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A Cadaveric Based Morphometric Analysis of the Sciatic Nerve with Clinical Implications

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Abstract

Background: The sciatic nerve is one of the very vital nerves of the body, which has importance not only in the field of Anatomy but also in various clinical fields such as Orthopaedics, Anaesthesia, Plastic & Reconstructive Surgery, and Neurosurgery. This study was the first attempt to analyze the different dimensions of the anatomically normal sciatic nerves at different levels, involving Malaysian cadavers. **Material & Methods:** The study was conducted on 78 adult, both cadaveric and disarticulated lower limb specimens belonging to both genders. The morphometric analysis was done in 64 specimens having anatomically normal sciatic nerves. The dimensions were measured by a digital Vernier caliper, a measuring tape, and thread. **Results:** The average width, thickness and circumference of the nerve at the lower border of piriformis muscle (PM) were 15.86 mm ± 1.47 (right) & 16.56 mm ± 1.08 (left); 4.22 mm ± 0.29 (right) & 4.10 mm ± 0.20 (left) and 27.70 mm ± 2.02 (right) & 27.72 mm ± 2.39 (left), respectively. Similarly, at the level between ischial tuberosity (IT) and greater trochanter (GT), the mean width was 11.59 mm ± 1.43 (right) & 11.50 mm ± 1.53 (left); thickness was 3.48 mm ± 0.18 (right) & 3.35 mm ± 0.17 (left) and circumference was 27.08 mm ± 2.79 (right) & 27.22 mm ± 2.87 (left). At bifurcation, the mean width was 8.66 mm ± 0.65 (right) & 8.90 mm ± 0.81 (left); thickness was 2.41 mm ± 0.12 (right) & 2.31 mm ± 0.15 (left) and circumference was 19.75 mm ± 1.44 (right) & 19.99 mm ± 1.45 (left). The average distance between IT and GT was 50.37 mm ± 4.47 (right) & 47.73 mm ± 4.24 (left); between lateral border of IT and medial border of sciatic nerve was 15.43 mm ± 1.45 (right) & 14.66 mm ± 1.37 (left); and between medial border of GT and lateral border of the nerve was 27.13 mm ± 1.38 (right) & 25.07 mm ± 1.73 (left). The average length of the nerve was 328.20 ± 26.26 (right) & 332.31 ± 21.89 (left); and that of the thigh was 412.19 ± 24.50 (right) & 407.24 ± 25.82 (left). **Conclusion:** This knowledge will not only aid future researchers but also will assist surgeons, orthopaedicians, anaesthetists, reconstructive surgeons, and neurosurgeons by preventing iatrogenic nerve injuries.

Keywords:- Sciatic nerve, width, thickness, circumference, distance.

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INTRODUCTION

The sciatic nerve, the largest nerve of the body is the main continuation of the sacral plexus.[1] The nerve has been commonly associated with accidental and iatrogenic injuries and should be protected when surgically exploring this area. It is one of the vital nerves in terms of anatomical and clinical aspects. It takes origin from the ventral primary rami of L4, L5, and S1, S2, S3 spinal nerves1. It has two components, the tibial component, formed by the ventral divisions of L4, L5, S1, S2, and S3 nerves and the common peroneal component, formed by the dorsal divisions of L4, L5, S1 and S2 nerves.[2] The nerve arises in the pelvis in front of the PM and leaves the pelvic cavity to enter the gluteal region through the infra-piriform part of the greater sciatic foramen.[3] In the gluteal region, it passes inferolaterally deep to the gluteus maximus (GM), running between the GT and IT. [4] It leaves the gluteal region at the lower border of the GM and descends through the midline of the back of the thigh.[3] Finally, it terminates by bifurcating into the tibial and common peroneal branches at the junction of the middle and lower thirds of the thigh, near the apex of the popliteal fossa.[4] The sciatic nerve is the most frequently injured nerve.[5] Profound knowledge on the anatomy of the sciatic nerve and relationship with the adjacent structures is fundamental not only to the anaesthesiologists, but also the surgeons in performing successful blockades and surgical approaches, respectively.[6] Continuous peripheral nerve blocks are attracting an increasingly notifiable interest principally for postoperative pain management which represents a challenge to the anaesthesiologists.[7] The vital nerves of thigh region are particularly important in the field of anaesthesia, as the use of peripheral nerve blocks in lower-extremity surgery is becoming a mainstay of perioperative pain management strategy.[8] Furthermore, the possibility of the presence of anatomical variations must be considered while performing surgical interventions and nerve blocks to avoid iatrogenic injuries and maximize the success rate.[9] The knowledge regarding the accurate location of the major nerves of the thigh in relation to the adjoining bony landmarks aids the surgeon in performing safe and successful blocks. Though several studies have been carried earlier on topographical anatomy of the sciatic nerve in different geographical locations, they have not been recorded involving the Malaysian cadavers. Hence, the present study is designed to establish a comprehensive cadaveric based analysis regarding the topographical anatomy of the sciatic nerve in the Malaysian cadavers, including its length, exact relationships with the important and easily identifiable bony landmarks; and to correlate the length of the nerve with the length of the thigh.

Objective of this Study

The objective of this study was to analyze the different dimensions of the anatomically normal sciatic nerves at different levels, involving Malaysian cadavers.

MATERIAL AND METHODS

This study was a descriptive, cross-sectional study which was conducted at the Faculty of Medicine in AIMST University, Malaysia and University Kebangsaan Malaysia (UKM). The study was carried out on 78 adult, cadaveric and

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disarticulated lower limb specimens belonging to both genders, during the period of June 2018 to February 2019.

Inclusion Criteria

- Properly embalmed and well-preserved specimens
- Adult lower limb specimens
- The specimens of both genders and different ethnicity

Exclusion Criteria

- Distorted limbs
- Disrupted nerves at any level of their course
- Destroyed surrounding structures such as muscles, vessels.

Among 78 specimens, 64 (32 right and 32 left including 4 disarticulated female lower limbs) were found to have the normal anatomical features of the investigating nerve. The remaining 14 lower limbs showed different variations. The morphometric analysis was performed only in 64 lower limbs with anatomically normal sciatic nerves. Most of the specimens were already dissected during the routine dissection procedure of both the universities. The course of the sciatic nerve in relation to the PM, IT, and GT was observed by careful dissection of the gluteal region and posterior compartment of the thigh and leg. The width, thickness, and distance were measured by a digital Vernier's slide caliper [Figure 1(a), 2(a), 2(b), 2(c), 2(d) and 3] the length was recorded by a measuring tape [Figure 4]. The circumference was recorded by a twine thread and marked by a marker pen. The marked area of the thread was then measured by a digital Vernier's slide caliper figure 1[b] and 1[c]. The parameters were tabulated and statistical analysis was performed using SPSS for Windows Version 22. The mean, maximum and minimum values were calculated.

RESULTS

The average diameter of the sciatic nerve at the lower margin of the PM was 15.86 mm ± 1.47 (12.52 - 18.29 mm) for the right side and 16.56 mm ± 1.08 (12.93 - 18.69 mm) for the left side. The 'F' value was 3.76 and equal variances assumed; the 't' was -2.16; the 'df' was 62, and the 'p' value was <0.05 (0.03). So, there was a statistically significant difference between the values of right and left sides. The current study found the average width of the sciatic nerve at the level between IT and GT was 11.59 mm ± 1.43 (7.43 - 14.62 mm) for the right limbs and 11.50 mm ± 1.53 (7.52 - 13.83 mm) for the left limbs. The 'F' value was 0.58 and equal variances assumed; the 't' was 2.43; the 'df' was 62, and the 'p' was >0.05 (0.81), indicating no statistically significant difference between the values of the right and left sides. As displayed in the table 1, the average width at the level of bifurcation was 8.66 mm ± 0.65 (6.42 - 9.70 mm) for the right limbs and 8.90 mm ± 0.81 (5.95 - 9.93 mm) for the left limbs. The 'F' was 1.46 and equal variances assumed; the 't' was -1.31; the 'df' was 62, and the 'p' was 0.19 (>0.05). So, there was no statistically significant difference in the width of SN at the level of bifurcation between right and left sides. The mean thickness of the sciatic nerve at the lower margin of PM was 4.22 mm ± 0.29 (3.58 - 4.86 mm) and 4.10 mm ± 0.20 (3.70 - 4.38 mm) for the right and left sides, respectively. The 'F' was 1.47 and equal variances assumed; the 't' was 2.01; the 'df' was 62, and the 'p' was 0.049 (<0.05). So, the mean thicknesses of the sciatic nerve at the lower

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Page no- 87-96 | Section- Research Article (Anatomy)

margin of PM were statistically different in right and left sides. The average thickness of the sciatic nerve at the level between IT and GT was 3.48 mm ± 0.18 (3.13 - 3.73 mm) and 3.35 mm ± 0.17 (3.07 - 3.74 mm) for the right and left sides, respectively [Table 1]. The 'F' was 0.00 and equal variances assumed; the 't' was 2.93; the 'df' was 62, and the 'p' was 0.005 (<0.05). So, there was a statistically significant difference in the thickness between the right and left sides. As the table 1, the mean thickness of the sciatic nerve at the level of bifurcation was 2.41 mm ± 0.12 (2.15 - 2.64 mm) and 2.31 mm ± 0.15 (2.05 - 2.64 mm) for the right and left sides, respectively. The 'F' value was 2.83 and equal variances assumed; the 't' was 3.09; the 'df' was 62, and the 'p' was 0.003 (<0.05). So, the thickness of the sciatic nerve at the level of bifurcation was statistically different in right and left sides. The mean circumference of the sciatic nerve at the lower margin of PM was 27.70 mm ± 2.02 (22.03 - 32.30 mm) and 27.72 mm ± 2.39 (21.11 - 34.74 mm) for the right and left sides [Table 1]. The 'F' was 0.08 and equal variances assumed; the 't' was -0.04; the 'df' was 62, and the 'p' value was >0.05 (0.97). So, there was no statistically significant difference between the values of the right and left sides. The average circumference of the sciatic nerve at the level between IT and GT was 27.08 mm ± 2.79 (20.43 - 33.05 mm) and 27.22 mm ± 2.87 (19.30 - 31.74 mm) for the right and left sides, respectively [Table 1]. The 'F' was 0.23 and equal variances assumed; the 't' was -0.21; the 'df' was 62 and the 'p' was >0.05 (0.84), which means there was no statistically significant difference in the circumferences between right and left sides. As per table 1, the mean circumference of the sciatic nerve at the level of bifurcation was 19.75 mm ± 1.44 (17.30 - 22.57 mm) and 19.99 mm ± 1.45 (17.46 - 22.48 mm) for the right and left sides, respectively. The 'F' was 0.18 and equal variances assumed; the 't' was -0.67; the 'df' was 62, and the 'p' was 0.51 (>0.05). So, there was no statistically significant difference in the circumferences of the sciatic nerve at the level of bifurcation between right and left sides. The table 1 describes the mean distance between GT and IT was 50.37 mm ± 4.47 (40.50 - 57.33 mm) and 47.73 mm ± 4.24 (38.76 - 55.57 mm) for the right and left sides, respectively. The 'F' was 0.53 and equal variances assumed; the 't' was 2.43; the 'df' was 62, and the 'p' was 0.02 (<0.05). So, there was a statistically significant difference in the distance between GT and IT between right and left sides. The average distance between the medial border of sciatic nerve and the lateral border of IT was 15.43 mm ± 1.45 (11.62 - 17.86 mm) for the right limbs and 14.66 mm ± 1.37 (11.73 - 16.73 mm) for the left limbs [Table 1]. The 'F' was 0.006 and equal variances assumed; the 't' was 2.17; the 'df' was 62; the 'p' value was 0.03 (<0.05). So, there was a statistically significant difference between the values of the right and left sides. The average distance between the lateral border of the sciatic nerve and medial border of GT was 27.13 mm ± 1.38 (23.49 - 29.63 mm) and 25.07 mm ± 1.73 (22.18 - 28.27 mm) for the right and left sides, respectively. The 'F' was 4.37 and equal variances assumed; the 't' was 5.26; the 'df' was 62, and 'p' was 0.00 (<0.05). So, there was a statistically significant difference between the values of the right and left sides. Table 1 is displaying the average length of the sciatic nerve was 328.20 mm ± 26.26 (280.00 - 380.00 mm) and 332.31 mm ± 21.89 (285.00 - 377.00 mm) for the right and left sides. The 'F' was 0.62 and equal variances assumed; the 't' was -0.68; the 'df' was 62, and the 'p' was 0.499

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Page no- 87-96 | Section- Research Article (Anatomy)

(>0.05). So, there was no statistically significant difference in the length of the sciatic nerve between right and left sides.

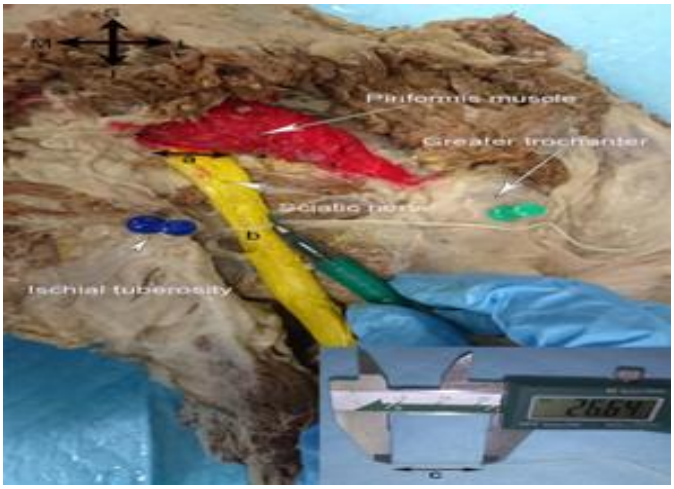

Figure 1(a): Procedure of measurement of width of the sciatic nerve at the lower border of PM. **Figure 1(b) & 1(c):** Procedure of measurement of circumference of the sciatic nerve at the level between IT and GT.

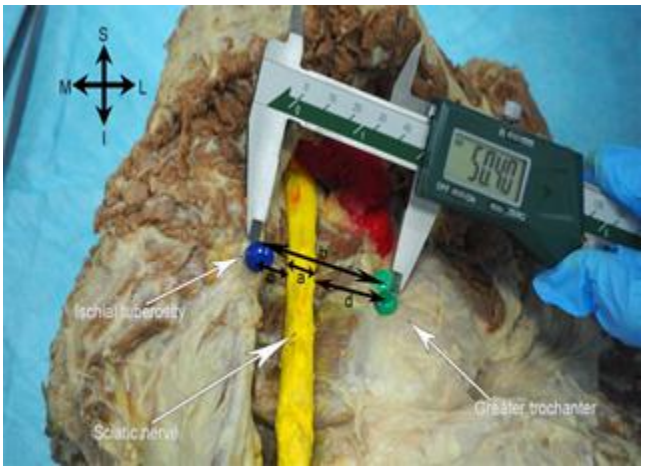

Figure 2: (a) Procedure of measurement of width of the sciatic nerve at the level between IT and GT. (b) Procedure of measurement of the distance between IT and GT. (c) Procedure of measurement of the distance between lateral border of IT and medial border of sciatic nerve. (d) Procedure if measurement of the distance between medial border of GT and lateral border of sciatic nerve.

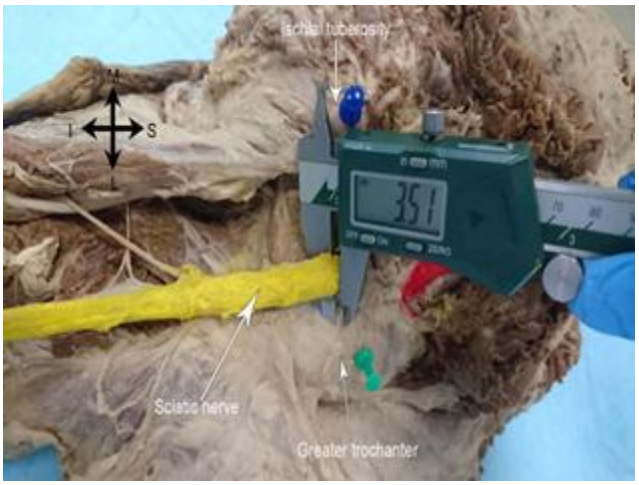

Figure 3: Produre of measurement of thickness of the sciatic nerve at the level between IT and GT.

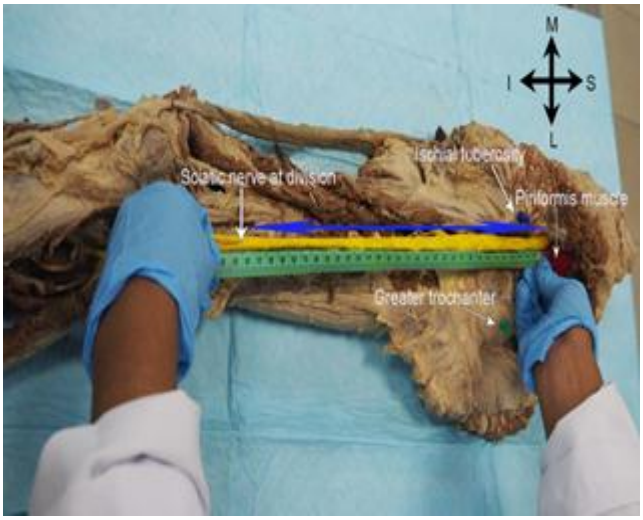

Figure 4: Procedure of measurement of the length of sciatic nerve from lower border of PM to its bifurcation.

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Page no- 87-96 | Section- Research Article (Anatomy)

Table 1: Summary of results of sciatic nerve

SCIATIC NERVE								
S.N.	**Parameters**	**Right lower limbs**			**Left lower limbs**			**'p' value**
		Max	**Min**	**Mean**	**Max**	**Min**	**Mean**	
01	Width of the sciatic nerve at the lower margin of the PM (mm)	18.29	12.52	15.86 ± 1.47	18.69	12.93	16.56 ± 1.08	<0.05
02	Width of the sciatic nerve at the level of between IT and GT (mm)	14.62	7.43	11.59 ± 1.43	13.83	7.52	11.50 ± 1.53	>0.05
03	Width of the sciatic nerve at the level of bifurcation (mm)	9.70	6.42	8.66 ± 0.65	9.93	5.95	8.90 ± 0.81	>0.05
04	Thickness of the sciatic nerve at the lower margin of PM (mm)	4.86	3.58	4.22 ± 0.29	4.38	3.70	4.10 ± 0.20	<0.05
05	Thickness of the sciatic nerve at the level of between IT and GT (mm)	3.73	3.13	3.48 ± 0.18	3.74	3.07	3.35 ± 0.17	<0.05
06	Thickness of the sciatic nerve at the level of bifurcation (mm)	2.64	2.15	2.41 ± 0.12	2.64	2.05	2.31 ± 0.15	<0.05
07	Circumference of the sciatic nerve at the lower margin of the PM (mm)	32.30	22.03	27.70 ± 2.02	34.74	21.11	27.72 ± 2.39	>0.05
08	Circumference of the sciatic nerve at the level of between IT and GT (mm)	33.05	20.43	27.08 ± 2.79	31.74	19.30	27.22 ± 2.87	>0.05
09	Circumference of the sciatic nerve at the level of bifurcation (mm)	22.57	17.30	19.75 ± 1.44	22.48	17.46	19.99 ± 1.45	>0.05
10	Distance between GT and IT (mm)	57.33	40.50	50.37 ± 4.47	55.57	38.76	47.73 ± 4.24	<0.05
11	Distance between medial border of sciatic nerve and lateral border of IT (mm)	17.86	11.62	15.43 ± 1.45	16.73	11.73	14.66 ± 1.37	<0.05
12	Distance between lateral border of sciatic nerve	29.63	23.49	27.13 ± 1.38	28.27	22.18	25.07 ± 1.73	<0.05

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Page no- 87-96 | Section- Research Article (Anatomy)

	and medial border of GT (mm)							
13	Length of sciatic nerve from the lower border of PM until its division (mm)	380.00	280.00	328.20 ± 26.26	377.00	285.00	332.31 ± 21.89	>0.05

DISCUSSION

In the present study, the length, width, thickness, circumference of the sciatic nerve at different levels, and distance of the nerve from various important bony landmarks have been recorded in the Malaysian cadavers. Though a handsome number of cadaveric studies on the nerves of the different parts of the body have been reported in the literature, there is a scarcity of such studies based on the Malaysian cadavers.

The average diameter of the sciatic nerve at the lower margin of the PM was 15.86 mm ± 1.47 (12.52 - 18.29 mm) for the right side and 16.56 mm ± 1.08 (12.93 - 18.69 mm) for the left side [Table 1, Figure 1(a)]. However, in a study, the nerve was found to be slightly wider at the lower border of PM where the mean diameters were 1.88 cm (1.2 - 2.4 cm) and 1.9 cm (1.2 - 2.4 cm) on the right and left sides, respectively.[10] Similarly, Guvencer and co-researchers found the mean width of the nerve at the aforementioned level as 17.00 mm ± 3.70.[11] The nerve was wider in another study conducted by Brooks and colleagues who reported the mean diameters of the non-variant sciatic nerves were 19.451 mm ± 5.246 (right) and 19.463 mm ± 5.238 (left).[12] On the other hand, researchers mentioned the pooled mean width of the nerve at the lower edge of PM as 15.55 mm.[13] Furthermore, the current study found the average width of the sciatic nerve at the level between IT and GT was 11.59 mm ± 1.43 (7.43 - 14.62 mm) for the right limbs and 11.50 mm ± 1.53 (7.52 - 13.83 mm) for the left limbs [Table 1, Figure 2(a)]. The mean result was quite identical to that of the study conducted by the scientists, where the average values were 10.6 mm (9 - 13.5 mm) and 9.7 mm (7.84 - 13 mm) for the right and left limbs, respectively 14. The mean width at bifurcation was found 8.66 mm ± 0.65 (6.42 - 9.70 mm) for the right limbs and 8.90 mm ± 0.81 (5.95 - 9.93 mm) for the left limbs [Table 1].

[Table 1] shows the mean thickness of the sciatic nerve at the lower margin of PM was 4.22 mm ± 0.29 (3.58 - 4.86 mm) and 4.10 mm ± 0.20 (3.70 - 4.38 mm) for the right and left sides, respectively. The average thickness of the nerve at the level between IT and GT 3.48 mm ± 0.18 (3.13 - 3.73 mm) and 3.35 mm ± 0.17 (3.07 - 3.74 mm) for the right and left sides, respectively [Figure 3, Table 1]. On the contrary, researchers mentioned the mean thickness of the nerve as 1.7 mm (1.4 – 1.9 mm) for the right and 1.9 mm (1.4 – 2.5 mm) for the left limbs, which was thinner than the current study14. We found the mean thickness at the bifurcation was 2.41 mm ± 0.12 (2.15 - 2.64 mm) and 2.31 mm ± 0.15 (2.05 - 2.64 mm) for the right and left sides, respectively [Table 1].

The mean circumference of the nerve at the inferior border of PM was 27.70 mm ± 2.02

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Page no- 87-96 | Section- Research Article (Anatomy)

(22.03 - 32.30 mm) and 27.72 mm ± 2.39 (21.11 - 34.74 mm) for the right and left sides, respectively [Table 1]. The average circumference at the level between IT and GT was 27.08 mm ± 2.79 (20.43 - 33.05 mm) for the right side and 27.22 mm ± 2.87 (19.30 - 31.74 mm) for the left side [Figure 1(b)]. The mean circumference at the level of bifurcation was 19.75 mm ± 1.44 (17.30 - 22.57 mm) and 19.99 mm ± 1.45 (17.46 - 22.48 mm) for the right and left sides, respectively [Table 1]. The circumference of the nerve was not reported in any medical literature.

This study found the average distance between GT and IT 50.37 mm ± 4.47 (40.50 - 57.33 mm) for the right and 47.73 mm ± 4.24 and (38.76 - 55.57 mm) for the left side [Figure 2(b), Table 1]. Similarly, in a study, the average distances were mentioned as 5.8 cm (5.5 - 6.4 cm) and 5.3 cm (5 - 5.8 cm) for the right and left sides, respectively 14. The result was in well agreement with our study. However, Wadhwa and co-researchers mentioned the distance from the midpoint of IT to the medial aspect of GT was 7.23 ± 1.27 cm 15. As per [Table 1], the mean distance between the medial border of the sciatic nerve and the lateral border of IT was 15.43 mm ± 1.45 (11.62 - 17.86 mm) for the right and 14.66 mm ± 1.37 (11.73 - 16.73 mm) for the left limbs [Figure 2(c)]. The finding resembled the study performed by scientists.[14] They reported the mean values as 2 cm (1.4 - 3.3 cm) and 1.4 cm (1.1 - 1.6) on the right and left sides, respectively. But researchers investigated the average distances between the midpoint of the sciatic nerve and that of IT was 2.8 ± 0.4 cm; and between the lateral aspect of the IT and the midpoint of the nerve was 1.88 ± 0.56 cm, which were more than that of the current results.[15] The mean distance between the lateral border of the sciatic nerve and medial border of GT was 27.13 mm ± 1.38 (23.49 - 29.63 mm) and 25.07 mm ± 1.73 (22.18 - 28.27 mm) for the right and left sides, respectively [Figure 2(d), Table 1]. That means the nerve descends maintaining a medial inclination. These mean values were in well agreement with that of the previous study where the mean values were mentioned as 3 cm (1.8 - 3.7 cm) for the right side and 2.8 cm (2 - 3.4 cm) for the left side.[15]

According to the [Table 1], our study found the average length of the sciatic nerve was 328.20 mm ± 26.26 (280.00 - 380.00 mm) and 332.31 mm ± 21.89 (285.00 - 377.00 mm) for the right and left sides, respectively [Figure 4]. On the other hand, another study mentioned the mean length was 29 cm (2 - 39.1 cm) for right and 29 cm (3 - 39 cm) for left limbs, where the mean results were slightly lesser than the present values.[10] Consecutively, researchers mentioned the average findings were 25.2 cm (10.1 - 36.5 cm) for the right and 23.5 cm (2.5 - 39 cm) for the left sides.[14] The reason for the divergences was the values of the variant sciatic nerves were included along with that of the normal sciatic nerves.[10,14] The average length of the thigh from GT to the knee joint fissure was 412.19 mm ± 24.50 (347.00- 454.00 mm) and 407.24 mm ± 25.82 (365.00 - 462.00 mm) for the right and left sides, respectively. But, Haładaj R. et al., reported the mean thigh length as 371 mm ± 20.3 (336 – 396 mm) in anatomically normal sciatic nerves.[16] A statistically significant correlation between the lengths of the sciatic nerve and the corresponding thigh has not been observed.

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Page no- 87-96 | Section- Research Article (Anatomy)

The sciatic nerve block is frequently used in most of the lower limb surgeries. There are many approaches to perform a sciatic nerve block. Therefore, a thorough knowledge of the dimensions and topographical anatomy of the sciatic nerve at different levels has become surgically important.[14] Karmakar and co-workers suggested an ultrasound-guided approach of the sciatic nerve in the subgluteal space.[17] The findings of this study, will thereafter, can be linked to their clinical implications mainly in relation to the fields of Radiology, Surgery, and Anaesthesiology.

CONCLUSIONS

The current study was designed to provide all the dimensions of the sciatic nerve frequently involved in clinical interventions. For radiological examinations of the nerves, the surrounding bony landmarks are of immense importance. This study has also paid importance to these landmarks. In addition, the radiological findings may not be unquestionably acceptable. Finally, although the radiological examinations of the nerves reported in the medical literature have been performed involving the parameters that vary from those of the cadaveric studies, there are mentionable similarities between the findings of both of them. Therefore, the findings of the cadaveric studies have endless importance in assisting the clinical procedures. Specifically, the present study has included some important parameters that have not been reported yet in previous research works. So, it can be stated that this study will be able to achieve the success of gaining reliability in the fields of different clinical areas.

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