately. Semimembranosus (SM), Biceps femoris (long head) (BFLH).

Table 1. Relationship between the Sciatic Nerve and Piriformis Muscle, Reported in a Previous Study Based on Beaton and Anson's Classification

Publications	Type-1 (%)	Type 2 (%)	Type-3 (%)	Type-4 (%)	Type-5 (%)	Type-6 (%)	*Type-7 (%)
Beaton (18)	90	7.1	2.1	0.8			
Beaton & Anson (12)	84.2	11.7	3.3	0.8	-	-	-
Berihu & Debeb (19)	75	11	2	-	-	-	-
Chiba (3)	66	34	-	-	-	-	-
Guvencer et al. (20)	76	16	8	-	-	-	-
Lewis et al. (21)	89	8.8	2.9	-	-	-	-
Machado et al. (22)	82	16	2	-	-	-	-
Ozaki et al. (23)	-	-	-	-	-	*One case	
Pecina (24)	93.1	6.15	-	-	-	-	-
Pokorny et al. (25)	79.1	14.3	4.4	2.2	-	-	-
Singh & Sharma (26)	96	4	-	-	-	-	-
Ugrenovic et al. (27)	96	2.5	1.5	-	-	-	-
Uluutku & Kurtoglu (28)	74	16	10	-	-	-	-
Present study	93	3.5	-	-	-	-	†3.5

*A case report; †Not included in the Beaton and Anson classification.

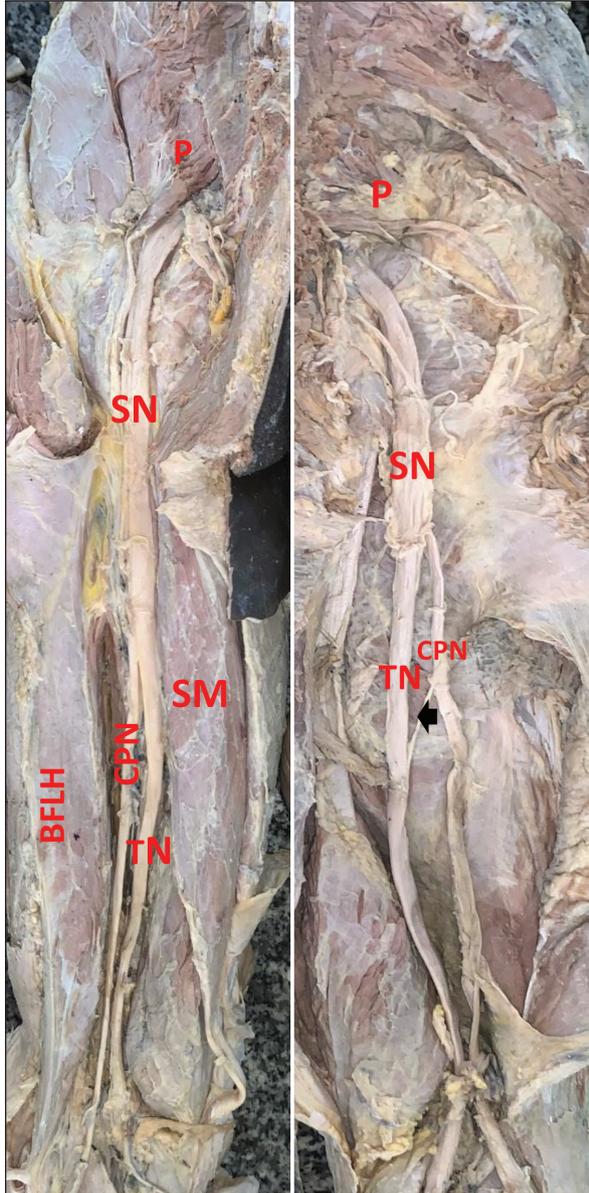


Figure 4. Bilateral sciatic nerve bifurcation variability in the thigh. A) Left lower limb showing undivided piriformis (P), with the sciatic nerve (SN) bifurcation into common peroneal nerve (CPN) and tibial nerve (TN) at the middle of the thigh. Semimembranosus (SM). B) Right lower limb showing undivided piriformis (P), sciatic nerve (SN) division into the common peroneal nerve (CPN) and tibial nerve (TN) in the upper one – third of the thigh, and a rare communicating twig (black arrow head) connecting the common peroneal nerve to the tibial nerve.

Discussion

In this study, we identified 92.9% of lower limbs with normal anatomy of the sciatic nerve in relation to the piriformis muscle, which corresponds to type 1 classification (Figure 1a). In two (3.6%) lower extremities of a particular cadaver, the common peroneal nerve and the tibial nerve were seen passing respectively through and below the piriformis muscle; this is a type-2 variant of the Beaton and Anson's classification and is the most widely reported variation, where the nerves descend separately throughout their course (3, 12). Nevertheless, there are ethnic or regional variations in sciatic nerve anatomy (3, 11, 18-28). Studies with Beaton and Anson's classification (11) show that the types 1 and 2 variations are seen in all human populations (Table 1). Types 1, 2, 3, and 4 were recorded among Americans (11) and Eastern Europeans (25). However, a similar study in an Eastern European population observed only types 1, 2, and 3 (25). Reports suggested that types 1 and 2 were the predominant variations among Indians (26) and Japanese (3, 28) respectively. A study conducted amongst the Ethiopians of sub-Saharan Africa suggested that types 4, 5, and 6 are rare, with only types 1, 2 and 3 observed (19). However, in the present work, we did not see the type-3 of the Beaton and Anson's classification among our study population (sub-Saharan Africa).

We also observed bilateral bifurcations of the sciatic nerves in the proximal half of the thighs in one cadaver, involving 2 (3.6%) limbs. The sciatic nerve bifurcates at the level of the upper third of the thigh on the right and the mid-thigh on the left. This observation suggests that the sciatic nerve can divide into its terminal divisions at any level in the thigh, consistent with previous reports (1, 10, 14). However, a bilateral variation of the sciatic nerve to the piriformis, and the varied bifurcation loci observed in a particular cadaver, as in this study, are a rare occurrence. The double-headed piriformis muscle reported in our study does not fit into the 6-type classification; it occupies a separate class. Although this variant was not anticipated by Beaton and Anson, they hypothesised

the possibility of two other types: one in which the nerve passes between and above the heads, and in the other, an undivided nerve passes above the undivided muscle (12). However, a more recent review article identified twelve variants, that is, seven additional variants to the Beaton and Anson variants (29). This suggests the possibility of a yet to be observed variation pattern. Interestingly, Barbosa et al. in their review article mentioned the occurrence of a rare variant where the sciatic nerve emerges divided, and the common peroneal nerve passes between the heads of a double piriformis, while the tibial nerve passes beneath the muscle (29). From this present study, we opined that knowledge of these anatomical variations might be useful in choosing the correct treatment for patients with piriformis syndrome or sciatica, as previously suggested (28, 30). This study highlights certain sciatic nerve variations around the gluteal region and its bifurcation loci in the thigh in a Nigerian population. It may be necessary to study the embryological basis of these anatomical variations to gain better understanding.

Conclusion

The location, bifurcation, and distribution of the sciatic nerve are of clinical importance. The long course of the sciatic nerve makes it vulnerable to injury as it is commonly involved in regular medical practices such as anaesthesia, rehabilitation, orthopaedics and neurology. Despite our findings that 7.1% of sciatic nerves have irregular anatomy, it is worth noting that none of the variations compromises intramuscular injection in the gluteal area.

What Is Already Known on This Topic:

The sciatic nerve is the thickest nerve in the human body, and the most important nerve for normal gait. It is documented in the literature that over 70% of sciatic nerves leave the pelvis undivided through the infra piriformis portion of the greater sciatic foramen, run down the posterior thigh and bifurcate in the popliteal fossa, as observed in this present study. To date, the term "idiopathic sciatica" is still in use. It is reasonable to speculate that an unknown variation from the normal anatomy of the sciatic nerve may be partly responsible for unexplainable sciatica.

What This Study Adds:

The possibility that intractable sciatica may be linked to unknown sciatic nerve variations justifies our study of its relationship with the piriformis muscle and bifurcation loci along its course. This study documents a common left side, peroneal nerve emerging between a double-headed piriformis muscle as an apparently unknown variation, not described in the original Beaton and Anson classification. We also report a rare communicating nerve connecting the common peroneal nerve with the tibial nerve near the mid-thigh. To our knowledge, these are two rare anatomical events.

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Conflict of Interest: The authors declare that they have no conflicts of interest.

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