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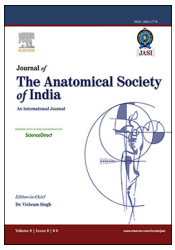

Original Article

Anatomical structure and topographic anatomy of sciatic nerve in human fetuses

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ABSTRACT

Introduction: Sciatic nerve is the longest and thickest nerve of the human body which divides into two branches in popliteal fossa. Variations of sciatic nerve can be observed during the course of the nerve. These anatomical variations contribute to some clinical manifestations such as piriformis syndrome, sciatalgia.

Methods: This study was conducted on 60 aborted fetuses aged between 9 and 40 gestational weeks and with no gross anomalies. Morphometrical measurements related to the nerve and the neighboring structures were performed and also incidence of anatomical variations was determined.

Results: All parametric data were seen increased with gestational age ($p < 0.05$). Also, no statistical differences between the parameters from right and left were found ($p > 0.05$). The sciatic nerve division was observed in 99 (82.5%) lower extremities in the popliteal fossa, 19 (15.83%) at a level above the popliteal fossa, and in 2 lower extremities (1.67%), high division was observed. Also, the status of sciatic nerve was assessed in regard to piriformis muscle. In 118 of the lower extremities (98.3%), sciatic nerve was observed leaving from underneath the piriformis muscle as one piece and the remaining 2 (1.67%) were observed as giving division at higher levels. In one of these lower extremities of the right side, tibial nerve branch was observed following a path under piriformis muscle and common peroneal nerve was observed passing through the piriformis nerve.

Discussion: We believe that our study will provide data regarding the development of sciatic nerve in fetal period and that data will contribute to related clinical studies and applications.

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1. Introduction

Sciatic nerve is the longest and thickest nerve of the human body and it is formed by the joining of anterior branches of L_4-S_3 spinal nerves. These branches come closer in order to create the sciatic nerve, which is an approximately 2 cm wide, flat, and thick band near the inferior margin of piriformis muscle. Sciatic nerve passes under the infrapiriform foramen and progresses inferolateral between the greater trochanter and ischial tuberosity under the cover created by gluteus maximus muscle. The nerve extends over the ischium and later passes behind the internal obturatory muscle, the quadratus femoris, and the adductor magnus muscles.[1] Sciatic nerve, which is formed by tibial nerve and common peroneal nerve, is surrounded by a single epineural sheath that is divided into its branches in popliteal fossa after its course in posterior thigh. This division point may be at different levels in popliteal fossa.[2]

Sciatic nerve is a long and thick and therefore a strong nerve. But it can also be damaged easily due to its features. Fractures and dislocations in gluteal region, penetrating injuries and surgical interventions, tumors in pelvis, improper hip injections usually applied to children and newborns, aneurism of internal iliac artery and its branches may injure sciatic nerve and the branches of this nerve along the posterior thigh. The anatomical variations in addition to these pathologies and the injury tendency are further increased. Therefore, it is very important to know the course of the nerve in both gluteal and posterior thigh and its relationships with its neighboring structures.[3–9]

In this study, we aimed to determine the anatomical course of the sciatic nerve, its distance from its neighboring structures , and its possible variations in human fetuses.

2. Methods

This study was performed with 60 fetuses (34 males and 26 females) without gross anomalies and aged between 9 and 40 gestational weeks. These fetuses were obtained from the fetus bank of Necmettin Erbakan University, Meram Medicine Faculty Anatomy Department (Table 1). Required permissions for the study were obtained from Necmettin Erbakan University, Meram Medicine Faculty Non-Interventional Clinical Research Ethics Committee with the decision number of 2012/74.

In the study, all fetuses were dissected from their gluteal regions and posterior thigh regions until the inferior edge of popliteal fossa. Microdissection instruments, 0.01 mm precision digital caliper (Stainless hardened), microsurgery microscope (Kaps Sam 62), and a camera (Canon D1000) were used. Measurements were performed in two categories: measurements of sciatic nerve length (SNL) and measurements of the distance between the sciatic nerve and its neighboring structures.

Table 1 – The distribution of fetus numbers according to gestational age.

Gestational age	1st Trimester (9–12 week)	2nd Trimester (13–26 week)	3rd Trimester (27–40 week)
Female	1	17	8
Male	6	16	12
Total	7	33	20

2.1. *Measurements related to sciatic nerve (Fig. 1):*

1. **SNL**: The distance between the place of the sciatic nerve where it passes under the piriformis muscle and its terminal branches.
2. **Proximal width of sciatic nerve**: The width of sciatic nerve where it leaves.
3. **Distal width of sciatic nerve**: The width of the sciatic nerve before it divides into its terminal branches.
4. **Division level of sciatic nerve**: The position of the place where the sciatic nerve divides into its terminal branches

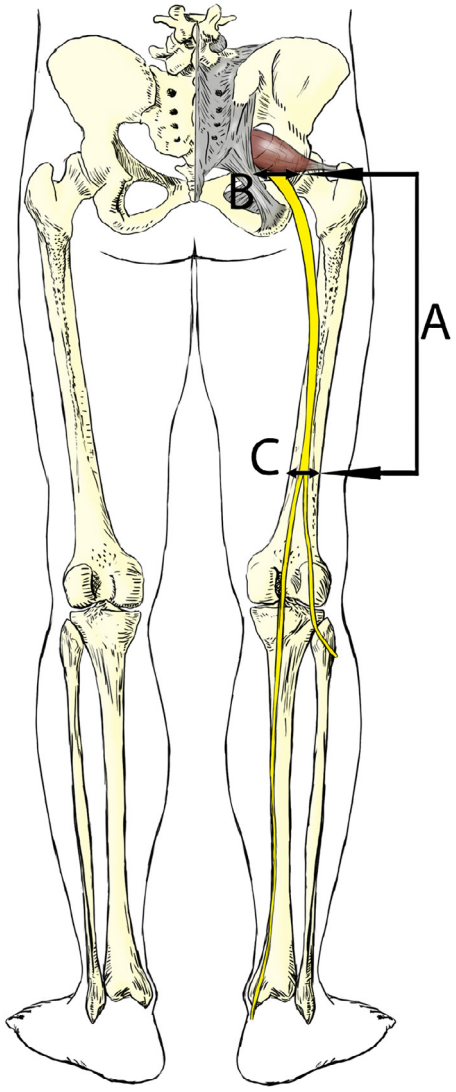

Fig. 1 – Measurements related to sciatic nerve (Drawn by Gökalp Şahin). A: Sciatic nerve length (SNL); B: Proximal width of sciatic nerve (PWSN); C: Distal width of sciatic nerve (DWSN).

according to popliteal fossa; 1 – inside the popliteal fossa, 2 – at a level above the popliteal fossa in the posterior thigh and 3 – high division (HD)-sciatic nerve divides inside lesser pelvis or just below the piriformis muscle.

2.2. *Measurements of the distance between the sciatic nerve and its neighboring structures (Fig. 2):*

1. **Distance between the sciatic nerve and the greater trochanter (SN-GT)**: The distance between the place where the sciatic nerve emerges under piriformis muscle and the superior margin of greater trochanter was measured.
2. **Distance between sciatic nerve and ischial tuberosity (SN-IT)**: The distance between the places where the sciatic nerve emerges under piriformis muscle and the superior margin of ischial tuberosity was measured.
3. **Distance between ischial tuberosity and greater trochanter (IT-GT)**: The distance between the superior margin of ischial tuberosity and the superior margin of greater trochanter was measured (Fig. 4A).
4. **Distance between sciatic nerve and intergluteal sulcus (SN-IGS)**: The distance between the sciatic nerve and the intergluteal sulcus was measured (Fig. 4B).
5. The relationship between the sciatic nerve and the quadratus femoris muscle was determined.

Data obtained from fetuses were analyzed by using SPSS 16.0 statistical program. Mean values and standard deviations of the parameters were determined according to trimesters. Level of significance of statistical analyses was determined as $p < 0.05$. Variant analysis (One Way ANOVA) was used in order to compare the groups between each other. Besides, Student's t-test was used in order to compare the parametric data between genders.

3. Results

In the study, the statistically significant differences were observed between trimesters according to all parameters regarding the sciatic nerve measurements and its relations with its neighboring structures ($p < 0.05$). All parameters were indicated as increasing with the gestational age (Table 5). Yet, there was no statistical difference between genders ($p > 0.05$).

The localization of the branching point of the sciatic nerve, which divides into its terminal branches tibial nerve and common peroneal nerve, according to popliteal fossa was assessed under 3 categories as 1 – in the popliteal fossa, 2 – at a level above popliteal fossa in posterior thigh region, and 3 – HD, at a level of piriformis muscle. Sciatic nerve was observed to divide into its terminal branches at a level above the popliteal fossa in a total of 120 lower extremities of both right and left side. Out of these 120 extremities, the division was observed in 99 lower extremities (82.5%) in the popliteal fossa (Fig. 5A) and 19 lower extremities (15.83%) at a level above the popliteal fossa (Fig. 5B). Additionally, we detected that the nerve divided into its HD branches at a level of piriformis muscle in 2 lower extremities (1.67%) (Table 2).

We determined the course of the sciatic nerve on the quadratus femoris muscle as lateral, medial, and central. Out of the 60 right lower extremities, we observed the sciatic nerve in 54 of them (90%) in the center of the quadratus femoris muscle, in 3 of them (5%) in the medial course of the muscle and in 3 of them (5%) in the lateral course of the muscle (Table 3).

Out of the 60 left lower extremities, 49 of them (81.7%) were in the central course of the quadratus femoris muscle, 6 of

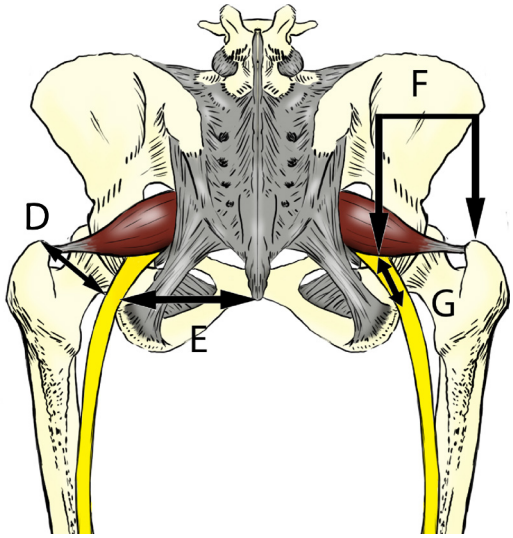

Fig. 2 – Measurements related to neighboring structures of sciatic nerve (Drawn by Gökalp Şahin). D: Distance between ischial tuberosity and greater trochanter (IT-GT); E: Distance between sciatic nerve and intergluteal sulcus (SN-IGS); F: Distance between sciatic nerve and greater trochanter (SN-GT); G: Distance between sciatic nerve and ischial tuberosity (SN-IT).

Table 2 – The division level of sciatic nerve (%).

Trimester	*n*	In the popliteal fossa		Above the popliteal fossa		High division (HD)	
		Right	Left	Right	Left	Right	Left
1st Trimester	7	6 (85.7%)	6 (85.7%)	1 (14.3%)	1 (14.3%)	0	0
2nd Trimester	33	28 (84.9%)	31 (94%)	5 (15.2%)	1 (3%)	0	1 (3%)
3rd Trimester	20	15 (75%)	13 (65%)	4 (20%)	7 (35%)	1 (5%)	0
Total	60	49 (81.7%)	50 (83.3%)	10 (16.7%)	9 (15%)	1 (1.67%)	1 (1.67%)

n = number of fetus.

Table 3 – The course of sciatic nerve on quadratus femoris muscle (%).

Trimester	*n*	Central course of ischiadic nerve		Medial course of ischiadic nerve		Lateral course of ischiadic nerve	
		Right	Left	Right	Left	Right	Left
1st Trimester	7	6 (85.71%)	6 (85.71%)	1 (14.3%)	1 (14.3%)	0	0
2nd Trimester	33	31 (94%)	28 (84.9%)	1 (3.03%)	2 (6.06%)	1 (3.03%)	3 (9.1%)
3rd Trimester	20	17 (85%)	15 (75%)	1 (50%)	3 (15%)	2 (10%)	2 (10%)
Total	60	54 (90%)	49 (81.7%)	3 (5%)	6 (10%)	3 (5%)	5 (8.33%)

n = number of fetus.

them (10%) were in the medial of the muscle, and 5 of them (8.33%) were in the lateral course of the muscle.

Position of the sciatic nerve according to piriformis muscle was also evaluated in our study. Out of 120 lower extremities, the sciatic nerve was observed emerging under piriformis muscle as one piece in 118 of them (98.3%) (Fig. 3A and B). It has been further observed that the sciatic nerve exerted a HD in the remaining 2 lower extremities (1.67%). It has been determined that the nerve divided into its terminal branches in gluteal region, tibial nerve passed under the piriformis muscle, and common peroneal nerve passed through the piriformis muscle in one of these 2 extremities (the right one) (Fig. 6). Finally, it has been shown that the nerve divided into its terminal branches just after it emerged under the piriformis muscle in the other extremity (Table 4).

We also assessed the piriformis muscle whether it is monopartite or bipartite and we determined that the piriformis muscle was monopartite in all of the lower extremities (100%).

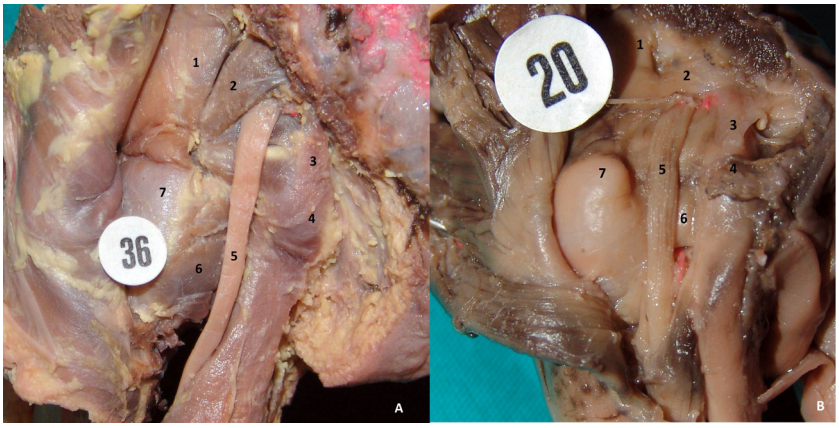

Fig. 3 – 1A: On the left side, course of sciatic nerve in the gluteal region in 30-week female fetus. 1B: On the left side, course of sciatic nerve in the gluteal region in 19-week male fetus. 1: gluteus medius muscle, 2: Piriformis muscle, 3: sacrotuberous ligament, 4: ischial tuberosity, 5: sciatic nerve, 6: quadratus femoris muscle, 7: greater trochanter.

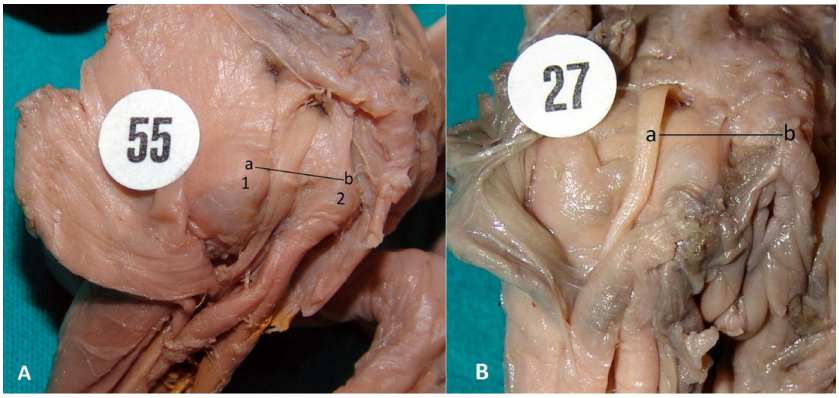

Fig. 4 – A: a-b: On the left side, distance between greater trochanter and ischial tuberosity in 15-week female fetus. 1: greater trochanter, 2: ischial tuberosity. B: a-b: On the left side, distance between sciatic nerve and intergluteal sulcus in 19-week female fetus.

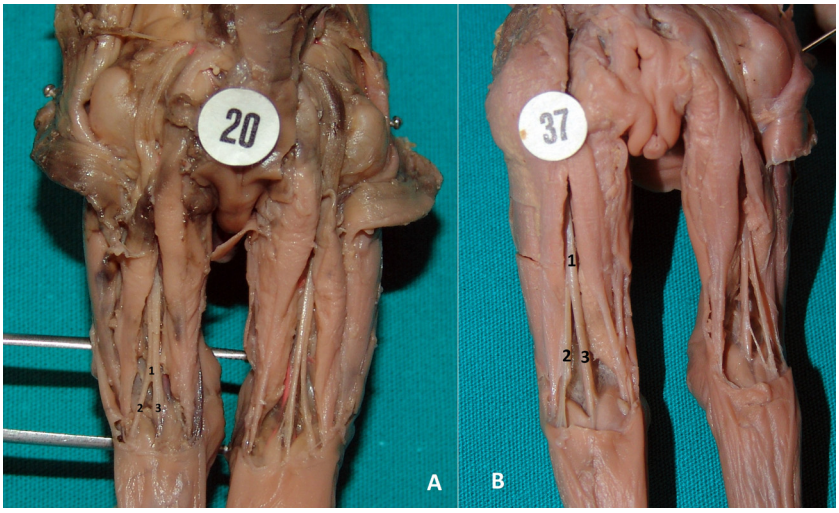

Fig. 5 – A: On the left side, sciatic nerve division in the popliteal fossa in 19-week male fetus. B: On the left side, sciatic nerve division at a level above the popliteal fossa in 15-week female fetus.

4. Discussion

The sciatic nerve provides the motor innervations of hamstring muscles and all the muscles of leg and foot, the sensorial innervations of external lateral and posterior of the leg and the skin of all the surfaces of the foot.[10] Therefore, an injury of the nerve can demonstrate different outcomes varying from the minor motor or sensory anomalies to full paralysis and the coxalgia.[11,12] One of the causes of sciatic nerve injuries in early infancy is the intramuscular injections.[13,14]

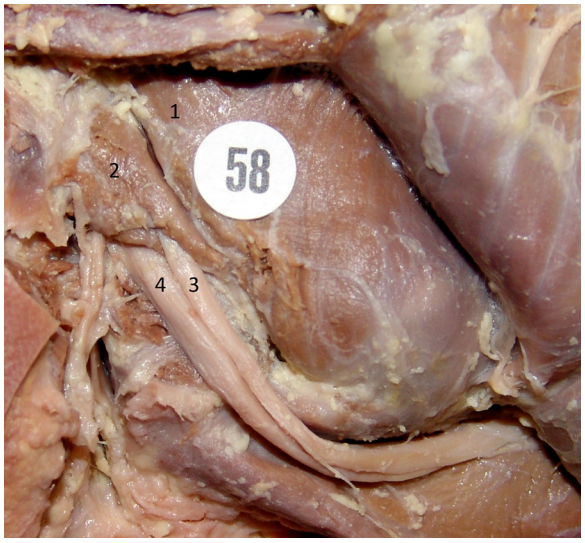

Fig. 6 – On the right side, sciatic nerve divides into its terminal branches above the piriformis muscle; common peroneal nerve passes through the piriformis muscle and tibial nerve passes below it in 34-week male fetus. 1: Gluteus medius muscle, 2: piriformis muscle, 3: common peroneal nerve, 4: tibial nerve.

Intramuscular injections are commonly used and indispensible implementations of the medical practice. Intramuscular injection areas are generally the gluteal region and the anterior thigh. It is possible to injure the sciatic nerve with the gluteal intramuscular injections. Gilles and French[7] have stated that intramuscular injections caused complications, especially in newborns and children. They have reported that injections applied with incorrect angles and inattentive behaviors can lead the injection needle to injure the sciatic nerve or the injection of the neurotoxic agents in the neurovascular structures or to a close vicinity.[7,15,16] The nerve may not be protected properly in newborns and the risk of the nerve damage due to the anatomical variations greatly increases. In many studies, it has been shown that these variations were the reasons for some clinical presentations such as piriformis syndrome sciatalgia, coxodynia, and muscle atrophy. This fact must be considered by clinicians who will perform the surgical intervention in the area of sciatic nerve and division points of the nerve in lower extremities.[17,18]

In our study, the relationships between the sciatic nerve and its neighboring structures and the measurements of sciatic nerve were assessed statistically. All parameters were observed as increasing with the gestational age ($p < 0.05$).

Davut et al.[19] performed a study with 34 fetuses. They have determined the proximal width of the sciatic nerve as approximately 2–6 mm and they did not find any significant relationship between the proximal width of the nerve and the gestational age. On the contrary, we observed that the proximal and distal width of the sciatic nerve increased with gestational age. Also, the width of the sciatic nerve in a region where it started was larger than the width of the nerve at the division point where it divided into its terminal branches in all fetuses. We believe that it was due to its branches throughout its course in the posterior thigh.

Anatomy is the most important factor in the peripheral nerve blockage independent of the techniques such as neural stimulator, ultrasound.[20] The sciatic nerve blockage is used in some surgical interventions in lower extremities of children

Table 4 – The position of sciatic nerve according to piriformis muscle (%).

Trimester	*n*	Undivided nerve passes below undivided piriformis muscle		High division	
		Right	Left	Right	Left
1st Trimester	7	7 (100%)	7 (100%)	0	0
2nd Trimester	33	33 (100%)	32 (97%)	0	1 (3%)
3rd Trimester	20	19 (95%)	20 (100%)	1 (5%)	0
Total	60	59 (98.3%)	59 (98.3%)	1 (1.67%)	1 (1.67%)

n = number of fetus.

Table 5 – Mean values and standard deviations of parameters belonging to sciatic nerve in all trimesters (mean ± SD).

	1st Trimester		2nd Trimester		3rd Trimester	
	Right	Left	Right	Left	Right	Left
SNL	18.9 ± 3.45	17.4 ± 3.64	38.97 ± 9.32	38.19 ± 9.71	52.38 ± 10.30	50.65 ± 10.14
PWSN	0.85 ± 0.1	0.79 ± 0.1	2.28 ± 0.76	2.2 ± 0.7	3.49 ± 0.87	3.66 ± 1.03
DWSN	0.52 ± 0.06	0.48 ± 0.1	1.43 ± 0.49	1.42 ± 0.42	2.42 ± 0.71	2.52 ± 0.72
SN-IT	3.6 ± 0.8	3.58 ± 0.81	7.32 ± 2.17	7.40 ± 2.16	10.13 ± 2.36	9.85 ± 2.60
SN-GT	4.8 ± 0.93	4.74 ± 1	9.84 ± 2.7	9.6 ± 2.7	12.82 ± 3.34	12.31 ± 3
SN-IGS	4.37 ± 1	3.64 ± 0.6	9.43 ± 2.84	9 ± 2.7	13.8 ± 3.33	12.52 ± 3.2

$p < 0.05$, differences between groups.
SNL: sciatic nerve length, PWSN: proximal width of sciatic nerve, DWSN: distal width of sciatic nerve, SN-IT: distance between sciatic nerve and ischial tuberosity, SN-GT: distance between sciatic nerve and greater trochanter, SN-IGS: distance between sciatic nerve and intergluteal sulcus.

such as surgical repair of club foot and ankle arthrodesis. Anatomical variations of the division points of the sciatic nerve are regarded as the reason for the failure of nerve blockage in the popliteal level.[2,21,22]

Shankar et al.[23] have determined the frequency of terminal branching of the sciatic nerve in 102 lower extremities by showing HD as 9.8% whereas we detected this frequency as 1.67%. Ugrenovic et al.[24] have conducted a study with 200 lower extremities and they detected the division of sciatic nerve to its terminal branches in popliteal fossa in 72.5% of the lower extremities whereas Kurtoglu et al.[25] have observed this terminal branching in all of the cases (in 20 fetuses). In our

Table 6 – The relationship between sciatic nerve and piriformis muscle and the comparison between present study and previous studies.[5,19,24,27,31–38]

Researchers	Samples	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	Type 7
Beaton and Anson[35]	120 Cadavers	84.2%	11.7%	3.3%	0.8%			
Beaton and Anson[32]	240 Cadavers	90%	7.1%	2.1%	0.8%			
Uluutku and Kurtoğlu[33]	25 Fetuses	74%	16%	10%				
Machado et al.[31]	100 Lower extremities	82%	16%	2%				
Ugrenovic et al.[24]	200 Lower extremities	96%	2.5%	1.5%				
Pokorny et al.[36]	91 Cadavers	79.1%	14.3%	4.4%	2.2%			
Parsons and Keith[37]	138 Lower extremities	85%	12.3%		2.2%			
Sulak et al.[34]	200 Fetuses	98%	1.25%	0.75%				
Davut et al.[19]	34 Fetuses	82%		6%				12%
Guvencer et al.[27]	25 Cadavers	76%	16%	8%				
Benzon et al.[38]	66 Lower extremities	98.5%	1.52%					
Patel et al.[5]	86 Lower extremities	91.8%	5.81%					2.33%
Our study	60 Fetuses	99.2%	1.67%					

Type 1: An undivided sciatic nerve passes distally below undivided fibers of the piriformis muscle.
Type 2: The nerve separates into two divisions above the piriformis muscle; common peroneal nerve passes through the piriformis muscle, tibial nerve passes below it.
Type 3: The nerve separates into two divisions above the piriformis muscle; common peroneal nerve passes above the piriformis muscle, tibial nerve passes below it.
Type 4: The undivided nerve passes through the piriformis muscle.
Type 5: The nerve separates into two divisions above the piriformis muscle; tibial nerve passes through the piriformis muscle, common peroneal nerve passes above it.
Type 6: The undivided nerve passes above the piriformis muscle.
Type 7: The nerve separates into terminal branches in gluteal region and two branches pass below piriformis muscle individually.

study, this rate was 82.5%. We observed higher rates compared to the results of Ugrenovic et al.[24] and lower rates compared to the results of Kurtoglu et al.[25]

Piriformis syndrome, as one of the causes of non-discogenic sciatica, is a neuropathy characterized with the symptoms such as the compression/irritation of sciatic nerve by piriformis muscle which is located in the output path of sciatic nerve. Differences/variations of the relationship between the sciatic nerve and the piriformis muscle lead to the piriformis syndrome. Type of the variation represents the clinical aspects of piriformis syndrome.[5,26–30] According to the study conducted by Beaton and Anson,[32] there were three types which explained the location of the nerves: Type I, II, and III. In Type I, the sciatic nerve passes under the piriformis muscle as one piece. In Type II, the tibial nerve passes under the piriformis muscle and the common fibular nerve passes through the piriformis muscle. In Type III, the tibial nerve leaves the sciatic nerve and passes under the piriformis muscle and common fibular nerve passes over the piriformis muscle. Machado et al.[31] have performed a study in which they dissected 100 gluteal regions. They have detected the rate of Type I as 82%, the rate of Type II as 16%, and the rate of Type III as 2%. In another study performed by Ugrenovic et al.[24] with 100 human fetuses, they found these rates as 96%, 2.5%, 1.5%, 25%, respectively. On the other hand, Uluutku and Kurtoğlu[33] have studied 25 infant cadavers and they showed the rates as 74%, 16%, and 10%, respectively. Davut et al.[19] performed a study with 34 fetuses and the rates were as 82%, 0%, and 6%, respectively. In the study conducted by Sulak et al.,[34] they showed the rates as 98%, 1.25%, and 0.75%, respectively. In our study, we detected these rates as 99.2%, 1.67%, and 0%, respectively. Our results related to Type I rates were similar to the findings of Ugrenovic et al.[24] and Sulak et al.[34]. However, our results were higher compared to the results of the study performed by Machado et al.,[31] Davut et al.,[19] and Uluutku and Kurtoğlu.[33]

Our findings regarding Type II rates were lower than the results of Ugrenovic et al.,[24] higher than the results of Davut et al.[19] and Sulak et al.[34] and greatly lower than the results of Machado et al.[31] and Uluutku and Kurtoğlu[33] (Table 6).

All in all, we believe that it is crucial to know some features of the sciatic nerve (such as the SNL, width, and its branching variations, the distance of the nerve from its neighboring structures in the fetal trimesters) in order to perform the proper surgical interventions and radiological investigations.

Author contributions

Anıl Didem Aydin Kabakci, Mustafa Buyukmumcu, PhD, VMD, Mehmet Tugrul Yilmaz, PhD, VMD; Aynur Emine Cicekcibasi, MD, Duygu Akin: Study design, Data acquisition, Manuscript preparation.

Conflicts of interest

The authors have none to declare.

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