ORIGINAL ARTICLE

Eur. J. Anat. 18 (4): 261-266 (2014)

Morphological variations of sciatic nerve and piriformis muscle in gluteal region during fetal period

Manisha B. Sinha[1], Anjali Aggarwal[2], Daisy Sahni[2], K. Harjeet[2], Richa Gupta[2] and Human P. Sinha[3]

[1]Department of Anatomy, All India Institute of Medical Sciences, Raipur, Chhattisgarh, India, [2]Department of Anatomy, Postgraduate Institute of Medical Education and Research, Chandigarh, India and [3]Department of Neurology, NHMMI Multispecialty hospital, Raipur, Chhattisgarh, India

SUMMARY

Intramuscular drug injection in the gluteal region is often the most frequent cause of sciatic nerve injury in preterm newborns. Local anatomic variation is one of the predisposing causes of iatrogenic sciatic nerve injury**.** The aim of this morphological study was to assess the relationship of sciatic nerve with the piriformis muscle and to elucidate variations of fusion of piriformis with neighboring muscles in the gluteal region of Indian human preterm fetuses. Four types of relationship of the sciatic nerve with the piriformis muscle were observed in one hundred gluteal regions of fifty spontaneously aborted, formalin-fixed fetuses, aged 20 to 36 week (24 males and 26 females). In 85% of the gluteal regions, the classic pattern was found, in which the two components of the sciatic nerve fuse with each other proximal to the piriformis, and the fused sciatic nerve emerges at the lower border of the piriformis. In the remaining 15% of the gluteal regions, variations in relationship were found. The most common variation, characterized by the passage of the common peroneal component through the piriformis and the emergence of the tibial part at the lower border of the piriformis, was seen in 9% of the gluteal regions. Common peroneal and tibial components passed above and below the muscle respectively in 3%, and the unsplit sciatic nerve passed through the piriformis in 3% of the gluteal regions. Four types of fusion of the piriformis with the neighboring muscles were seen: namely, no fusion; fusion with superior gamellus; fusion with gluteus medius, or fusion with gluteus medius and obturator internus complex in 28%, 43%, 26% and 3% of the gluteal regions respectively. Anatomical variations of the sciatic nerve in relation to the piriformis muscle should be kept in mind while performing medical or surgical interventions in this region.

Key words: Piriformis muscle – Sciatic nerve – Gluteal region – Obturator internus complex

Abbreviations: PM- Piriformis muscle, CPN- Common peroneal nerve, TN- Tibial nerve, SN- Sciatic nerve.

INTRODUCTION

The sciatic nerve (SN) is the thickest nerve in our body meant to innervate the posterior compartment of the thigh and all compartments of the lower leg and foot. The piriformis muscle (PM) belongs to the pelvitrochantric muscle group. Anatomically, this muscle, after originating from the anterior surface of the sacrum, passes through the greater sciatic notch to reach its final destination: the greater trochanter. The sciatic nerve runs on the ventral aspect of the piriformis in the pelvic cavity, where it becomes dorsal to the piriformis in the gluteal region. In the past, the anatomic variations of SN in relation to PM (Parsons and Keith., 1896; Beaton and Anson, 1937; Hollinshead,

Corresponding author: Manisha B. Sinha. Department of Anatomy, All India Institute of Medical Sciences, Raipur, Chhattisgarh, 492099 India. Tel: 07389507576 / 8518881710. E-mail: manishab80@gmail.com

Submitted: 13 December, 2013. *Accepted:* 10 March, 2014.

1982; Pokorny et al., 2006) and variant forms of PM in adults (Windisch, 2007) have been discussed. Fusion of PM with adjacent muscles has also been reported in adults (Windisch, 2007), but not in fetuses.

Sciatic nerve palsy coupled with umbilical artery catheterization has been assumed to be caused by vascular occlusion of the inferior gluteal artery (Giannakopoulou et al., 2002). Intragluteal intramuscular drug injection is often an underestimated cause of SN injury. Iatrogenic sciatic nerve injury is more frequent in preterm newborns (Sennes et al., 2009). Sensori-motor palsy of lower limb of variable degree secondary to intramuscular injection in gluteal region in premature infants is often misdiagnosed. Local anatomical variations often predispose the nerve to such injury. In these authors' knowledge, a handful of articles describing the structure under the gluteus maximus, variations of SN in relation to PM in fetuses, are available (Machado et al., 2003; Ugrenovic et al., 2005). The fusion of the piriformis with the adjoining gluteal muscles could be the cause of piriformis syndrome in later stages of life, as the whole thickness of SN or a part of it can be compressed by the contracture or spasm of obturator internus complex (Meknas et al., 2003). The aim of our study was to evaluate the topographic relationship of the sciatic nerve with PM and the fusion of PM with adjacent muscles in fetuses.

MATERIAL AND METHODS

After getting approval from the institutional ethical committee and informed parental consent, 100 gluteal regions of 50 fetuses (24 males and 26 females) between ages of 20 and 36 weeks were dissected. All the fetuses used in this study were spontaneously aborted and later preserved in 10% formalin in the department of anatomy of the institute. Fetuses with any apparent congenital anomalies were excluded. Skin over gluteal region was dissected up to mid-thigh. The gluteus maximus was cut in the middle to expose the SN and PM. All microdissection was carried out under 2.5X loupe magnifying lenses. Photo documentation of all specimens was made with digital camera (DSC-W90, Cybershot 8.1 Megapixael, Sony, Japan).

RESULTS

We found four morphological types of SN in relation to the piriformis (Table 1, Fig. 1).

Type I- Tibial and peroneal components fused before entering the gluteal region and the unsplit SN passed infrapiriformis in 85 (85%) of the limbs.

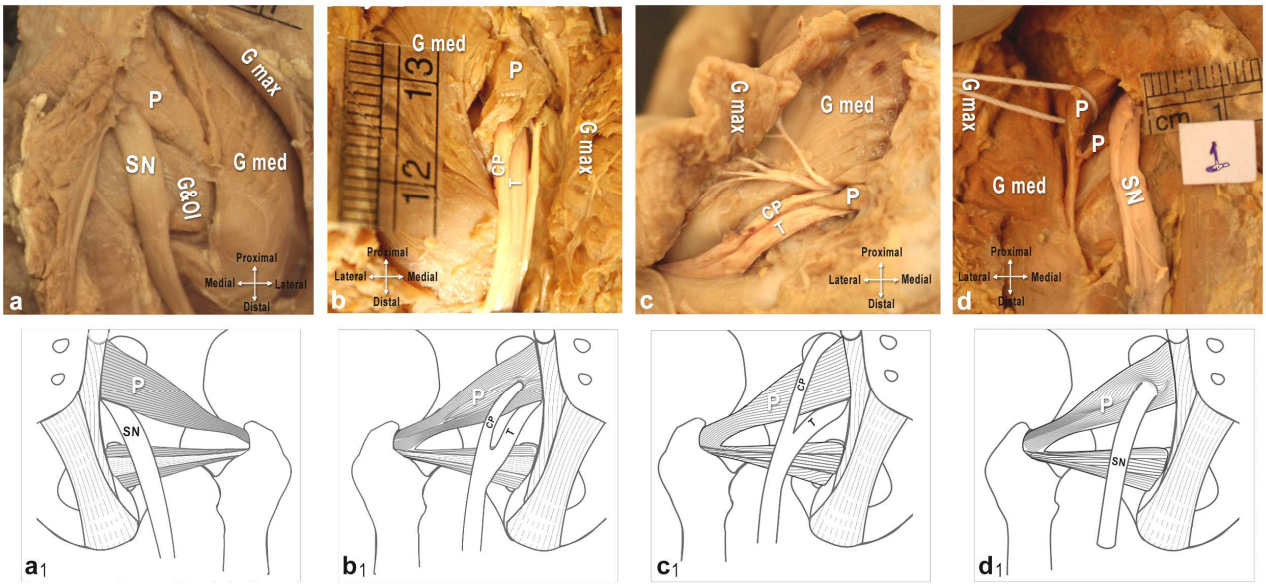

Fig. 1. Dissection of gluteal region and schematic diagram showing variations of relationship of sciatic nerve with piriformis. a and a1: Type I (Right side). b and b1: Type II (Left side). c and c1: Type III (Left side). d and d1: Type IV (Left side). P, piriformis; SN, sciatic nerve; G med, gluteus medius; G max, gluteus maximus; G & OI gamelli with obturator internus complex; T, tibial nerve; CP, common peroneal.

Table 1. Relationship between sciatic nerve and piriformis. N= Number of fetuses; n= Number of limbs

Morphological type of sciatic nerve	Unilateral		Bilateral	Total no. of limbs (%)
	Left	Right	n (N)	
Type I	4	1	80(40)	85
Type II	1	2	6(3)	9
Type III	0	1	2(1)	3
Type IV	1	2	-	3
∑	6	6	88(44)	100

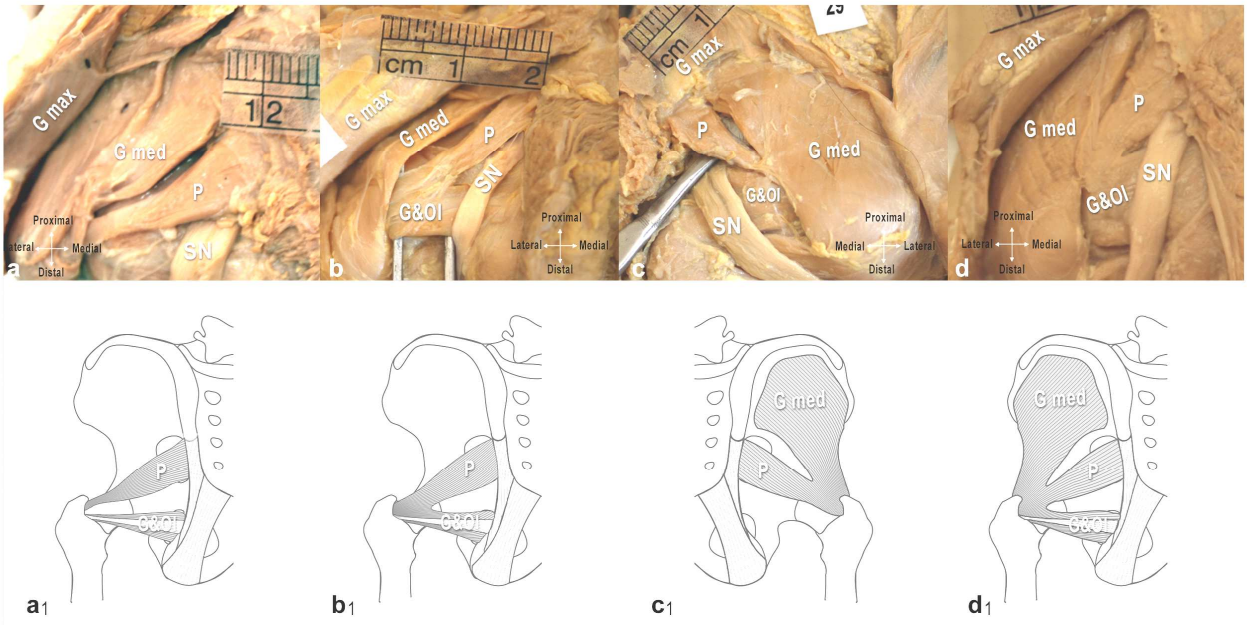

Fig. 2. Dissection of gluteal region and schematic diagram showing variants of fusion of piriformis with adjacent muscle a and a1 (Type A). b and b1 (Type B). c and c1 (Type C). d and d1 (Type D). P, piriformis; SN, sciatic nerve; G med, gluteus medius; G max, gluteus maximus; G & OI, gamelli with obturator internus complex.

Table 2. Relationship between various patterns of sciatic nerve and fusion of piriformis tendon with neighbouring muscles

Morphological type of sciatic nerve	Variants of fusion of piriformis			
	No fusion (Type A)	Fusion with Superior gamellus (Type B)	Fusion with Gluteus medius (Type C)	Fusion with Superior gamellus & Gluteus medius (Type D)
Type I	28%	31%	25%	2%
Type II	-	7%	_	1%
Type III	-	2%	1%	-
Type IV	-	3%	_	-

In 40 fetuses (80% of the limbs) this pattern was present bilaterally and unilaterally in 5 fetuses (5 % of the limbs).

Type II- Sciatic nerve splitted before reaching PM. Common peroneal component passed through the piriformis resulting in splitting of the piriformis, whereas the tibial nerve passed below the piriformis. This type was found in 9 (9%) limbs, bilaterally in 3 fetuses (6%) and unilaterally in 3 fetuses (3%, 1% on the left and 2% on the right side).

Type III- This type was characterized by nerve splitting before the piriformis. The common peroneal component passed above the muscle and the tibial component passed below the muscle. The piriformis was sandwiched between the two components. This pattern was observed in 3 limbs (3%), unilaterally in 1fetus (1% limb), none was on the right extremity, and bilaterally in 1 fetus (2 % limbs).

Type IV- In this variant the unsplit nerve passed through the piriformis muscle. This variant was noticed unilaterally in 3% of the limbs.

Order of incidence in fetuses, irrespective of sex was I>II>III> IV (85%> 9%>3%=3%). Order of incidence of type of variations in 48 limbs of male fetuses was type I> III>II>IV (87.5% > 6.25% >4.16% >2.08% respectively) and in 52 limbs of female fetuses was type I> II > IV > III (82.69%> 13.46% >3.84%> 0% respectively).

We also observed partial or total fusion of the piriformis muscle with the superior gemellus and gluteus medius (Table 2, Fig. 2). Fusion of the piriformis was grouped into four types.

Type A- The piriformis inserted independently on the medial surface of the greater trochanter. It was seen in 28% of the limbs.

Type B – The piriformis fused with the superior gemellus thus to obturator internus complex indirectly. It was seen in 43 % of the limbs.

Type C – The piriformis fused with the gluteus medius in 26% of the limbs.

Type D- PM fused with both gluteus medius and obturator internus complex. It was observed in 3% limbs.

DISCUSSION

The sciatic nerve is the most common nerve injured by intramuscular injection, especially in chil-

dren (Idowu et al., 2011). SN as a whole or either of its components may be accidently injured, leading to sensory, motor and trophic disturbances in the area of its distribution. The resulting pain and paresis in the gluteal region may affect the biomechanical function of the pelvis and may also lead to postural instabilities and locomotor abnormalities (Beaton and Anson, 1938; Pecina, 1979).

Six types of relationships of SN with the piriformis have been described in the literature (Beaton and Anson, 1937). Early separation of the common peroneal and tibial nerves at their origins and further unusual courses of two divisions in buttock accounts for presence of anatomical variations. Relationship of SN with the piriformis is relatively less studied in fetuses. Type I, in which the undivided SN passes inferior to the unsplit piriformis, is considered as the normal relationship between two structures, and it has been reported in 65% to 98.5 % of adult gluteal regions (Beaton et al., 1937; Parsons and Keith, 1896; Pokorny et al., 2006). Machado et al. (2003), Uluutku and Kurtoglu (1999), and Ugrenovic et al. (2005) reported type I variation in 80%, 74% and 96% limbs respectively. In the present study, a normal relationship was seen in 85% of limbs. Prevalence of anomalous relationships represented by types II–VI in adults has been reported as 1.5-35.8%. Relatively lesser prevalence (4-26%) has been reported in fetuses (Machado et al., 2003; Uluutku and Kurtoglu 1999; Ugrenovic et al., 2005). Type 2 in which the common peroneal nerve passes through the PM and the tibial nerve exits at the inferior margin of the muscle has been reported as the most common variant in both adults as well as fetuses. This type of course of SN had been described in adults in approximately 12-20% % of limbs (Table 3) (Parsons and Keith, 1896; Beaton and Anson, 1937; Pokorny et al., 2006; Guvencer et al., 2008, 2009). We found this pattern in 9% of gluteal regions. Machado et al. (2003) and Uluutku and Kurtoglu (1999) observed this type in 16% of extremities whereas Ugrenovic et al. (2005) reports this form in only 2.5% of limbs. Type III, characterized by passage of the common peroneal nerve above the superior margin of PM and the tibial nerve beneath its inferior margin, thus trapping the muscle between two divisions, was seen in 3% of limbs in the current study, which is close to the observations of fetal studies of Machado et al. (2003) and Ugrenovic et al. (2005). In Uluutku and Kurtoglu's fetal study conducted in 1999, the prevalence was relatively higher. This type had been reported in 0-8% of adult lower extremities (Smoll, 2010). Machado et al. (2003) found this in 2% of cases but did not define the laterality. Type IV variant, in which undivided nerve passes through the muscle, had been found in 0-2.7% of adult limbs (Parsons and Keith, 1896; Smoll, 2010) (Table 3). While in our study it was noted in 3% of limbs, all were unilateral with right predominance. Machado et al. (2003) found this in 2% of limbs, whereas Ugrenovic et al. (2005) and Uluutku and Kurtoglu (1999) did not find any case of type IV. We did not find variants V and VI. Type V has been reported only by Lee and Tsai (1974) and Type VI, one case each by Sayson et al. (1994) and Ozaki et al. (1999) in 5 extremities (3%). In current study Types II, III and IV were predominantly found on the right side (5%).

Compression of the sciatic nerve or its part between the superior border of the piriformis and the superior margin of the sciatic notch can occur during flexion, abduction and the external rotation of the thigh, and leads to piriformis syndrome (Ozaki et al., 1999). In such cases people with type III variation will be affected more commonly. If the whole sciatic nerve or part of it penetrated the muscle (i.e., Types II and IV), then a division or resection of the piriformis muscle (i.e., tenotomy) could cause sciatic nerve palsy (Sosna et al., 2005; Pokorny et al., 2006). The piriformis muscle runs from the lower spine to the thigh. Spasms can result from overuse, injury, or hip problems, triggering pressure on the sciatic nerve, which results in buttock and leg pain or numbness. In some individuals, especially those who build up the PM in gym or during a professional sports career, the PM may occupy the entire greater sciatic foramen to the degree of eliciting pressure on the neurological and vascular structures located in this anatomical

Table 3. Prevalence of variants of relationship between the sciatic nerve and piriformis muscle in published papers

	I	II	III	IV	V	VI
Beaton and Anson (240 cadavers)	**90**	**7.1**	**2.1**	**0.8**	**Hypothetical**	**Hypothetical**
Guvencer et al. (50 adult limbs) %	**76**	**16**	**8**	**0**	**0**	**0**
Pokorny et al. (91 adult limbs) %	**79.1**	**14.3**	**4.4**	**2.2**	**0**	**0**
Uluutku and Kurtoglu (50 fetal limbs)	**74**	**16**	**10**	**0**	**0**	**0**
Ugrenovic et al. (200 fetal limbs)	**96**	**2.5**	**1.5**	**0**	**0**	**0**
Machado et al. (100 fetal limbs)%	**80**	**16**	**2**	**2**	**0**	**0**
Current study (100 fetal limbs)%	**85%**	**9**	**3**	**3**	**0**	**0**

opening (Ripani et al., 2006).

If we rely on the traditional description, the piriformis muscle inserts on the medial side of the upper border of the greater trochanter of the femur via a rounded tendon. However, such insertion was seen only in 28% of limbs in our study (Table 2, Fig. 2a, a_1). And yet Windisch et al. (2007) observed such independent insertion in 53.57% of adult limbs, which was much more than that found in our study. In the current study, the piriformis was found to be fused with the gemellus superior and the obturator internus (type B) in 43% of limbs (Table 2, Fig. 2b, b_1), whereas another study on fetal limbs conducted by Machado et al. (2003) found such fusion in 54% of limbs. Windisch et al. (2007) found fusion in 29.46% of adult limbs. Thus, the incidence of such fusion was much higher in fetuses than in adults. They also emphasized that in such fusion cases, stretching of the piriformis during passive internal rotation of the thigh is associated with stretching of the obturator internus, and hence the stretching of both muscles may trigger pain. If fusion persists in later periods of life, both the piriformis and the obturator internus may be the cause of piriformis syndrome. In 26% of limbs, we observed fusion of piriformis with gluteus medius (type C), (Table 2, Fig. 2c, c_1). Windisch et al. (2007) found such fusion in 3.57% of limbs only. Machado et al. (2003), in their study on fetal limbs, found fusion of these two muscles in 2% of limbs which was quite close to Windisch et al's observation made in adult limbs (2007). Incidence in our study was many times more than in these two studies. We also found fusion of piriformis with gluteus medius placed above it and obturator internus complex placed below it (type D), (Table 2, FIG. 2d, d_1) in 3% of limbs in our study, whereas as Windisch et al. (2007) found similar fusion in 13.39% of adult limbs. Machado et al. (2003) did not report any case of such fusion in his study on fetal limbs.

Windisch et al. (2007) gave an embryological basis to explain fusion of the abovementioned muscles. During the fifth week, two mesenchymal condensations (ventral and dorsal) appear along axial mesenchymal column. Piriformis, the muscle of the dorsal group, spreads out from the dorsal aspect of the pelvis through the greater sciatic foramen to reach the inner side of the sacrum. During development, the piriformis comes in close contact to muscles of ventral mass; if parts of tendons or even muscle fibers stick together, fusions of piriformis with obturator internus, superior gemellus or the gluteus medius follows.

The incidence of different types of variations of passage of sciatic nerve or its parts in relation to piriformis muscle in fetuses was same as in adult. These anatomic variations may increase the sciatic nerve's susceptibility to injury.

The overall incidence of nonseperation of piriformis (72% of case) with adjacent muscle, namely gamellius superior, or gluteus medius, or obturator internus was much more in fetuses than the standard description of independent insertion of muscle on greater trochanter. More work is needed to be done in this area.

ACKNOWLEDGEMENTS

The authors wish to thank Mr VijayKant Bakshi, Senior artist of the Department of Anatomy, PGIMER, Chandigarh, India, for contribution in artwork.

REFERENCES

Beaton LE, Anson BJ (1937) The relation of the sciatic nerve and of its subdivisions to the piriformis muscle. *Anat Rec*, 70: 1-5.

Beaton LE, Anson BJ (1938) The sciatic nerve and the piriformis muscle: Their interrelation a possible cause of coccygodynia. *J Bone Joint Surg*, 20: 686-688.

Giannakopoulou C, Korakaki E, Hatzidaki E, Manoura A, Aligizakis A, Velivasakis E (2002) Peroneal nerve palsy: a complication of umbilical artery catheterization in the full-term newborn of a mother with diabetes. *Pediatrics*, 109: 66.

Guvencer M, Akyer P, Iyem C, Tetik S, Naderi S (2008) Anatomic considerations and the relationship between the piriformis muscle and the sciatic nerve. *Surg Radiol Anat*, 30: 467-474.

Guvencer M, Iyem C, Akyer P, Tetik S, Naderi S (2009) Variations in the high division of the sciatic nerve and relationship between the sciatic nerve and the piriformis. *Turk Neurosurg*, 19: 139-144.

Hollinshead WH (1982) *Anatomy for Surgeons*: The Back and Limbs. Philadelphia: Harper & Row, Publishers.

Idowu OA, Ogunrinu AE, Akinremi A, Adelugba JK (2011) Injection induced sciatic nerve injury among children managed in Nigerian physiotherapy clinic: A five-year review. *AJPARS,* 1: 13-16.

Lee CS, Tsai TL (1974) The relation of the sciatic nerve to the piriformis muscle. *Taiwan Yi Xue Hui Za Zhi*, 73: 75-80.

Machado FA, Babinski MA, Brasil FB, Favorito LA, Abidu-Figueiredo M, Costa MG (2003) Anatomical variations between sciatic nerve and piriformis muscle during fetal period in Human. *Int J Morphol*, 21: 29-35.

Meknas K, Christensen A, Johansen O (2003) The internal obturator muscle may cause sciatic pain. *Pain*, 104: 375-380.

Ozaki S, Hamabe T, Muro T (1999) Piriformis syndrome resultingfrom an anomalous relationship between the sciatic nerve and piriformis muscle. *Orthopedics*, 22: 771-772.

Parsons FG, Keith A (1896) The relation of the great sicatic nerve to the pyriformis muscle. *J Anat Physiol,* 31(Pt 1): 31-44.

Pecina M (1979) Contribution to the etiological explanation of the piriformis syndrome. *Acta Anat*, 105: 181-

187.

Pokorny D, Jahoda D, Veigl D, Pinskerova V, Sonsa A (2006) Topographic variations of relationship of the sciatic nerve and the piriformis muscle and its relevance to palsy after total hip arthroplasty. *Surg Radiol Anat*, 28: 88-91.

Ripani M, Continenza MA, cacchio A, Barile A, Parisi A, De Paulis F (2006) The ischiatic region: normal and MRI anatomy. *J Sports Med Phys Fitness*, 46: 468-475.

Sayson SC, Ducey JP, Maybrey JB, Wesley RL, Vermilion D (1994) Sciatic entrapment neuropathy associated with an anomalous piriformis muscle. *Pain*, 59: 149-152.

Sense FM, Campus R, Becchetti F, Catena N (2009) Sciatic nerve injection palsy in the child: early microsurgical treatment and long term results. *Microsurgery*, 29: 443-448.

Smoll NR (2010) Variations of the piriformis and sciatic nerve with clinical consequences: a review. *Clin Anat*, 23: 8-17.

Sosna A, Pokorny D, Jahoda D (2005) Sciatic nerve palsy after total hip replacement. *J Bone Joint Surg Br*, 87-B: 1140-1141.

Ugrenovic S, Jovanovic I, Krstic V, Stojanovic I, Vasovic I, Antic S, Pavlovic S (2005) The level of sciatic nerve division and its relations to the piriformis muscle. *Vojnosanit pregl*, 62: 45-49.

Uluutku MH, Kurtoglu Z (1999) Variations of nerves located in deep gluteal region. *Okajimas Folia Anat Jpn*, 76: 273-276.

Windisch G, Braun EM, Anderhuber F (2007) Piriformis muscle: clinical anatomy and consideration of piriformis syndrome. *Surg Radiol Anat,* 29: 37-45.