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ORIGINAL RESEARCH **GENERAL ANESTHESIA**

Ultrasound assessment of the sciatic nerve depth and its relationship with anthropometric parameters

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ABSTRACT

Background & objective: Sciatic nerve blocks under ultrasound guidance serve as fundamental procedures for lower limb anesthesia because they provide better safety and accuracy. The procedural outcome depends on sciatic nerve depth variations which become more significant when patients have high BMI or systemic comorbidities or musculoskeletal abnormalities.

The research investigated sciatic nerve depth measurements in the popliteal fossa through ultrasound imaging while analyzing its connection to patient demographics and American Society of Anesthesiologists classifications and anthropometric measurements.

Methodology: The research involved 90 adult patients who underwent lower limb surgery with 45 males and 45 females. Researchers recorded demographic information together with BMI measurements and thigh size and leg length data. The popliteal fossa sciatic nerve depth was measured through ultrasound examinations. The research team performed statistical tests that included Pearson correlation and multiple linear regression analysis and subgroup comparisons through gender, ASA grade, and BMI category.

Results: The ultrasound measurements showed that female patients had deeper sciatic nerves than male patients (3.8 ± 1.0 cm vs. 3.4 ± 0.8 cm; P = 0.03). A positive relationship existed between BMI measurements and mid-thigh diameter dimensions when compared against nerve depth measurements in patients (r = 0.28, P = 0.007 and r = 0.21, P = 0.04 respectively). The independent predictors of increased sciatic nerve depth included BMI (β = 0.06, P = 0.004), mid-thigh diameter (β = 0.03, P = 0.010) and female gender (β = 0.42, P = 0.008) and ASA Grade III (β = 0.37, P = 0.030). The nerve depth increased progressively from normal weight patients (3.2 cm) to obese patients (4.1 cm) with statistical significance (P < 0.001). The study revealed anatomical variations in 57.8% of the patients.

Conclusion: The depth of the sciatic nerve in the popliteal fossa shows a direct correlation with BMI and thigh diameter and gender and ASA classification. The results demonstrate why healthcare providers should perform customized preoperative assessments to maximize the effectiveness of ultrasound-guided blocks especially when treating patients with complex body structures or obesity.

Keywords: BMI; Nerve Block; Regional Anesthesia; Sciatic Nerve; Thigh Circumference; Ultrasonography;

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1. INTRODUCTION

Regional anesthesia serves as an essential principle of contemporary perioperative pain management especially during orthopedic procedures that need maximal postoperative analgesic intervention. The sciatic nerve block at the popliteal fossa stands as a popular technique because it delivers strong anesthesia and analgesia to the distal lower extremity without affecting quadriceps motor function. Through ultrasound guidance for regional anesthesia practitioners have achieved greater accuracy and safety as well as higher block success rates when performing sciatic nerve blocks because of visual nerve structure observation together with anatomical awareness.[1]

Several obstacles continue to hinder the achievement of reliable outcomes through ultrasound-guided sciatic nerve blocks. The depth of the sciatic nerve below skin surface shows wide individual differences among patients. The precise measurement of nerve depth serves as an essential requirement for both excellent needle path planning and avoidance of nerve harm and vascular and blockage failure complications.

Studies from the past year show that human body measurements affect how deep the sciatic nerve extends below the skin surface. The research by Valera-Calero et al. (2021) used ultrasound to study how body mass index (BMI) and thigh girth and weight measurements directly influence sciatic nerve depth in healthy adults.[1] The research confirms that measuring patient anthropometry before procedures helps doctors select appropriate block approaches and determine proper insertion depths particularly when treating patients with diverse body types.

The medical community has consistently recognized obesity as a major complication that affects regional anesthesia procedures. The presence of obesity in patients results in deeper adipose tissue which makes anatomical identification more challenging while simultaneously degrading ultrasound image quality thus creating procedural obstacles. Scientific studies conducted by Lam et al. (2018) established that sciatic nerve block success rate increased notably when ultrasonography replaced traditional landmark techniques for obese patients.[2] The study results demonstrate why patients with high BMI need personalized image-guided procedures because standard depth assumptions prove inaccurate in their case.[2]

The accessibility of the sciatic nerve during block procedures depends on both body composition and clinical factors including ASA classification and musculoskeletal abnormalities and history of limb surgeries. Medical procedures aimed at challenging patients who underwent traumatic experiences or display limb abnormalities plus swelling or physical deformations need individualized treatment plans. Physical therapy and rehabilitation medicine implement structured assessments for determining targeted interventions due to acknowledged patient anatomical variations (Baladaniya & Baldania, 2023). Analysts from various specialties understand the significance of personified anatomical scans which start with therapy interventions and continue through anesthesia preparations.[3,4]

The current literature mainly investigates healthy adults while neglecting to study sciatic nerve depth in actual surgical patients who have different ASA grades and anatomical variations. Research on nerve depth evaluation remains incomplete because of insufficient connection between patient classification systems and anthropometric measurements. The lack of understanding about sciatic nerve depth poses significant clinical challenges because anesthesia providers treat patients with diverse anatomical and systemic conditions during routine procedures.

The current research investigates the complete connection between sciatic nerve depth and human body measurements together with gender-based differences and ASA classification and anatomical conditions. Our goal was to create reference values and predictors for sciatic nerve depth through high-resolution ultrasound studies of surgical patients to enhance individualized regional anesthesia planning and improve block safety and effectiveness.

2. METHODOLOGY

This prospective observational study was carried out in the Department of Anesthesiology at Vinayaka Missions Kirupananda Variyar Medical College & Hospitals, Salem. Prior to commencement, ethical clearance was secured from the Institutional Ethics Committee (Ref No: VMKVMC&H/IEC/24/160), and the study adhered to national ethical guidelines established by the Indian Council of Medical Research (ICMR) and Good Clinical Practice standards. All participants provided informed written consent before enrolment. A total of 90 adult patients, aged 18 years and above, classified as ASA physical status I to III, were included. Patients were excluded if they belonged to ASA Grade IV, were scheduled for emergency surgeries, or had conditions such as limb asymmetry, previous limb surgeries or amputations, or edema-prone states including heart failure, lymphedema, or deep vein thrombosis. Eligible participants were recruited consecutively during routine preoperative evaluations.

The sample size was estimated using G*Power software (version 3.1), targeting a moderate correlation (r = 0.3) between BMI and sciatic nerve depth, with a significance threshold of 0.05 and statistical power of 80%. This yielded a minimum required sample size of 85. To account for potential dropouts or exclusions, the final sample was increased to 90 participants.

Data collection was conducted in a standardized manner. Patients were positioned laterally with both lower limbs exposed for measurement. Height and weight were recorded using calibrated tools, and BMI was computed accordingly. Mid-thigh diameter was measured at the midpoint between the anterior superior iliac spine and the popliteal crease. Thigh length was defined as the linear distance from the anterior superior iliac spine to the popliteal crease, while leg length extended from the popliteal crease to the calcaneus.

Sciatic nerve imaging was performed using a SonoSite M Turbo ultrasound system equipped with a 38 mm linear broadband transducer (6–13 MHz) and color Doppler functionality. The nerve was located in the popliteal fossa, and depth from the skin surface to the nerve was measured in centimeters. Additional parameters such as side (right or left) and bifurcation distance from the popliteal crease were also documented. All sonographic assessments were performed by anesthesiologists trained in ultrasound-guided regional techniques, and digital images were stored for independent verification.

Collected data were compiled in a structured database and analyzed using the Epidemiological Information Package (EPI 2010). Continuous variables (e.g., nerve depth, BMI) were expressed as mean ± standard deviation. Group comparisons were performed using the Kruskal–Wallis test for non-normally distributed data. Categorical data (e.g., gender, ASA grade, presence of anatomical variations) were evaluated using Yates' corrected chi-square test. Correlation between anthropometric parameters and nerve depth was assessed using Pearson or Spearman correlation coefficients, depending on distribution characteristics. A p-value of less than 0.05 was considered statistically significant.

To ensure methodological rigor, all measurements were taken according to predefined protocols, and ultrasound findings were independently reviewed by two investigators to reduce inter-observer variability. Equipment calibration was verified regularly. Ethical safeguards were maintained throughout, with no additional procedures beyond routine preoperative assessments. Participant anonymity was preserved, and the right to withdraw at any point without compromising medical care was ensured. This methodology supports the study's aim to improve anatomical understanding of sciatic nerve depth in relation to individual body characteristics, ultimately enhancing the precision and efficacy of regional anesthesia.

3. RESULTS

3.1. Demographic and anthropometric characteristics

The study included 90 adult patients (45 males and 45 females) undergoing lower limb surgeries. The overall mean age was 47.2 ± 15.8 years. Gender-wise analysis revealed significant differences in several anthropometric measures, including height, weight, mid-thigh diameter, thigh length, and sciatic nerve depth. However, no statistically significant difference was observed in BMI or leg length.

As shown in Table 1, males had significantly greater height, weight, mid-thigh diameter, and thigh length than females. Interestingly, despite similar BMI, females exhibited significantly greater sciatic nerve depth (3.8 ± 1.0 cm vs. 3.4 ± 0.8 cm, P = 0.03). These differences are crucial when planning nerve localization and block depth, especially in ultrasound-guided procedures.

3.2. ASA Classification and Type of Surgery

The clinical profiles of the participants were examined in terms of their ASA physical status classification and

Table 1: Demographic and anthropometric characteristics (n = 90)

Variable	Overall (n = 90)	Male (n = 45)	Female (n = 45)	p-value
Age (years)	47.2 ± 15.8	46.5 ± 14.3	47.9 ± 17.2	0.65
Height (cm)	170.2 ± 11.4	176.1 ± 8.9	164.3 ± 9.7	<0.001*
Weight (kg)	76.8 ± 18.6	82.3 ± 16.1	71.3 ± 18.9	0.002*
BMI (kg/m²)	26.5 ± 6.3	26.3 ± 5.8	26.7 ± 6.8	0.74
Mid-Thigh Diameter (cm)	48.9 ± 8.7	50.6 ± 7.9	47.2 ± 9.1	0.03*
Thigh Length (cm)	42.8 ± 4.3	43.6 ± 4.0	42.0 ± 4.5	0.04*
Leg Length (cm)	44.7 ± 5.6	45.5 ± 5.3	43.9 ± 5.8	0.12
Sciatic Nerve Depth (cm)	3.6 ± 0.9	3.4 ± 0.8	3.8 ± 1.0	0.03*

**P < 0.05 was considered statistically significant. Values expressed as mean ± SD; Independent samples t-test was used to compare male and female groups.*

Table 2: ASA classification and type of surgery (n = 90)

Category	n (%)
ASA Grade I	32 (35.6)
ASA Grade II	38 (42.2)
ASA Grade III	20 (22.2)
Knee Surgery	34 (37.8)
Foot Surgery	29 (32.2)
Other Lower Limb Surgeries	27 (30.0)

ASA: American Society of Anesthesiologists classification. Percentages are rounded to one decimal point.

Table 3: Anatomical variants and comorbidities (n = 90)

Variable	n (%)
Structural Malformations or Limb Asymmetry	36 (40.0)
History of Previous Lower Limb Surgery	48 (53.3)
Presence of Lower Limb Edema	41 (45.6)
Existing Lower Limb Musculoskeletal Conditions	52 (57.8)

Percentages are based on the total sample (n = 90). More than one condition could coexist in a single patient.

the type of lower limb surgery performed. Most patients were classified as ASA Grade II, indicating mild systemic disease, while knee surgeries were the most frequently performed procedures.

As shown in Table 2, ASA Grade II patients formed the largest subgroup (42.2), followed by Grade I (35.6%) and Grade III (22.2%). No patients were classified as ASA Grade IV or above, consistent with the study's exclusion criteria. Regarding surgical type, knee surgeries were most common (37.8%), followed by foot surgeries (32.2%) and other lower limb procedures (30.0%).

3.3. Anatomical Variants and Comorbidities

Clinical examination and ultrasound assessments revealed several anatomical features and pre-existing conditions that may influence sciatic nerve localization. These variations were documented to understand their potential impact on nerve depth and block performance.

As shown in Table 3, 57.8% of patients had pre-existing musculoskeletal conditions, and 53.3% had a history of prior lower limb surgery. Additionally, 40.0% demonstrated structural malformations or limb asymmetry, and 45.6% presented with lower limb edema at the time of assessment. These findings emphasize the importance of individualized anatomical consideration during regional block procedures.

3.4. Correlation and Multivariate Predictors of Sciatic Nerve Depth

A two-step analysis was conducted to identify factors influencing sciatic nerve depth. First, Pearson correlation coefficients were calculated to evaluate univariate associations between anthropometric variables and nerve depth. Subsequently, multiple linear regression was used to determine independent predictors while adjusting for confounders.

As shown in Table 4, BMI ($r = 0.28$, $P = 0.007$), weight ($r = 0.24$, $P = 0.020$), and mid-thigh diameter ($r = 0.21$, $P = 0.040$) showed significant positive correlations with sciatic nerve depth. In multivariable analysis, BMI, mid-thigh diameter, female gender, and ASA Grade

Table 4: Correlation and multivariate predictors of sciatic nerve depth (n = 90)

Variable	Correlation Coefficient (r)	P-value	Regression Coefficient (β)	95% CI	p-value
BMI (kg/m²)	0.28	0.007*	0.06	0.02 to 0.10	0.004*
Weight (kg)	0.24	0.020*	–	–	–
Mid-Thigh Diameter (cm)	0.21	0.040*	0.03	0.01 to 0.05	0.010*
Height (cm)	–0.18	0.090	–	–	–
Thigh Length (cm)	–0.14	0.190	–	–	–
Leg Length (cm)	–0.11	0.300	–	–	–
Female Gender (vs. Male)	–	–	0.42	0.11 to 0.73	0.008*
ASA Grade III (vs. Grade I)	–	–	0.37	0.05 to 0.70	0.030*

** Statistically significant at P < 0.05; Only variables with significant univariate associations or clinical relevance were entered into the regression model.*

Table 5: Sciatic nerve depth and bifurcation symmetry by gender and ASA Grade (n = 90)

Group	Sciatic Nerve Depth (cm)	p-value	Bifurcation Symmetry Present	P-value
Male (n = 45)	3.4 ± 0.8		30 (66.7%)	
Female (n = 45)	3.8 ± 1.0	0.03*	17 (37.8%)	0.002*
ASA Grade I (n = 32)	3.2 ± 0.7		25 (78.1%)	
ASA Grade II (n = 38)	3.6 ± 0.9		14 (36.8%)	
ASA Grade III (n = 20)	4.0 ± 1.1	0.024*	8 (40.0%)	0.009*

** Statistically significant at P < 0.05. Nerve depth is expressed as mean ± SD; P-values calculated using independent samples t-test (for gender) and Kruskal-Wallis test (for ASA grades); Yates' corrected Chi-square test was used for categorical comparisons.*

III emerged as independent predictors of increased nerve depth. These findings underline the combined influence of body composition and clinical status on nerve block planning.

3.5. Group Comparisons by Gender and ASA Grade

Subgroup analysis was conducted to assess differences in sciatic nerve characteristics across gender and ASA physical status categories. Particular attention was given to nerve depth and bifurcation symmetry, which are

clinically relevant for ultrasound-guided block planning. As shown in Table 5, females had significantly deeper sciatic nerve placement compared to males (3.8 ± 1.0 cm vs. 3.4 ± 0.8 cm, P = 0.03). Notably, bifurcation symmetry was more commonly observed in males (66.7%) than females (37.8%) (P = 0.002). Further, patients in ASA Grade III had deeper sciatic nerves (4.0 ± 1.1 cm) and reduced bifurcation symmetry compared to ASA I counterparts. These findings suggest that both gender and ASA status are associated with anatomical variations, which may influence block technique and success.

3.6. Sciatic Nerve Depth by BMI Category

To further explore the relationship between body composition and nerve depth, participants were grouped by BMI category. Mean sciatic nerve depth was

Table 6: Sciatic nerve depth across BMI categories (n = 90)

BMI Category	n	Mean Nerve Depth (cm)	P-value vs. Normal
Normal (18.5–24.9 kg/m²)	31	3.2 ± 0.7	Reference
Overweight (25–29.9)	30	3.6 ± 0.9	0.01*
Obese (≥30)	29	4.1 ± 1.1	< 0.001*

**P < 0.05 considered significant; Data expressed as mean ± SD; Comparison by one-way ANOVA with post-hoc analysis using Bonferroni correction.*

Table 7: Comparative analysis of sciatic nerve depth studies [8,11]

Study	Sample Size	Population	BMI Correlation	Thigh Circumference	Gender Difference	Height Correlation	Anatomic Variations Included
Current Study	90	ASA I–III surgical patients	r = 0.28*	r = 0.21*	Females deeper*	Not significant	Yes (57.8%)
Schiarite et al. (2015)	62	Healthy adults	Not reported	P < 0.001*	Not significant	Not significant	Not assessed
Chiang et al. (2013)	50	Healthy volunteers	Not reported	Not assessed	Females deeper*	Inverse*	Not assessed
Mínguez-Esteban et al. (2024)	50	Healthy Spanish adults	r ≈ 0.4–0.5*	R^2 = 0.223*	Not significant	Not significant	Excluded
Crabtree et al. (2006)	40	Surgical patients	Not reported	Linear regression slope = 0.43	Not assessed	Not assessed	Not assessed

**P < 0.05 considered significant*

compared across normal weight, overweight, and obese groups.

As seen in Table 6, a significant trend was observed where sciatic nerve depth increased with rising BMI. The mean nerve depth was 3.2 ± 0.7 cm in normal BMI participants, compared to 3.6 ± 0.9 cm in overweight (P = 0.01) and 4.1 ± 1.1 cm in obese participants (P < 0.001). These results reinforce the importance of BMI as a key factor influencing needle depth during sciatic nerve block administration.

4. DISCUSSION

A prospective study investigated the factors that affect sciatic nerve depth measurements at the popliteal fossa through ultrasound imaging for patients requiring lower limb surgical procedures. The evaluation of anthropometric parameters together with ASA classification and gender and clinical comorbidities enables a complete understanding of nerve localization factors in regional anesthesia. The research demonstrates that BMI together with mid-thigh diameter and gender and ASA grade serve as important predictors of nerve depth which affects both block planning and execution.5

The research showed that BMI directly influenced sciatic nerve depth (r = 0.28, P = 0.007) in agreement with previous findings which demonstrated deeper nerve positioning with increased subcutaneous tissue. The research conducted by Mínguez-Esteban et al. on Spanish adults produced stronger relationships (r ≈ 0.4–0.5) between BMI measurements and sciatic nerve depth. The analysis revealed that mid-thigh diameter predicted depth independently (β = 0.03, P = 0.010) while showing a correlation of r = 0.21 (P = 0.040). The research of Schiarite et al. shows that thigh circumference stands as the most reliable predictor with a P value below 0.001.

The measurements of height, thigh length and leg length failed to demonstrate any statistically meaningful relationships. Our study contradicts the previous findings by Chiang et al. who reported an inverse relationship between height and nerve depth because our results indicate that localized body habitus stands as the more relevant factor for clinical practice.

The sciatic nerve depth measured 3.8 ± 1.0 cm in females while males displayed 3.4 ± 0.8 cm depth (P = 0.03) which remained significant in multivariate analysis (β = 0.42, P = 0.008). The research by Chiang et al. with non-surgical volunteers showed identical results that they linked to natural gender differences in fat distribution patterns. The study conducted by Schiarite et al. revealed no substantial gender variations in their research population. It is possible that differences between the study groups regarding their population composition and surgical exposure contributed to this disagreement.[6,7]

The analysis of nerve depth according to BMI categories revealed that the depth increased progressively from normal (3.2 ± 0.7 cm) to overweight (3.6 ± 0.9 cm, P = 0.01) and finally reached 4.1 ± 1.1 cm in obese patients (P < 0.001). The study findings support existing literature which recommends depth-adapted block techniques when performing regional blocks in overweight and obese patients. Preprocedural ultrasound assessment should be performed to reduce both failed attempts and complications according to these findings.

Table 7 shows our study findings support previous research findings and goes beyond them. The research confirms BMI and thigh diameter as reliable predictors and adds ASA classification and comorbidities and anatomical asymmetry to address previous research gaps. The controlled regression model demonstrates that gender and ASA grade independently affect sciatic nerve depth measurements despite inconsistent findings from previous studies.

ASA Grade III patients demonstrated deeper brachial plexus nerve depth (4.0 ± 1.1 cm) and increased bifurcation asymmetry compared to patients with ASA Grade I. The regression analysis identified ASA Grade III as an independent predictor which demonstrated a β value of 0.37 (P = 0.030). The research introduces a new discovery because previous studies including Mínguez-Esteban et al. and Chiang et al. excluded patients with moderate to severe systemic illness.[8] The data indicates that disease severity together with tissue modifications such as fluid accumulation and altered body fat distribution affects the visibility of anatomical structures and the difficulty of performing procedures.[12,13]

The study participants included 53.3% who underwent previous limb surgeries and 57.8% with musculoskeletal deformities and 45.6% with edema which could impact both ultrasound imaging and nerve localization. Previous studies excluded these elements which restricted their practical use outside of the laboratory setting. Our research included a diversity of anatomical cases which enhances the clinical value of the study by showing how healthcare practices need to adjust anesthetic approaches to individual anatomical features.[14]

The results indicate that healthcare providers should perform preprocedural BMI and thigh diameter and ASA status assessments to enhance the accuracy and success rates of sciatic nerve blocks. Real-time ultrasound should be used to modify the procedure for patients who have unique anatomical characteristics. The planning process in advance proves beneficial for females and obese patients by minimizing complications and failed attempts while enhancing analgesic outcomes.

5. LIMITATIONS

The study limitations stem from its single-site research design and small participant count along with the exclusion of patients classified as ASA Grade IV or critical illness. The study did not track long-term block success rates or complications so additional multicenter trials must be conducted for validation purposes.

6. CONCLUSION

The research validates the importance of conducting personal assessments for both anatomy and clinical condition to improve ultrasound-based sciatic nerve blocks. The depth of the nerve increases independently when patients have BMI, thigh diameter, female gender and ASA Grade III status. Procedural planning should incorporate individualized anesthetic approaches since anatomical variations and comorbidities affect planning.

7. Data Availability

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

8. Ethical Approval

Approval was obtained from the Institutional Ethics Committee of Vinayaka Missions Kirupananda Variyar Medical College & Hospitals, Salem (Ref No: VMKVMC&H/IEC/24/160).

9. Informed Consent

All participants provided written informed consent prior to inclusion in the study.

10. Conflict of Interest

The authors declare no conflict of interest.

11. Funding

No external funding was received for the conduct of this study.

12. Authors contribution

SM: Concept, conduction of the study work, and manuscript editing

PKS: Literature search, data collection, and statistical analysis

VKK, KG: Data collection and manuscript editing

BR: Supervision and manuscript editing

AKC: Statistical analysis and manuscript editing

PPP: Literature search and data collection

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