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Assessment in location of sciatic nerve between the ischial tuberosity and the greater trochanter of the femur: A cadaveric study

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ABSTRACT

Background: The location description of the sciatic nerve (SN) of adult between the ischial tuberosity (IT) and the greater trochanter of the femur (GT) is inconsistent in publications, this impels us to investigate and measure the distance relationship with SN between IT and GT.
Methods: Thirty-one adult cadavers were dissected to investigate the distance relationship of SN with the posterior prominent position of the ischial tuberosity (ppIT), the medial edge of IT (mIT) and the lateral prominent position of GT (lGT).
Results: SN passed through the point of the junction of medial one-third and middle one-third of a length from ppIT to lGT, and the midpoint of a length from mIT to lGT from the average data of the total studied cadavers. From average data of female and male, the left SN passed through the point of the junction of the medial two-fifths and the lateral three-fifths of the length between mIT and lGT. Between ppIT and lGT, SN located in a range of proportions from 0.1 to 0.6 from medial to lateral. Between mIT and lGT, SN located in a range of proportions from 0.2 to 0.7 from medial to lateral and all SN passed through the middle third of the length.
Conclusions: Different bony landmarks draw different location descriptions of anatomic structure. In anatomic study and clinical practice, the utilized bony landmark should be clearly and accurately identified the reference point, inaccurate bony landmark can result in erroneous localization of the interested anatomic structure and lead to operation failure or iatrogenic injury.

1. Introduction

Sciatic nerve (SN) is the widest and longest peripheral nerve in human body, it originates from sacral plexus in pelvic cavity and penetrates the greater sciatic foramen to emerge in gluteal region, and then it continues down the posterior compartment of the thigh [1]. The course of SN in gluteal region is clinically practical for many medical procedures such as SN block [2]. As the widest and frequently used peripheral nerve, theoretically, the course should be clearly described in publications. However, the course of SN described in textbooks and other publications between the ischial tuberosity (IT) and the greater trochanter of femur (GT) is inconsistent. Gray's Anatomy [3], Clinical Anatomy [4], and Clinical Oriented Anatomy [5] describe "a point midway" between IT and GT. Last's Anatomy [6] presents "midpoint". Surface Anatomy [7] demonstrates "midpoint or middle third". Regional Anatomy [8]

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textbook for Chinese medical student describes "a point of junction of medial one-third and middle one-third". Currin et al. [9] reported "half way". Mbaka and Osinubi [10] stated "slightly medial to midpoint" which was similar to the finding by Berihu and Debeb [11]. Wan-Ae-Loh et al. [12] reported the midpoint of SN was located at the point of 37.87 ± 8.27 % of the length from IT to GT.

We initially considered that racial and geographic differences were contributions to the different location descriptions for adult. However, we find many figures in publications from many countries involving living human bodies and cadavers from different races show SN is closer to IT than to GT [1–14]. Based on the teaching experience in human anatomy, we realize the selected landmark is another cause we should take seriously, because different landmarks get different location descriptions. The above-mentioned bony landmarks were IT and GT. However, there are many sites for GT and IT to utilize to locate SN, such as the tip of GT, the lateral prominent point of GT (lGT), the midpoint of IT, the posterior prominent point of IT (ppIT), the medial edge of IT (mIT) and the lateral edge of IT. Of these sites, lGT is the outmost site of GT in a standard anatomical position, mIT is lateral to the anus, and ppIT is the posterior prominent bony structure of the gluteal region.

Thus, the inconsistency of location descriptions of SN impels us to investigate the anatomic location of SN between IT and GT using mIT, ppIT and lGT on adult cadavers to verify the location descriptions published.

2. Materials and methods

Sixty-two gluteal regions from 31 adult Chinese cadavers (24 males and 7 females; age range, 18–85 years) preserved in formalin solution were included in this study (Table 1). Cadavers with trauma, surgery, tumor, and inflammatory diseases that could alter the position of investigated structures in gluteal region were excluded from this study. Cadavers were placed in prone position on dissecting table without internal or external rotation of hip joint, and all gluteal regions were dissected with standard dissection protocol to expose SN, IT and GT, with SN in its original position (Fig. 1). The following measurements were taken according to Fig. 2 and recorded: width of SN along the line between IT and GT (WSN), distance from ppIT to lGT, distance from ppIT to the medial edge of SN, and distance from mIT to the medial edge of SN. The measured data were entered in an Excel file to calculate the distance from the medial edge to the posterior prominent position of IT, distance from mIT to lGT, proportion of distance from ppIT to the medial edge of SN to distance from ppIT to lGT, proportion of distance of ppIT to lateral edge of sciatic nerve to distance from ppIT to lGT, proportion of distance of ppIT to midpoint of sciatic nerve to distance from ppIT to lGT, proportion of distance from mIT to the medial edge of SN to distance from mIT to lGT, proportion of distance of mIT to lateral edge of sciatic nerve to distance from mIT to lGT, and proportion of distance of mIT to the midpoint of sciatic nerve to distance from mIT to lGT. A digital caliper accurate to 1 mm was used to take these measurements. In cadaver with piriformis muscle variant and/or abnormal SN regardless of course and branching pattern, WSN was measured as the width of the SN along the line between bony landmarks, the lateral edge of sciatic nerve was regarded as the outmost edge of SN and the medial edge of SN as the innermost edge of SN along the line between bony landmarks.

The measured and calculated data were presented as mean ± standard deviation (SD) and analyzed by IBM SPSS Statistics 27. A paired samples *t*-test was used to compare the data of left and right side. Statistical significance was defined as $p < 0.05$.

Ethics committee of our institute (2022YX035) approved this study.

3. Results

Table 2 shows the measured and calculated data of the male, female, and total cadavers. From proportions of total cadavers, the location of SN for adult on left and right side between ppIT and lGT was at the length of 29 % up to 42 % from medial to lateral, and the midpoint of sciatic nerve must be within this range. Namely, for adult regardless of sex, at the point of junction of medial one-third and middle one-third of the length from ppIT and lGT, SN located at this point. In the same way, according to proportions of male and female, the location of SN must be at the point of junction of medial one-third and middle one-third of the length from ppIT and lGT.

From proportions of total cadavers, SN between mIT and lGT on left and right side located at the length of 41 % up to 50 % from medial to lateral, namely, SN must be detected at the midpoint of the length from mIT and lGT, but the point was located on the lateral part of SN. In the same way, from proportions of male and female, SN lied at the midpoint of the length between mIT and lGT except the left side of female. The left female SN located at the point of junction of medial two-fifths and lateral three-fifths of the length and medial to the midpoint of the length between mIT and lGT. From proportions of the left side of male, SN passed also through the point of junction of medial two-fifths and lateral three-fifths of the length between mIT and lGT, however, the point was located on the medial part of SN.

Table 3 presents cadavers with SN not passing the point of the length between ppIT and lGT and between mIT and lGT for male and female, respectively. Fig. 3 exhibits proportions of 31 cadavers in the measurement of SN from ppIT to lGT, it showed the proportions were in a wide range from 0.1 to 0.6. From Tables 2 and 3 and Fig. 3, in the measurement from ppIT and lGT, SN passing through the

Table 1
Anthropometric data of the cadavers.

Sex	Number	Age (year)			Length (cm)		
		mean	SD	range	mean	SD	range
Female	7	32.4	11.3	18–43	147	8.53	137–161
Male	24	52.8	14.7	32–85	165	8.88	152–183

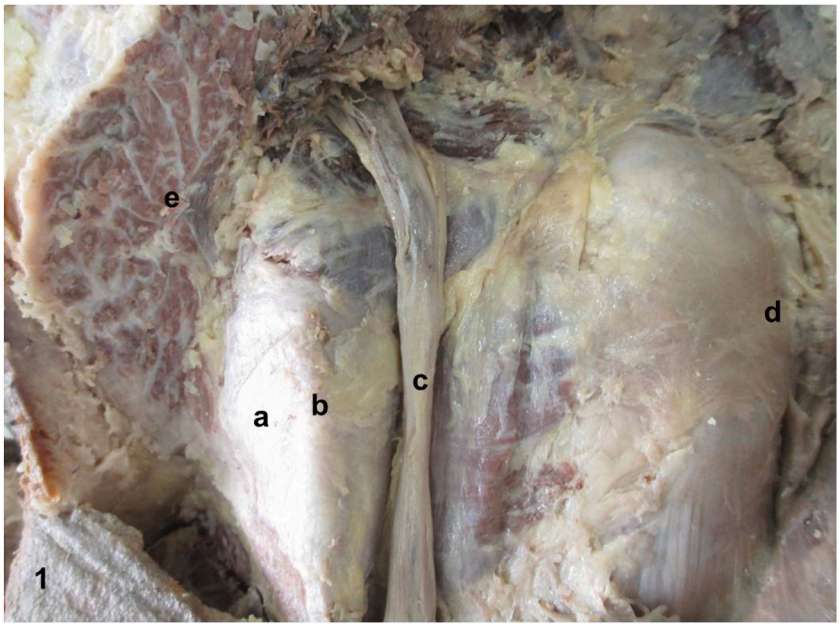

Fig. 1. Photograph of sciatic nerve in gluteal region. a: Medial edge of the ischial tuberosity; b: The posterior prominent position of the ischial tuberosity; c: Sciatic nerve; d: Lateral process of greater trochanter of femur; e: Gluteus maximus.

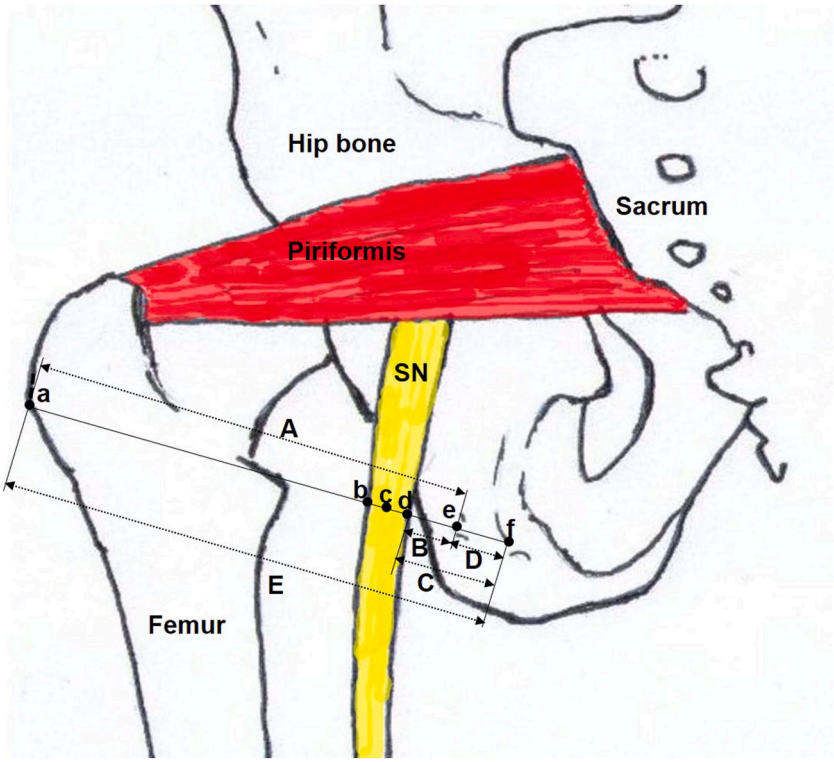

Fig. 2. Drawing diagram of the measurements. a: the lateral prominent point of GT, lGT; b: the lateral edge of SN; c: the midpoint of SN; d: the medial edge of SN; e: the posterior prominent point of IT, ppIT; f: the medial edge of IT, mIT; A: distance from ppIT to lGT; B: distance from ppIT to the medial edge of SN; C: distance from mIT to the medial edge of the SN; D: distance from the medial edge to the posterior prominent point of IT; E: distance from mIT to lGT.

Table 2
Measured and calculated data of cadaver (Mean ± SD) .

Paramters	Male		Female		Total	
	Left side	Right side	Left side	Right side	Left side	Right side
WSN (cm)	1.03 ± 0.23	1.03 ± 0.26	0.81 ± 0.12	0.83 ± 0.10	0.98 ± 0.23	0.98 ± 0.25
A (cm)	7.17 ± 0.95	7.18 ± 1.06	6.80 ± 0.63	5.95 ± 1.03	7.09 ± 0.89	6.90 ± 1.16
B (cm)	2.02 ± 0.39	2.10 ± 0.61	1.82 ± 0.47	1.56 ± 0.20	1.98 ± 0.41	1.98 ± 0.59
C (cm)	3.18 ± 0.39	3.46 ± 0.62	2.98 ± 0.46	2.94 ± 0.20	3.13 ± 0.41	3.34 ± 0.60
D (cm)	1.15 ± 0.03	1.36 ± 0.03	1.16 ± 0.02	1.37 ± 0.01	1.16 ± 0.03	1.36 ± 0.02
E (cm)	8.32 ± 0.96	8.54 ± 1.07	7.96 ± 0.63	7.32 ± 1.03	8.24 ± 0.90	8.27 ± 1.17
F	0.28 ± 0.05	0.29 ± 0.06	0.27 ± 0.06	0.27 ± 0.08	0.28 ± 0.05	0.29 ± 0.06
G	0.43 ± 0.05	0.43 ± 0.07	0.39 ± 0.05	0.42 ± 0.09	0.42 ± 0.05	0.43 ± 0.07
H	0.36 ± 0.05	0.36 ± 0.06	0.33 ± 0.05	0.35 ± 0.09	0.35 ± 0.05	0.36 ± 0.07
I	0.38 ± 0.05	0.41 ± 0.05	0.37 ± 0.05	0.41 ± 0.08	0.38 ± 0.05	0.41 ± 0.06
J	0.51 ± 0.05	0.53 ± 0.06	0.48 ± 0.04	0.53 ± 0.09	0.50 ± 0.05	0.53 ± 0.06
K	0.45 ± 0.05	0.47 ± 0.05	0.43 ± 0.04	0.47 ± 0.09	0.44 ± 0.05	0.47 ± 0.06

WSN: width of SN between IT and GT; A: distance from ppIT to lGT; B: distance from ppIT to the medial edge of SN; C: distance from mIT to the medial edge of the SN; D: distance from the medial edge to the posterior prominent point of IT; E: distance from mIT to lGT; F: proportion of distance from ppIT to the medial edge of SN to the distance from ppIT to lGT; G: proportion of distance of ppIT to lateral edge of sciatic nerve to the distance from ppIT to lGT; H: proportion of distance of ppIT to midpoint of sciatic nerve to the distance from ppIT to lGT; I: proportion of distance from mIT to the medial edge of SN to the distance from mIT to lGT; J: proportion of distance of mIT to the lateral edge of sciatic nerve to the distance from mIT to lGT; K: proportion of distance of mIT to the midpoint of sciatic nerve to the distance from mIT to lGT.

Table 3
Cadavers with SN not passing the point of the length between ppIT and lGT and between mIT and lGT for male and female, respectively.

	From ppIT to lGT (Point of 1/3; middle third)			From mIT to lGT (Point of 1/2; point of 2/5; middle third)		
Sex (number)	Only left	Only right	Bilateral	Only left	Only right	Bilateral
Male (24)	4; 0	6; 2	1; 1	4; 1; 0	2; 6; 0	3; 8; 0
Female (7)	1; 1	2; 0	1; 1	2; 1; 0	0; 2; 0	4; 2; 0

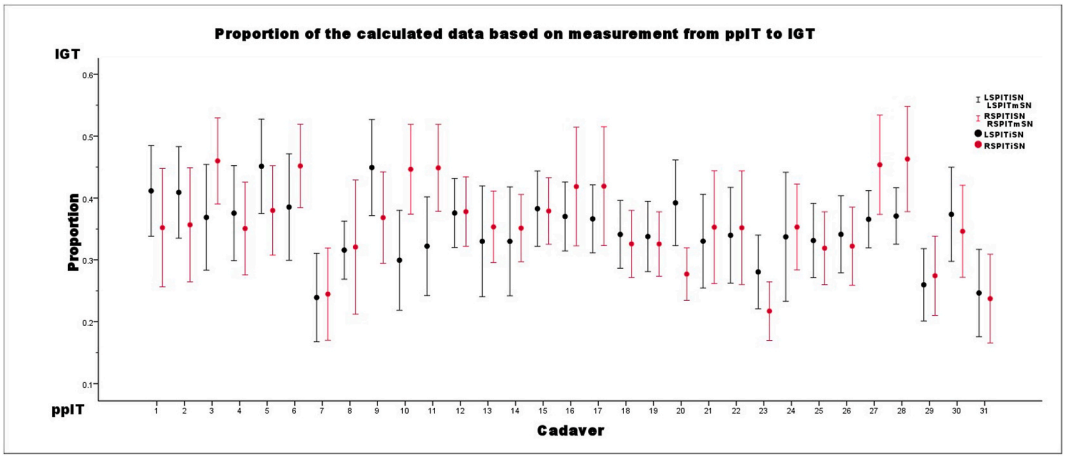

Fig. 3. Proportions of 31 cadavers in the measurement of SN from ppIT to lGT
Abbreviations: posterior prominent position of the ischial tuberosity, ppIT; lateral prominent position of GT, lGT; proportion of distance of ppIT to lateral edge of sciatic nerve to the distance from ppIT to lGT of left side, LSPITlSN; proportion of distance of ppIT to medial edge of sciatic nerve to the distance from ppIT to lGT of left side, LSPITmSN; proportion of distance of ppIT to lateral edge of sciatic nerve to the distance from ppIT to lGT of right side, RSPITlSN; proportion of distance of ppIT to medial edge of sciatic nerve to the distance from ppIT to lGT of right side, RSPITmSN; proportion of distance of ppIT to midpoint of sciatic nerve to the distance from ppIT to lGT of left side, LSPITiSN; proportion of distance of ppIT to midpoint of sciatic nerve to the distance from ppIT to lGT of right side, RSPITiSN.

point of junction of medial one-third and middle one-third of the length was in 73 % of 62 total sides, 75 % of 48 male sides and 64 % of 14 female sides; SN passing through the middle third of the length was in 89 % of total sides, 92 % of male sides and 79 % of female sides.

Fig. 4 presents proportions in the measurement of SN from mIT to lGT, it showed the proportions were in a wide range from 0.2 to 0.7. From Tables 2 and 3 and Fig. 4, in the measurement from mIT to lGT, SN passing through the midpoint of the length was in 65 % of

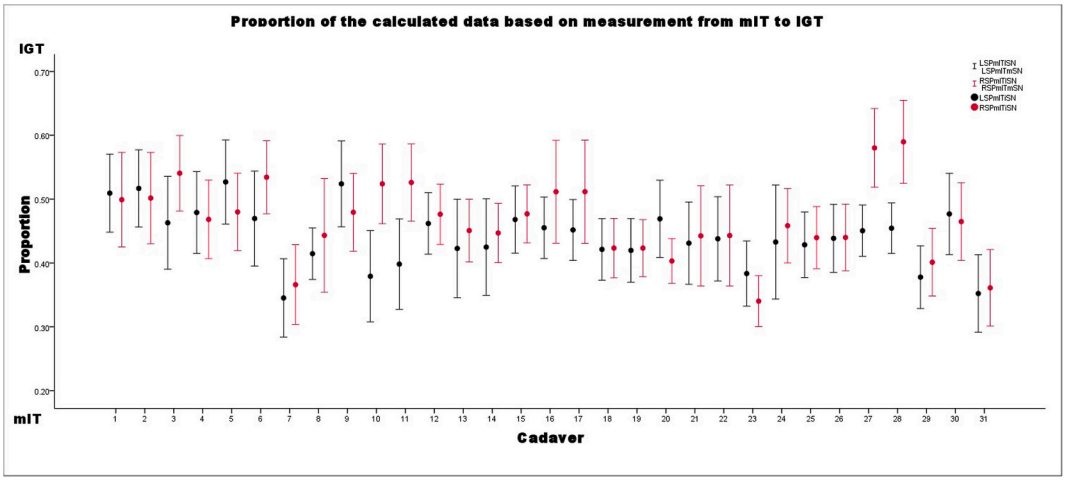

Fig. 4. Proportions of 31 cadavers in the measurement of SN from mIT to lGT
Abbreviations: medial edge of IT, mIT; lateral prominent position of GT, lGT; proportion of distance of mIT to lateral edge of sciatic nerve to the distance from mIT to lGT of left side, LSPmITlSN; proportion of distance of mIT to medial edge of sciatic nerve to the distance from mIT to lGT of left side, LSPmITmSN; proportion of distance of mIT to lateral edge of sciatic nerve to the distance from mIT to lGT of right side, RSPmITlSN; proportion of distance of mIT to medial edge of sciatic nerve to the distance from mIT to lGT of right side, RSPmITmSN; proportion of distance of mIT to midpoint of sciatic nerve to the distance from mIT to lGT of left side, LSPmITiSN; proportion of distance of mIT to midpoint of sciatic nerve to the distance from mIT to lGT of right side, RSPmITiSN.

total sides, 75 % of male sides and 29 % of female sides; SN passing through the point of junction of medial two-fifths and lateral three-fifths of the length was in 52 % of total sides, 52 % of male sides and 50 % of female sides, and all the SN passed through the middle third of the length.

The measured and calculated data of left and right side were analyzed by a paired samples *t*-test. The distance from the medial edge to the posterior prominent position of IT ($p < 0.001$), proportion of distance from mIT to the medial edge of SN to distance from mIT to lGT ($p = 0.015$), proportion of distance of mIT to lateral edge of sciatic nerve to distance from mIT to lGT ($p = 0.030$) and proportion of distance of mIT to the midpoint of sciatic nerve to distance from mIT to lGT ($p = 0.016$) were statistically significant difference between left and right side, and others revealed no significant difference.

4. Discussion

Different bony landmarks draw different location descriptions of anatomic structure. In anatomic study and clinical practice, the utilized bony landmark should be clearly and accurately identified. Usually, IT and GT are used as an anatomic and surgical landmark: the accurate site of IT, such as the lateral border, the midpoint, mIT and ppIT can be easily palpated on body surface, the lateral border of IT is lateral to mIT and ppIT and closer to SN; lGT and the medial border of GT are easily palpable on body surface. In our study, we used mIT and ppIT separately as the medial bony landmark and lGT as the lateral bony landmark to identify the distance relationship with SN. The distance between mIT and ppIT is over 1 cm and greater than WSN in our study from average data of total cadavers. Furthermore, this distance alters the distance relationship with SN and leads to different results: between mIT and lGT, SN passes through the midpoint of the length; between ppIT and lGT, through the point of junction of the medial one-third and middle one-third of the length. If we additionally use the lateral border of IT as a medial bony landmark, the proportion will be smaller.

Gray's Anatomy [3], Clinical Anatomy [4] and Clinically Oriented Anatomy [5] describe SN passes through "a point midway" between IT and GT. Last's Anatomy [6] presents "midpoint". Surface Anatomy [7] demonstrates "midpoint or middle third". Currin et al. [9] reported "half way". Study by Mbaka and Osinubi [10] and study by Berihu and Debeb [11] stated "medial to midpoint". The above-mentioned location descriptions are in agreement with the result of the measurement from mIT to lGT in our study that was from proportion of the total studied cadavers regardless of sex and side.

Regional Anatomy [8] textbook for Chinese medical student describes SN passes through "a point of junction of the medial one-third and middle one-third" of the length from IT and GT, which is in agreement with the result of the measurement from ppIT to lGT in our study with cadavers from Chinese origin. Interestingly, Wan-Ae-Loh et al. [12] reported that the midpoint of sciatic nerve located at a point of 37.87 ± 8.27 % of the line from the lowest point of IT to the outermost point of GT which is slightly greater than proportion of distance of ppIT to midpoint of sciatic nerve to distance from ppIT to lGT (left side: 0.35 ± 0.05; right side: 0.36 ± 0.07) and much less than proportion of distance of mIT to the midpoint of sciatic nerve to distance from mIT to lGT (left side: 0.44 ± 0.05; right side: 0.47 ± 0.06) from our study. From figures in study by Wan-Ae-Loh et al. [12], the outermost point of GT mentioned was the lGT, and the lowest point of IT was close to ppIT. So, the finding of Wan-Ae-Loh et al. [12] is close to the result of a point of junction of the medial one-third and middle one-third of the length from ppIT and lGT.

Wadhwa et al. [15] stated that SN lied medial to the midpoint of the length from midpoint of IT to inner border of GT. Morphologically, ppIT and the midpoint of IT are possibly the same site, but the inner border of GT must be medial to lGT. Therefore, the result of Wadhwa et al. [15] confirmed the location of SN was not at the midpoint of the length from midpoint of IT to inner border of GT and was close to our finding of the point of junction of medial one-third and middle one-third of the length from ppIT and lGT.

Currin et al. found the mean position of SN between IT and GT had no significant differences between sides and sexes [9]. In our study, from the average proportions of male and female between ppIT and lGT respectively, the location point is consistent, and so is for the left side and right side respectively for male and female; from the average proportions of male and female between mIT and lGT respectively, the location point is the same, and so is for the left side and right side of male and the right side of female, but the location point of the left side of female is different and locates on the point of junction of medial two-fifths and lateral three-fifths and medial to the midpoint of the length between mIT and lGT.

In our study, the location of SN exhibits a wide range of distributions and shows individual difference. The location points of SN in our study: the midpoint of the length between mIT and lGT and the point of junction of the medial one-third and middle one-third of the length between ppIT and lGT, are not 100 % accurate, but the distribution range of SN, especially in the middle third of the length between mIT to lGT is 100 % accurate. In clinical practice, the accurate fixed site, such as the midpoint between mIT and lGT, provides the clear injection site for SN block in gluteal region. Clinically, clinicians select one point for injection site by one method or the combination of several methods. For outpatient and inpatient, clinicians can determine sciatic nerve by ultrasonography [16–18], computed tomography [19] or magnetic resonance imaging [18], which improves the success rate of treatment and the total medical cost. Therefore, knowledge of the location description plays an important role in selecting injection site when outside the hospital without aid of such medical equipment.

Small sample size was a limitation in our study, because insufficient cadavers (especially female cadaver) for anatomical teaching and research persist in present China [20]. Limited cadavers meet the teaching needs above all, we cannot satisfy our research aim to impede the normal teaching. Another limitation was the localization of bony landmark. In our study, we removed the soft tissue to expose the bony landmarks and took measurements under direct vision accurately. In clinical setting, clinicians palpate and locate the bony landmarks on skin surface without visualization, this manipulation can produce inaccurate localization of bony landmarks.

5. Conclusions

Different bony landmarks draw different location descriptions of anatomic structure. In anatomic study and clinical practice, the utilized bony landmark should be clearly and accurately identified the reference point, inaccurate bony landmark can result in erroneous localization of the interested anatomic structure and lead to operation failure or iatrogenic injury. From our study, many publications stating the midpoint location of SN between IT and GT indicate that SN is between mIT to lGT in general population regardless of sex and side. Others describing SN locates at a point of junction of medial one-third and middle one-third between IT and GT mean SN is between ppIT and lGT in total population regardless of sex and side. In addition, we observed that the left side SN passes through the point of the junction of the medial two-fifths and the lateral three-fifths of the length between mIT and lGT from average proportions of female and male; SN locates in a range of proportions from 0.1 to 0.6 from medial to lateral between ppIT and lGT; and between mIT and lGT, the SN locates in a range from 0.2 to 0.7 from medial to lateral, all SN passes through the middle third of the length.

Ethical publication statement

All the authors confirm that we have read the Journal's position on issues involved in ethical publication and affirm that this report is consistent with those guidelines. This study was received approval from ethics committee of our institute (2022YX035).

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None.

Data availability statement

Data will be made available on request.

CRediT authorship contribution statement

Chunming Ma: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Supervision, Visualization, Writing – original draft, Writing – review & editing. **Xiaocui Wang:** Investigation, Validation, Writing – review & editing. **Jin Li:** Investigation, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Abbreviations

sciatic nerve SN
ischial tuberosity IT
greater trochanter of the femur GT
posterior prominent position of the ischial tuberosity ppIT
medial edge of IT mIT
lateral prominent position of GT lGT
width of SN along the line between IT and GT WSN
standard deviation SD

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