SCIATIC NERVE VARIATIONS AROUND THE PIRIFORMIS MUSCLE AND BIFURCATION LEVEL: AN ANATOMICAL STUDY

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ABSTRACT

Background: The ventral rami from the fourth lumbar to the third sacral spinal nerves form the Sciatic Nerve (SN). SN exits the pelvis through the greater sciatic foramen at the inferior border of the Piriformis Muscle (PM), and then it bifurcates into the common fibular and tibial nerves in the popliteal fossa, however it may present different patterns.

Objectives: To identify the SN relation to the PM and the level of bifurcation.

Method: Twenty-two lower limbs were dissected to expose the SNs, then the SN position to the PM were studied, and then the levels of the SN bifurcation from the inferior border of the PM were measured and compared to the thigh lengths.

Results: SN patterns to PM were as follows: 4% were type B in which one component of the SN passed under the PM, while the other component passed through the piriformis muscle. Twenty three percent were type G in which the divided SN components pass under the PM, and 73% were type A in which the undivided SN passed under the PM. SN bifurcated at the following levels: 18% in pelvic region, 14% in the upper 1/3 of the thigh, and 4% in the middle 1/3 of the thigh. Two SN (9%) showed different patterns where one bifurcated in the pelvis, reunited in mid-thigh, and bifurcated again in the inferior 1/3 of the thigh. Another one bifurcated in the gluteal region at the inferior edge of the piriformis muscle, reunited in upper one third of the thigh, and then bifurcated again in popliteal fossae. The remaining 12 (55%) SN bifurcated in the popliteal fossae.

Conclusion: Knowledge of the variants of the SN is needed for the accuracy and the safety of the procedures in this area.

Key words: Sciatic nerve, Tibial nerve, Common fibular nerve, Anatomical variation, Anatomical pattern

INTRODUCTION

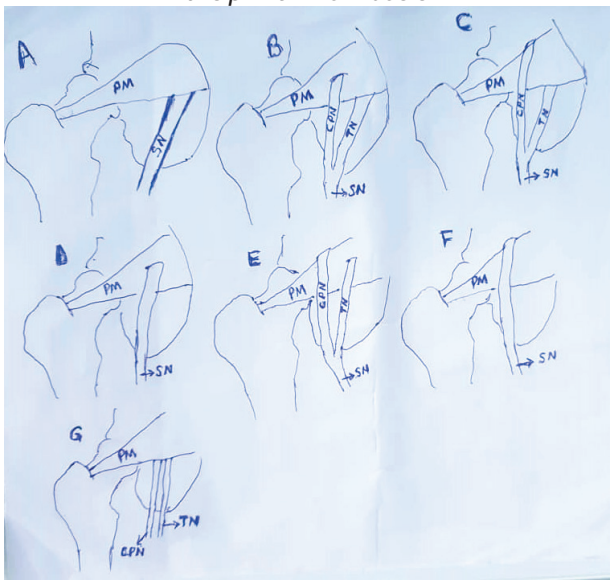
The Sciatic Nerve (SN) is the thickest, widest, and longest nerve in the human body which supplies the muscles of the posterior thigh, the whole leg, and the foot (1). The SN is formed by the joining of the ventral rami of the fourth lumbar (L4) to the third sacral (S3) spinal nerve in the pelvis (2). The sciatic nerve is composed of two components, the tibial and the common fibular components which both form a common trunk (3). The trunk of the SN exits the pelvis through the greater sciatic foramen at the inferior edge of the Piriformis Muscle (PM), and enters the gluteal region, it then continues inferiorly on the posterior compartment of the thigh under the long head of biceps femoris muscle. At the level of the upper angle of the popliteal fossa, the two components of the SN

bifurcates into the Common Peroneal Nerve (CPN) and Tibial Nerve (TN) (4).

The sciatic nerve may present different patterns; the whole SN trunk may exit the pelvis at the superior edge of the PM or through the piriformis muscle (5). The SN may also bifurcate before crossing the piriformis muscle, and then its two components exit the pelvis by passing at the inferior edge, through, or, at the superior edge of the piriformis muscle separately (6). These anatomical patterns of the sciatic nerve relating to the piriformis muscle are grouped into seven types as follows: type A- the entire SN passes below the PM; type B- the CPN passes through the PM, while the TN passes below the PM; type C- the CPN passes superior to PM, whereas the TN passes below the PM; type D- the entire SN passes through the PM; type E- the TN passes through PM, whereas the CPN passes superior to PM; type F- the entire SN passes superior to the PM; and type G- both CPN and TN pass below the PM separately (7,8). This is illustrated in the Figure 1. The variations of the SN in relation to the PM can increase the risk of intraoperative injury, either due to direct injury when a piriformis muscle tenotomy is required or improper Hofmann retractor placement. Once the SN is severely injured, the posterior thigh, the leg and foot muscles lack the nerve supply, and therefore it becomes difficult to walk (8).

Figure 1

Illustrating the sciatic nerve variations in relation to the piriformis muscle



Legend: PM: Piriformis Muscle, TN: Tibial Nerve, CPN: Common Peroneal (Fibular) Nerve, SN: Sciatic Nerve

The sciatic nerve may bifurcate usually in the popliteal fossa. However, it can bifurcate at different levels including, the pelvic cavity, the gluteal region, the superior, middle and inferior part of the posterior thigh region (9). The knowledge of the different patterns in bifurcation level of this nerve is clinically important, especially in cases where sciatic nerve blockage is to be performed (10).

MATERIALS AND METHODS

The study was a descriptive anatomical study involving twenty-two lower limbs of human donors in the anatomy laboratory of the School of Medicine and Pharmacy at the University of Rwanda. The gluteal and posterior thigh regions were dissected according to the dissection textbook (11). The donors were treated according to the law regulating the use of the human donations in Rwanda (12). The SN morphometric characteristics and dissection were determined adopting the methods of Mbaka & Osinubi (13) by putting the cadaver in the prone position, then made a vertical incision at the mid-line sacrum level and horizontal incisions at ischial tuberosity level, and then one vertical incision on the middle posterior thigh on each side up to the popliteal fossae. The skin and subcutaneous tissues were then reflected to expose the deep fascia and the underlying muscles. The gluteus maximus was cut midway with each half reflected superiorly and inferiorly to expose the gluteus medius, the piriformis muscle, and the underlying sciatic nerve. To keep tracing the sciatic nerve inferior to the piriformis muscle, the biceps femoris was also cut and retracted to expose the nerve at the upper part of the thigh up to the popliteal fossa. The fatty and connective tissues covering the sciatic nerve were removed to fully observe its pattern.

Donors with the above knee amputation and deep gluteal injuries were excluded from this study. The objectives of the study were to identify the anatomical pattern of the sciatic nerve from its relationship to the piriformis muscle, and its level of bifurcation from the inferior border of the piriformis muscle up to the popliteal fossa.

The SN positional relationship to the piriformis muscle was observed and the images were captured using Nikon D7200 Camera for recording. A flexible tape was used for measuring the level of bifurcation from the PM, and then determine whether the SN bifurcated in the upper,

middle or lower one third of the thigh adopting the method used by Haladaj *et al*. (14). In cases where the SN bifurcated before crossing the PM, the length was recorded as 0 cm.

Microsoft excel was used for storing and cleaning of data. IBM SPSS Statistics v23 x 86 was used for data analysis. Statistical significance of associations at 0.05 and 0.01 confidence levels were determined using a Mann-Whitney Test.

Ethical clearance was received from the University of Rwanda, College of Medicine and Health Sciences Institutional Review Board (CMHS/IRB/555/2023).

RESULTS

Relation of the SN with the PM and the thigh length

Sixteen SNs (73%) were type A; undivided SN passes below the PM. One SN (4%) was type B; the common fibular component passed through the PM, and the tibial component passed below the PM (Figure 3). Five SNs (23%) were type G; both the tibial and common fibular components were divided, and passed below the PM (Figures 4 and 5). The relation of the sciatic nerve to the piriformis muscle is summarized in Figure 2.

Figure 2

Rates of each type of the SN variation in relation to the piriformis muscle

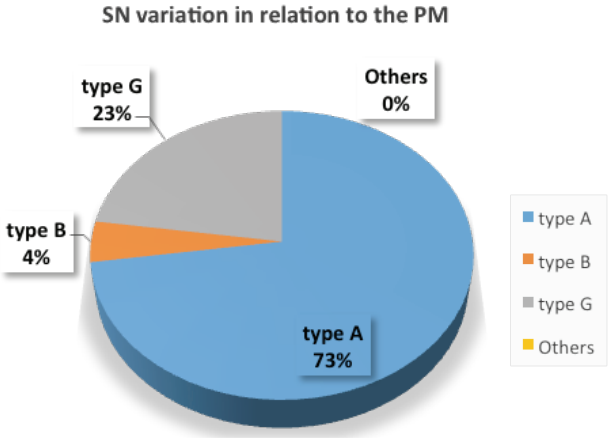
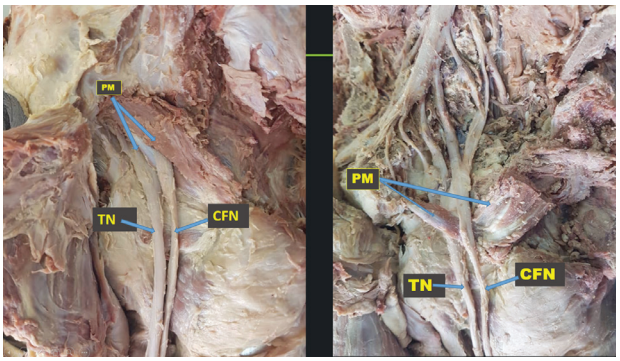


Figure 3

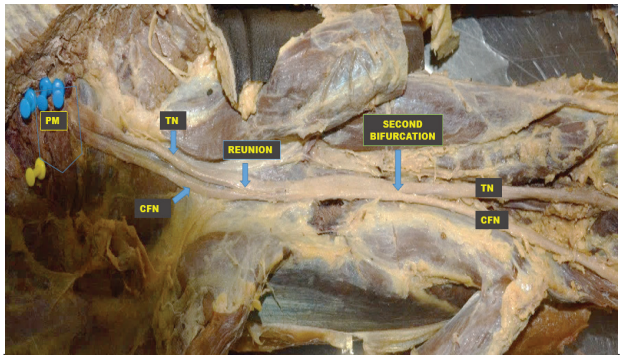
Type B SN variation in relation to PM



Legend: PM: Piriformis Muscle, TN: Tibial Nerve, CFN: Common Fibular Nerve

Figure 4

SN that passed under the PM divided (Type G), reunited in the mid-thigh and bifurcated in the lower 1/3 of the thigh



Legend: PM: Piriformis Muscle, TN: Tibial Nerve, CFN: Common Fibular Nerve

Figure 5

Type G SN variations in relation to PM

Legend: PM: Piriformis Muscle, TN: Tibial Nerve, CFN: Common Fibular Nerve

The level of bifurcation of the SN compared to the thigh length

The maximum thigh length was 42.0cm and the minimum thigh length was 37cm. The mean Thigh Length (TL) was 39.445cm ± 1.6. The maximum distance from the inferior border of the PM to the point of bifurcation of the SN was 32.2cm, the minimum distance was 0cm (bifurcation before PM), and the mean distance was 30.345cm ± 12.54 (Table 1).

Table 1

Thigh length and the level of bifurcation

	N	Mean	Std. Deviation	Minimum	Maximum
TL (cm)	22	39.445	1.6002	37.0	42.0
PM to bifurcation (cm)	20	20.345	12.5413	.0	32.2

There was no significant statistical difference in the thigh length, and in the distance from the inferior border of the piriformis muscle to the point of bifurcation (Table 2).

Table 2

Test statistics for the thigh length and the level of bifurcation

	TL (cm)	PM to bifurcation (cm)
Mann-Whitney U	60.500	43.000
Wilcoxon W	126.500	98.000
Z	.000	-.531
Asymp. Sig. (2-tailed)	1.000	.595
Exact Sig. [2*(1-tailed Sig.)]	1.000[b]	.631[b]

Four SNs (18%) bifurcated in the pelvic region before crossing the PM, and continued inferiorly without joining (Figure 5). One SN (4.5%) bifurcated in the pelvis before crossing the PM, and reunited in the mid-thigh, and then bifurcated again in the inferior one third of the thigh (Figure 4). Another SN (4.5%) bifurcated before crossing the piriformis muscle, and reunited in the upper one third of the thigh (Figure 6). Three SN (13.5%) bifurcated in the upper one third of the thigh, and continued inferiorly separated without joining (Figure 7). One SN (4.5%) bifurcated in the middle one third of the thigh, and continued separated without joining (Figure 8). The remaining 12 SNs (55%) bifurcated in the popliteal fossae. There were no statistically significant differences in the length from the inferior border of the PM to the point of bifurcation of the SN (Table 2). The distribution of the SN from the inferior border of the PM to the point of bifurcation in relation to the thigh length is presented in Table 3.

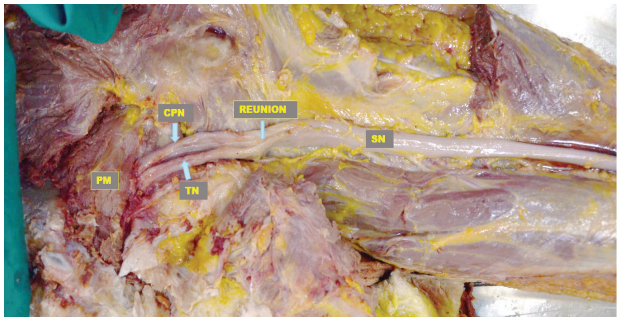
Table 3

Summary of the level of the sciatic nerve bifurcation

Pelvic region	Upper 1/3 of the thigh	Middle 1/3 of the thigh	Pelvic region, reunited in mid-thigh, then bifurcation in the inferior 1/3 of the thigh	Pelvic region and reunited in upper 1/3 of the thigh, then bifurcated in the popliteal fossa	Popliteal fossa
4	3	1	1	1	12
18%	14%	4.3%	4.3%	4.4%	55%

Figure 6

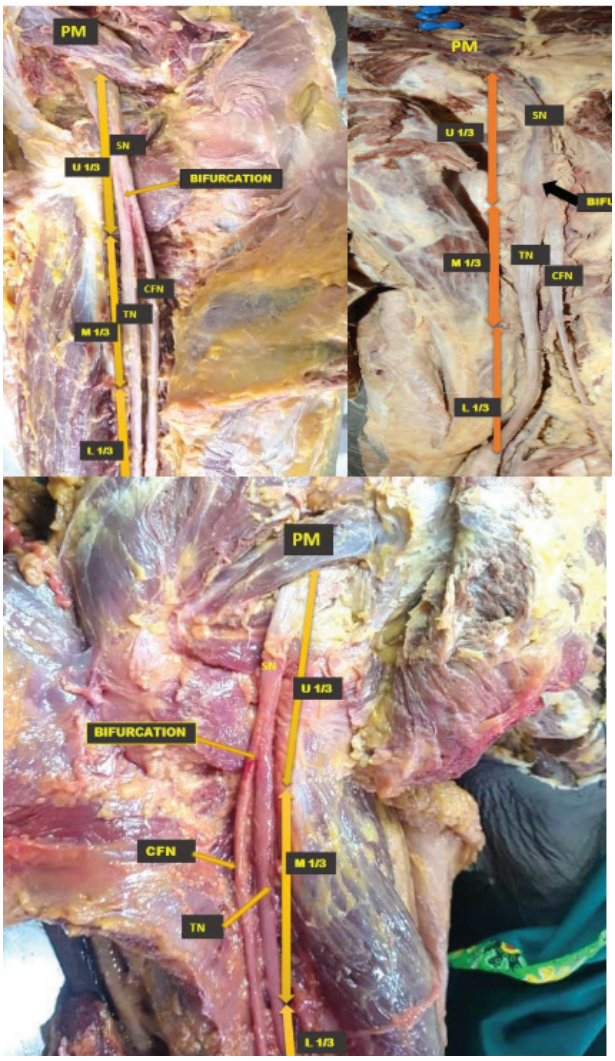
Sciatic nerve bifurcation in the pelvic region and reunited in upper 1/3 of the thigh, then bifurcated in popliteal fossae



Legend: PM: Piriformis Muscle, SN: Sciatic Nerve, TN: Tibial Nerve, CFN: Common Fibular Nerve

Figure 7

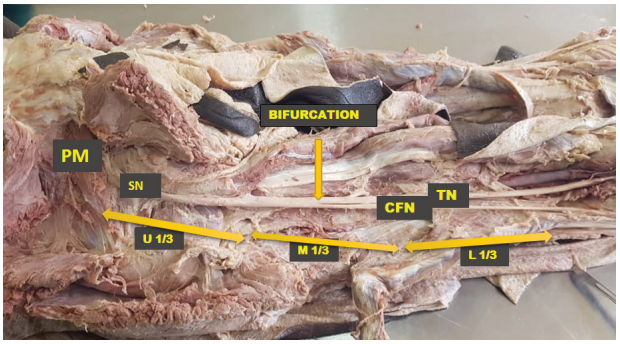
SN that bifurcated in the upper 1/3 of the thigh but passed under the PM undivided (type A)



Legend: PM: Piriformis Muscle, SN: Sciatic Nerve, TN: Tibial Nerve, CFN: Common Fibular Nerve, U 1/3: Upper one third of the thigh, M1/3: Middle one third of the thigh, L1/3: Lower one third of the thigh

Figure 8

Bifurcation of the SN in the middle 1/3 of the thigh



Legend: PM: Piriformis Muscle, SN: Sciatic Nerve, TN: Tibial Nerve, CFN: Common Fibular Nerve, U 1/3: Upper one third of the thigh, M1/3: Middle one third of the thigh, L1/3: Lower one third of the thigh

DISCUSSION

In the majority of the cases studied, the SN passes below the inferior border of the PM undivided (15). Different studies have shown that the SN presents substantial variations in relation to the piriformis muscle in other climes. The present study revealed the different patterns of the SN in relation to the PM in Rwanda. Type A was the most common pattern observed in 73% of the donors. This is similar to what has been documented in Nigeria (14) and Kenya (22) where Type A was observed in 83% and 83.8% respectively.

In our study, Type B variant of the SN was observed in 4% of the donors. This is lower than the 7.1% documented in Nigeria (14), and 20% documented in Poland (17), and higher than the 3.2% documented in Saudi Arabia (18). The Type G pattern of the SN was observed in 23% of the donors in our study, this is lower than 37.5% reported in India (19).

The SN bifurcated in the popliteal fossa in the majority (55%) of the donors, in our study. This pattern of popliteal fossa bifurcation is the most common documentation reported by authors. Reynoso *et al.* (20) in their study reported a similar rate of 55% popliteal fossa bifurcation of the SN in their population of study. The SN bifurcated in the pelvis in 18% of the donors, in our study. This is lower than the 33.3% reported in the study by Pais *et al.* (21). The SN bifurcated in the middle one-third of the thigh in 4.5% of the donors, in our study, this is lower than the 10% reported by Reynoso *et al.* (20), and the 10.4% reported by Ogeng *et al.* (22). The present study also observed that the SN bifurcated in the upper one-third of the thigh in

13.5% of the donors. This is higher than the 3.6% reported by Atoni *et al*. (16). All observations in the current study suggest that the sciatic nerve may have different relations to the piriformis muscle, and it can divide into its terminal two divisions at any level in the thigh, consistent with previous reports.

CONCLUSION

Variations of the SN may pose a risk or failure during medical interventions on the nerve or its proximity, for instance popliteal block failure when there is higher bifurcation of the SN. Therefore, the outcomes of this study will be a good tool in raising awareness about the existence of different sciatic nerve patterns in Rwanda. This will guide the clinicians, surgeons, anaesthesiologists, physiotherapists, massage therapists, and other health professionals during decision-making and treatment to avoid iatrogenic injury and failure.

STUDY LIMITATION

This study was limited to the human cadavers in the anatomy laboratory of the University of Rwanda. Therefore, the data generated from this study cannot be generalized in its entirety to reflect the whole population in Rwanda. Another limitation of the study is the issue of gender balance or equality. Majority (99%) of the human body donations available at the Anatomy Department, University of Rwanda are males, therefore the challenge of gender balance is a limitation in this study. Lastly, anatomical studies involving the use of human cadavers may not have a large sample population, as human body donations are limited.

ACKNOWLEDGEMENTS

We are grateful to the human donors, to the School of Medicine and Pharmacy, University of Rwanda staff for their great support in proving all needed tools for dissection and personal protective equipment's. Appreciation also goes to the Government of Rwanda for providing the law on the use of human bodies.

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