

Ultrasonographic Assessment of the Distance of Sciatic Nerve Bifurcation from the Popliteal Crease and its Depth from Skin in Volunteers

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ABSTRACT

Background

Sciatic nerve block used for various surgeries below knee and for maintenance of analgesia demonstrates wide variability regarding its bifurcation into tibial and common peroneal nerves, frequently accounting for incomplete nerve blocks.

Objective

To determine the variation of sciatic nerve bifurcation among Nepalese volunteers.

Method

This cross sectional study was conducted in the Department of Anesthesiology of Kathmandu Medical College Teaching Hospital from March to May 2019, where 110 healthy volunteers underwent ultrasonography of sciatic nerve starting from popliteal fossa to its bifurcation. The distance between the bifurcation of sciatic nerve from popliteal crease and depth of the nerve at that point from the skin were measured.

Result

The mean distance at which sciatic nerve bifurcated from the popliteal crease was 5.42 ± 1.37 cm. Most commonly, the sciatic nerve bifurcated at a distance of 5-7 cm from the popliteal crease in 110 limbs (50.45%). However, in 80 limbs (36.69%), the bifurcation was found at less than 5 cm from the popliteal crease. The depth of the nerve from the skin at the point of bifurcation was 1.72 ± 0.54 cm, with results showing it was deeper in females compared to males (p value < 0.001).

Conclusion

This study showed that though the distance of sciatic nerve bifurcation from the popliteal crease in our study group was coherent with the published literature of 5-12 cm; many volunteers also had this bifurcation at distances less than 5 cm. Females showed nerves to be deeper at the point of bifurcation than males.

KEY WORDS

Anatomic variation, Nepalese, Sciatic nerve bifurcation, Ultrasonography

INTRODUCTION

Sciatic nerve (SN) block is a peripheral nerve block used for surgeries and maintenance of analgesia below the knee especially where neuraxial blocks are contra-indicated.^{1,2} The SN can be easily blocked with ultrasonography at the popliteal fossa.³ To avoid an incomplete block, it should be blocked before it bifurcates into tibial and common peroneal nerves. In 85-89% of the population, SN divides at the junction of middle and lower third of posterior part of thigh; near the apex of popliteal fossa.^{4,5} However, wide variation exists.⁴⁻⁸

Traditionally, SN is blocked at popliteal fossa by inserting a needle 7 cm above the popliteal crease. Vloka et al. found SN to divide within 7 cm of popliteal crease in only 57% of cadavers dissected.⁹ That means, with landmark approach, we could be blocking only one component in more than 30% of cases. Ultrasound has been a blessing in this regard. Its use helps us to identify anatomic variations instantly.¹⁰ However, in a developing country like ours, we still lack ultrasound in many parts of the country.

Our study aims to assess the level of bifurcation of SN among Nepali volunteers with ultrasound. The primary objective is to study the distance of SN bifurcation from popliteal crease and secondary objectives are to find the depth of SN at its bifurcation and the popliteal crease to SN bifurcation distance in both limbs. This will help establish a reference point in our population which will be helpful when performing popliteal sciatic blocks.

METHODS

Following institutional review board approval and informed written consent, this descriptive cross-sectional study was done in Kathmandu Medical College Teaching Hospital in 110 healthy volunteers in the age group of 18 to 60 years from March to May 2019. The sample size was calculated based on a previous study where the proportion of patients who had variation in sciatic nerve bifurcation of more than 8 cm was 21%. The formula $n = z^2 pq / e^2$ was used, where z is the z score at 95% confidence interval (1.96), p is the proportion of patients with variation in sciatic nerve bifurcation (0.21), q is $1-p$ (0.79) and e is the allowable error at 8%.¹¹ The sample size was calculated to be 99 and considering a dropout of 10%, a sample size of 110 was taken.

Volunteers with pregnancy, limb deformity or history of trauma to lower limb were excluded from the study. American Society of Anaesthesiologists (ASA) I or II status was ensured and their height and weight were taken. A portable ultrasound (Mindray Z6) with 4.1 cm linear array transducer and frequency of 10 to 5 MHz was utilized for scanning. Examination was done in prone position and bilateral lower extremities were exposed. Popliteal crease was marked by elevation of leg with muscles palpated

against resistance. The ultrasound probe was placed transversely in the popliteal crease and the popliteal artery and vein were identified in B mode as well as color doppler modes. Once the tibial component was visualized, the area was scanned proximally until the common peroneal component was visualized coming from the lateral side and joining the tibial nerve to form the sciatic nerve (Fig. 1). The distance of this point from the popliteal crease (crease-nerve distance) was measured with the help of a ruler and a marker. At the same time, the depth of the sciatic nerve from the skin was measured via the calipers from the ultrasound and the same procedure was repeated on the left side. An expert anesthesiologist with experience in ultrasound guided regional blocks was called when the bifurcation of the sciatic nerve was not visualized or identified by the principal investigator, who otherwise did all the scans.



Figure 1. Ultrasound anatomy of the sciatic nerve at its bifurcation

The results obtained were expressed as mean \pm standard deviation (SD) and confidence interval for continuous data. Differences in mean values of the variables between two groups were tested using independent samples t-test and paired-t test was used for means from the same group. A p value of <0.05 was taken as significant. Analyses were done with SPSS Statistical Package for Social Sciences (SPSS) Version 20.

RESULTS

One hundred and ten ASA I and II classification volunteers were enrolled. The sciatic nerve division in the popliteal fossa was visualized only in 109 (99.1%) volunteers, even after expert consultation. Hence, 109 volunteers were used for the final data analysis. The demographic profiles

of the volunteers are tabulated in Table 1. The mean of the crease-nerve distance along with the depth of the nerve from the skin at that point in the whole sample have been shown in Table 2.

Table 1. Demographic characteristics of the volunteers

Characteristics	Mean ±S.D. [Range]
Age (years)	34.11 ± 14.02 [18 to 60]
Gender male:female	53:56
Weight (kg)	60.56 ±10.86 [35-84]
Height (cm)	161.72 ±9.86 [143 to 195.5]
BMI (kg/m ²)	23.12 ±3.52 [15.83 to 32.42]

Table 2. The crease-nerve distance and depth from the skin in the whole sample

Characteristics	Mean ±S.D. [Range]
Mean distance of bifurcation of SN from the popliteal crease (cm)	5.42±1.37 [2.5 to 9.8]
Mean depth of the sciatic nerve from the skin at the point of bifurcation (cm)	1.72 ±0.54 [0.5 to 3.4]

The distance from the popliteal crease to the bifurcation of the sciatic nerve:

The mean distance from the popliteal crease to the point where the nerve divided into its two components was 5.36 ± 1.29 cm, 95% CI [5.12, 5.6] in females while the mean for males was 5.49 ± 1.46 cm, 95% CI [5.21, 5.78]. The t-test (Independent samples t-test) comparing the population means of the two groups does not distinguish a difference between genders. (p value 0.464)

The distance between the popliteal crease and the point of bifurcation of SN (crease-nerve distance) has been further sub-divided in Table 3.

Table 3. Analysis of the crease-nerve distance

Crease- nerve distance	Number of limbs (%)
< 5 cm	80 (36.69)
5 to 7 cm	110 (50.45)
>7 to 8 cm	17 (7.79)
>8 cm	11 (5.04)
5-12 cm	138 (63.3)

Comparison of the crease-nerve distances between right and left leg:

The mean distance from the popliteal crease to the bifurcation of the right sciatic nerve was found to be 5.47 ± 1.30 cm, 95% CI [5.21, 5.71]. Similarly, the same distance for the left sciatic nerve was 5.39 ± 1.44 cm, 95% CI [5.12, 5.67]. Using paired samples t-test, when the means of two groups were compared, there was no statistically significant difference in the bifurcation between the two groups. (p value -0.527) (Table 4)

Table 4. Comparison of the crease-nerve distances between right and left leg

	Right leg Mean ±SD [95%CI]	Left leg Mean ±SD [95%CI]	P value
Crease-nerve distance (cm)	5.47 ±1.30 95% CI [5.21, 5.71]	5.39 ±1.44 95% CI [5.12, 5.67]	0.527

Paired t-test applied

Comparison of distance of bifurcation of sciatic nerve in the same patient in both lower limbs:

When the crease-nerve distance between the right and left leg of the same subject was compared, the absolute difference for crease-nerve distance was 0.95 cm, 95% CI [0.79, 1.10]. Nine of 109 (8.25%) volunteers had a difference in crease-nerve distance more than 2 cm between two legs. When the means of this absolute difference was measured and the means were compared between males and females using independent samples t-test, it was found that there was no statistically significant difference. (p value 0.49)

The depth of the sciatic nerve from the skin at the point of bifurcation of the nerve into two components:

The depth of the sciatic nerve from the skin at the point of bifurcation of the nerve into two components was measured and the mean was 1.91 ± 0.5 cm, 95% CI [1.81, 1.99] for females while the mean for male was 1.52 ± 0.51 cm, 95% CI [1.42, 1.61]. The t-test comparing the population means of the two groups showed significant difference with a p value < 0.001, which shows that females have deeper nerves than their male counterparts (Table 5). On measuring the depth of the nerve in the right and left leg of the same subject, it was seen that the absolute difference between legs is 0.33 cm, 95% CI [0.27, 0.38] and this difference was not statistically significant when compared between males and females(Independent samples t-test, p-value-0.376).

Table 5. Comparison of the depth of sciatic nerve from skin at the point of bifurcation in males and females

	Males Mean ±SD [95%CI]	Females Mean ±SD [95%CI]	P value
Skin- nerve depth (cm)	1.52 ± 0.51 95% CI [1.42, 1.61]	1.91 ± 0.5 95% CI [1.81, 1.99]	< 0.001

Independent samples t-test applied

DISCUSSION

In this study, it was found that 63.3% of the volunteers had the division of the sciatic nerve within the normal range of 5-12 cm.¹² Meanwhile, 50% of the volunteers had bifurcation of the sciatic nerve within 5-7 cm of the popliteal crease. Our finding correlates with the study by Chiang et al where the mean distance of SN bifurcation was 5.77 cm and 6.02 cm for the females and males respectively.¹¹ Similar was the finding by Vloka et al. and this cadaveric

study showed that SN divided at 6.05 ± 2.70 cm from the popliteal crease.⁹ The lesson to take away is that these distances varied greatly, from 0 to 11.5 cm, and that too in a small number of cadavers. The anatomical variation in our study is also evident and this further strengthens the point made by Vloka.⁹ Silverman et al. found the sciatic nerve to bifurcate at a mean distance of 4.8 ± 1.6 cm from the popliteal crease whereas, Schwemmer et al. found that the same distance to be 8.25 ± 3.04 cm, which is also quite high in comparison to our study.^{10,13} The clinical implication of this variability is that the classical landmark technique for blocking SN will frequently be inadequate. In cases where the nerve bifurcated above 7-8 cm above the crease, we would be blocking just a single branch of the nerve. The two components of the SN travel together, in a single epineural sheath; also known as Vloka's sheath.¹⁴ However, they do not share their nerve fibers and extraepineural injections distal to the division of the nerve have been a notorious cause for the partial or complete failure of the blocks.¹⁵

As mentioned previously, the sciatic nerve bifurcates most commonly at the junction of the mid third and lower third of the thigh. Berihsu and Debeb have mentioned that "the division of the sciatic nerve may occur at any level above this, though rarely below it".⁵ However, our study shows that 36.7% of the volunteers had their SN bifurcating very close to the crease which might be due to the short average height of the Nepalese population.¹⁶ This means that we may have to search for the point of nerve bifurcation relatively closer to the popliteal crease in our population than the western population. Our findings may also be supported by claims that this division occurs more commonly near to the crease and only less commonly in the proximal areas of the thigh.¹⁷ And ultrasound greatly enhances our ability to identify these variations. New York Society Of Regional Anesthesia states that a larger volume of local anesthetic will be needed for complete blockade of the sciatic nerve if only parasthesia or nerve stimulator is only used, as there is a large variability and the SN is also very thick. Schwemmer also admits that though the visualization of the division of the nerve was inferior to Magnetic Resonance Imaging or cadaveric dissections, portable ultrasound does provide reliable data.¹⁰

Apart from the posterior compartment of the thigh, sciatic nerve can have a high division in the gluteal region too and its relation with the piriformis muscle has greatly been studied. Normally, after entering the gluteal region through the greater sciatic foramen, the sciatic nerve passes under the piriformis muscle and reaches the back of thigh. Then, it continues its journey downwards and finally divides on reaching the superior angle of the popliteal fossa. The incidence of high division of the nerve varies too, from 8% (25 adult cadavers, 24 male and 1 female) to as high as 48% (25 adult male cadavers).^{18,19} A study done on Nepalese cadavers found structural variation in only 7.5%.²⁰ The nerve can divide above or just below the piriformis muscle;

the common peroneal component can either pierce the piriformis or go over it with the tibial component usually arising below the muscle.¹⁸ Some cadaveric studies have even found trifurcation of the sciatic nerve into tibial, common peroneal and sural components.^{5,18} We identified SN bifurcation in 99.1% volunteers but these types of variations were not found.

Variations in nerve bifurcations exist even in the same individual and the abnormality could be either bilateral or just unilateral. Among the 25 cadavers Anbumani et al. studied, 20% (five cadavers) had branching variability of the sciatic nerve, with 16% (four cadavers) having bilateral variation and 4% (one cadaver) showing unilateral variations.¹⁸ Even though there is no abnormality, the distance from the popliteal crease to the point of nerve bifurcation between two limbs can vary. Chiang et al. have stated in their study that 28% of their volunteers had more than 2 cm difference in the crease to nerve distance in their right and left legs and have expressed concern this difference could be significant if an extra-epineural injection is performed and there could be an incomplete block.¹¹ Our study has shown that this variation of more than 2 cm between limbs of the same individual is only 8.25%, less than the study by Chiang et al.¹¹ The same study also found a predictable variability in the depth of bifurcation of sciatic nerve at the popliteal fossa and found consistent deeper skin depth values for female patients than males, 0.4 cm to be exact. Our study strengthens this view because our data shows that women have greater mean skin-nerve distances than men. The reason for this might be that females usually accumulate adipose tissue in lower body and is usually subcutaneous in nature.^{11,21} The depth of the sciatic nerve from the skin was found to be at 20 to 50 mm from the skin in the study by Schwemmer et al. and the multiple linear regression analysis showed it to correlate positively only with the knee joint diameter and not with age, gender, weight or height.¹⁰ We have not measured the knee-joint line and this may be a limitation of the study. Another limitation is that we have not calculated the cross-sectional area (CSA) of the SN before and after its bifurcation; the size could give us a clue regarding which nerve we are visualizing. So, in cases where we have difficulty visualizing the bifurcation while giving a popliteal block, the reference values could definitely help in identifying the nerve.²²

CONCLUSION

Ultrasonographic assessment of the bifurcation of the sciatic nerve into its components found the division to be at varying distances from the popliteal crease; most commonly from 5 to 7 cm. One of the differences from the published literature is that many volunteers had this bifurcation quite near to the popliteal crease, at distances less than 5 cm. The depth of sciatic nerve at the point of bifurcation in Nepalese volunteer population is also coherent with standard publication with females showed

deeper skin depth of the nerve than the males. Use of ultrasound helps in identifying the variation of bifurcation and improves the ability to correctly identify the nerves. Recognizing demographic variation can help us to improve our performance even in the absence of ultrasound.

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