Journal of Orthopaedics 16 (2019) 64–68

Contents lists available at ScienceDirect

Journal of Orthopaedics

journal homepage: www.elsevier.com/locate/jor

Macroscopic observations of muscular bundles of accessory iliopsoas muscle as the cause of femoral nerve compression

Fuat Unat, Suzan Sirinturk, Pınar Cagimni, Yelda Pinar, Figen Govsa*, Gkionoul Nteli Chatzioglou

Department of Anatomy, Faculty of Medicine, Ege University, Izmir, Turkey

ARTICLE INFO

Keywords:
Femoral nerve
Iliacus muscle
Psoas major muscle
Entrapment syndrome
Leg pain
Neuropathic pain
Compression
Muscular variations
Peripheral nerve stimulation

ABSTRACT

Compression of the femoral nerve (FN) to the iliac fossa has been reported as a consequence of several pathologies as well as due to the aberrant muscles. The purpose of this research was to investigate the patterns of the accessory muscles of iliopsoas muscles and the relationship of the FN in fifty semi pelvis. Accessory muscular slips from iliacus and psoas, piercing or covering the FN, were found in 19 specimens (7.9%). Based on the macroscopic structure, the muscle was categorized into two types. Pattern 1 as the more frequent variation, was sheet muscular type covering the FN (17 specimens, 89.5%). Pattern 2, the less frequent variation was found on a muscular slip covering the FN (2 specimens, 10.5%). Iliac and psoas muscles and their variants on both types were defined. Appraising the relation between the muscle and the nerves, each disposition of the patterns may be a potential risk for nerve entrapment. The knowledge about the possible variations of the iliopsoas muscle complex and the FN may also give surgeons confidence during pelvic surgery. Recognition of these variations in normal anatomy may be useful to the clinicians when treating patients with refractory leg pain.

1. Introduction

Entrapment neuropathy is defined as the nerve entrapment of the peripheral nerves on the passageway of one segment of the body to another one.[1–4] Entrapment neuropathy due to neuropraxia takes place on the basis of the ischemia and mechanical cases.[5–9] Many peripheral nerves are susceptible to entrapment syndrome, most of which as a consequence of their position in relation to other anatomical structures such as muscles, ligaments, or retinacula.[10,11] Examples in the upper limb are the median nerve in carpal tunnel syndrome, or ulnar nerve entrapment of the elbow.[5,11,13] In the lower limb, the peripheral nerve entrapments include the sciatic nerve passing through piriformis or dividing around the superior gemellus muscle and the lateral cutaneous nerve of the thigh passing through the inguinal ligament, meralgia paresthetica.[2,4,11,12,14–18]

The femoral nerve (FN) descends in a groove between psoas and iliacus muscles, deep to the iliac fascia, passing under the inguinal ligament and it enters the thigh where it gives its terminal branches.[5,19,20] Compression to the FN has mostly been described as being due to bleeding disorders, when an iliac haematoma compresses it at three possible levels: against the inguinal ligament; at its lumbar roots; or in the space between the psoas and iliacus muscles where the overlying fascia is thicker.[20–24]

The principal symptoms are thigh weakness along with the anterior thigh and medial leg numbness. It is characterized by quadriceps weakness and numbness over the anteromedial aspect of the thigh. When severe, the patient may be unable to stand without support.[19–25]

Several reports have described variant muscular slips or sheets forming longitudinal fascicles or wide bands associated with psoas and iliacus, but most of them are not related to the FN.[1,4] The iliopsoas tendon or muscle may be split by the FN, but we have found only two reports that describe the FN itself being split by iliopsoas muscle slips.[24,25] Defined topographical details of the FN and accessory iliopsoas muscles can help understanding of the treatment of the leg pain.

The relationship between the accessory iliopsoas muscles and FN, regarding compression to the FN had not been carefully examined; the reports on various types of the muscle's possible effects upon neural entrapment were limited. The aim of this study was to analyze the relationship of the FN to variable muscular slips of iliopsoas, and to consider their potential as a factor in FN entrapment.

2. Material and method

Fifty cadaver (30–72 years) pelvises were dissected iliac, psoas and femoral regions (Fig. 1). Aberrant muscles on the FN were classified by the macroscopic specter of muscles (Fig. 2). The accessory muscle was

* Corresponding author. Department of Anatomy, Faculty of Medicine, Ege University, TR-35100, Izmir, Turkey.
E-mail address: figen.govsa@ege.edu.tr (F. Govsa).

https://doi.org/10.1016/j.jor.2018.12.009
Received 25 October 2018; Accepted 2 December 2018
Available online 21 December 2018

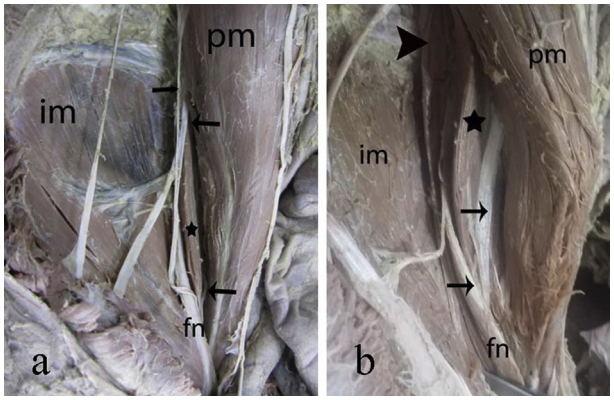

Fig. 1. Accessory sheet muscle (**star**) bundle along with the length of right iliacus region showing femoral nerve (**fn**) **a.** Fn covered by the anterior bundles of the iliacus muscle (**im**) and bundles stroking the nerve interiorly. **b.** Sheet muscle fibers made up of the posterior bundles of the accessory muscle of psoas major (**pm**) stroking fn exteriorly. **ic:** iliac crest.

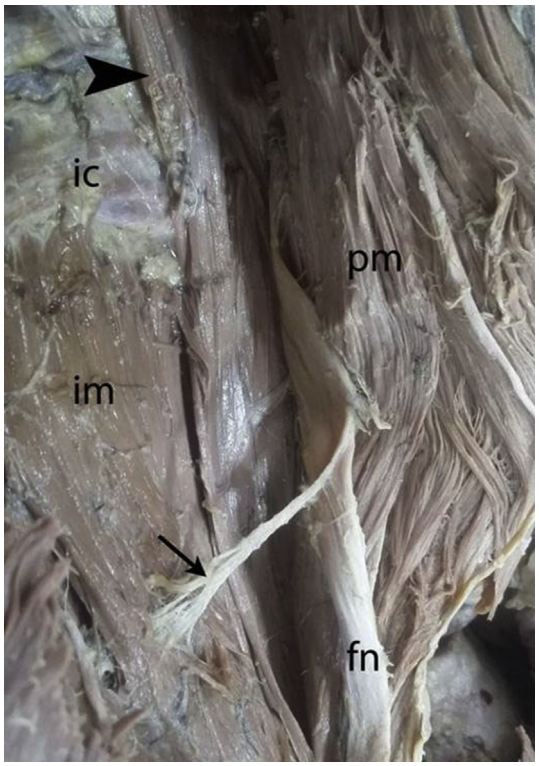

Fig. 2. Accessory muscle (**arrow**) composed of both the iliacus (**im**) and psoas major (**pm**) muscle covers the femoral nerve (**fn**) like a wide sheet. **ic:** iliac crest.

divided into two patterns as sheet or slip. Following this classification of pattern, the categorization was as accessory muscle origin of the iliacus, psoas and both psoas and iliacus.

3. Results

The iliac fascia was found to cover psoas and iliacus from their origin to the insertion. The iliacus appeared as a triangular sheet of muscle arising from the superior two-thirds of the concavity of the iliac fossa, the inner lip of the iliac crest (Figs. 1–3), and the upper surface of the lateral part of the sacrum. The FN was found to descend through the psoas, emerging low on its lateral border and then passing between the psoas and iliacus, behind the inguinal ligament (Figs. 1, 3 and 4). In the

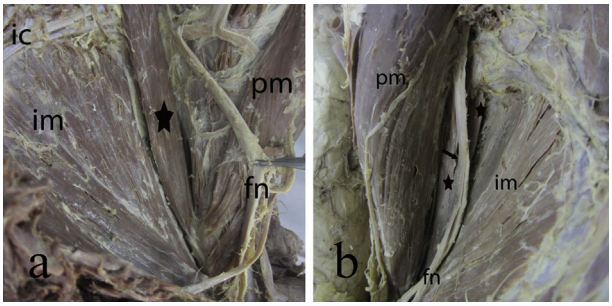

Fig. 3. a. Wide, sheet like accessory muscle made up of the anterior bundles of the iliacus muscle (**im**) and posterior bundles of the psoas major (**pm**). Some branches of the femoral nerve (**fn**) are placed superior the muscle and some inferior the muscle. **b.** Fn is exposed inferior the wide accessory muscle (**star**) made up of the anterior bundles of the im and posterior bundles of the pm. **ic:** iliac crest.

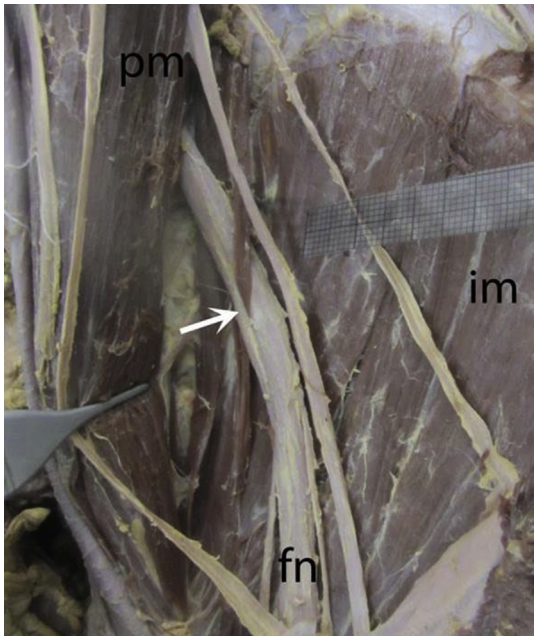

Fig. 4. Accessory muscle bundles made up of the iliac muscle (**im**) has formed a circle passing inside the femoral nerve (**fn**). The fn was pierced by muscular slip (**arrow**) from im. **ic**: iliac crest, **pm**: psoas major.

abdomen, the nerve supplies the iliacus through its small branches (Figs. 1 and 2).

Slips of iliacus piercing or covering the FN were found in 19 specimens (7.9%) (Figs. 1–5), with no statistical differences by sex or side, and were seen bilaterally in only two specimens. Two different patterns were described.

3.1. Pattern 1: sheet muscle pattern

The common characteristic of this type is covering the FN like a sheet. The FN was split by a muscular sheet in 17 specimens (89.5%) (Figs. 1–3). The common trait in Pattern 1 is that accessory muscle originating from either iliacus, psoas or both types, the muscle covering the FN covers the nerve like a sheet. This group contained the following variations: a psoas slip in 4 specimens (Fig. 1b), an iliacus slip in 12 specimens (Fig. 1a), or both patterns in 1 dissection. This type of accessory muscles are thought to cause more compression as they are wide, are placed by the internal side of the FN and they cover the nerve like a sheet.

Iliac origin type (42%): This type of accessory muscle was

observed on vertical direction medially and slightly inferior. It was attached proximally to the lateral part of the iliolumbal ligament, ran inferiorly, posterior to the iliolumbar vessels. The muscle was found to lie anterior to, separate from, iliacus muscle. The accessory iliacus originated from the middle third of inner lip of iliac crest and was covered by a separate fascia, which was distinguishable from the iliacus fascia and the muscle. They were mainly made up of the front fibers of the iliacus. The accessory iliacus were compressed more at the inner side of the FN (Fig. 1a).

Psoas origin type (25%): Accessory psoas muscle bundle were like sheet composed of the posterior bundles of the psoas. As they were situated inferior and exterior the psoas, they cause compression. Psoas together with accessory psoas form a dense muscle bundle (Fig. 1b). FN proceeds laterally inferior to those two muscle types. The FN was formed by nerve slips coming through psoas muscle. The nerves were placed exterior the muscle. Accessory psoas was bilateral in one cadaver. Three left and one right specimen have accessory psoas (8%). The thickness of the accessory psoas was calculated as 3.71 ± 0.8 mm.

Both iliacus and psoas major origin type (22.5%): It was a wide accessory muscle like a sheet made up of by the anterior bundles of the iliacus and the posterior bundles of the psoas (Figs. 2 and 3a,b).

3.2. Pattern 2: slip muscle pattern

The FN was covered by a muscular slip, the less frequent variant, found only in two specimens (10.5%) (Figs. 4 and 5). In one case, the FN appeared in the groove between the psoas and iliacus at the pelvic brim, before descending laterally on iliacus to pass under the muscular slip and leave the pelvis, beneath the inguinal ligament (Figs. 4 and 5). The slip from iliacus muscle rejoined to iliacus, respectively after passing over FN (Fig. 4).

In the second case, the overlying muscular slips were so extensive that they were visible on the FN in the iliac fossa, but then they were immediately divided into two branches. The medial slip followed the expected vertical course, close to the anterior longitudinal ligament (Fig. 5). In this specimen, accessory muscle was attached to the anterior face of quadratus lumborum with aponeurosis band. Additionally, the accessory muscles' relationship with the nerve bundles of FN was determined. One slip of the accessory muscle was caused by the penetrating FN. Then, it separated after a short course in the iliac fossa before passing under the inguinal ligament (Fig. 5). Thickness of the accessory psoas muscle was measured as 4.44 ± 0.48 mm. The more distal one crossed the FN and left the pelvis under the inguinal ligament with the FN.

The distance of the middle point where the FN was formed by nerve slips on the iliac fossa and inguinal ligament was calculated as 52.81 ± 5.17 mm (Fig. 5). But in one case, there was only a slim slip from iliacus muscle piercing the FN. The width and the thickness of the slip were 3.38 mm and 2.2 mm (Fig. 5). In 6 specimens, mean width and thickness of the slips were 2.7 mm and 1.8 mm, respectively.

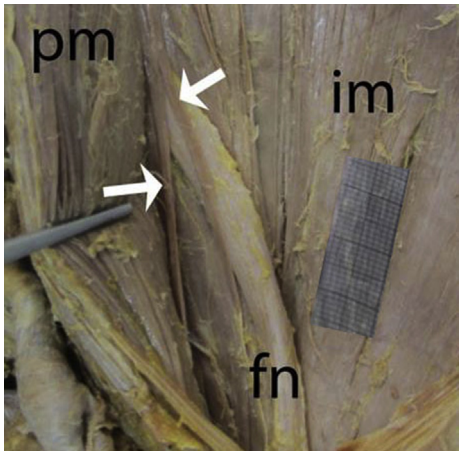

Fig. 5. The femoral nerve (**fn**) was pierced by slim muscular slips (**arrow**) from iliac muscle (**im**). Two slips from iliac muscle rejoined to psoas muscle (**pm**) and im, respectively after passing over the fn.

4. Discussion

Entrapment syndromes are quite widespread decreasing life quality and work profitability. Clinical investigations and cadaveric studies revealed that most intraoperative FN injuries that are associated with gynecologic surgical procedures result from the improper placement of self-retaining retractors.[24–26] Postoperative femoral neuropathy has been reported in abdominal hysterectomy as the most common operation in addition to other types of surgical procedures, including appendectomy, renal transplantation, aortic aneurysm repair, and hip replacement.[1,28–32] The main mechanism underlying this neuropathy is stretching and/or prolonged compression of the nerve.[1,2,14,15]

Some studies have reported cases of variant muscle slips of the psoas and iliacus may split the FN causing a potential risk for nerve entrapment.[12,21,33,34] Several reports have described variant muscular slips or sheets forming longitudinal fascicles or wide bands associated with psoas and iliacus, but most of them are not related to the FN.[4,22,23] Vazquez et al. reported variations of iliacus and psoas piercing the FN, piercing of the FN by a muscular slip, or a muscular slip/sheet covering the FN as it lay on the iliacus (7.9%).[30] Muscular variations, such as those mentioned above, most probably do not cause any considerable disturbance in the lower limb movements.[35] Mainly because of the frequent co-existence with an unusual course and formation of the FN, these muscular variations are of a great importance to clinical practice. The "critical zone" of FN entrapment has been described as the fibromuscular ring that is bounded superficially by the inguinal ligament, deeply by iliopsoas, and medially by the iliopectineal band.[16,17] Nevertheless other regions such as the space between psoas and iliacus have been regarded as zones of "entrapment-risk" when trying to explain different FN entrapment syndromes following surgery or due to anticoagulant therapy.[6,8,24,25] In only one report such variations are described as a possible cause of the entrapment.28 Both the cadaver studies described these variant dispositions in 5.9% specimens, although they both had small sample sizes. We have been unable to find any references to our observations that the FN might not be seen in the iliac fossa because of a sheet of muscle derived from the iliacus muscle. Furthermore, no attempts to classify these kinds of variant dispositions have been made previously.

Battaglia found that the FN emerged both lateral and deep to the psoas muscle between the psoas and iliacus muscles covered in iliac fascia.[13] It was then pierced and divided into two separate divisions by an accessory slip of the iliacus muscle. Just proximal to the inguinal ligament, these two separate divisions rejoined and the FN passed as one under the inguinal ligament and then was divided into its usual anterior and posterior branches (Fig. 2). The accessory slip of iliacus was then dissected proximally up to its origin on the inferior aspect of the iliac crest. It was detached from its origin confirming it had no attachment to the iliolumbar ligament.[21,24,33] The muscular slip was then followed distally until it blended into other iliacus and psoas fibers to incorporate into the iliopsoas which inserted on the femur. The FN was found to be formed from the posterior division of the L2-L4 ventral nerve roots and was fully formed prior to being pierced by the accessory slip of the iliacus. No other lumbar plexus variations were detected. The FN on the right side of the specimen followed a routine course.

This study has defined two different muscle patterns, psoas and iliacus accessory muscle that may have the potential to compress the FN. The frequency of this pattern was investigated. Also, the study included reports on variations of iliacus and psoas muscles piercing the FN, piercing of the FN by a muscular slip (Figs. 4 and 5), or a muscular slip/sheet (Figs. 1–3) covering the FN as it lay on the iliacus (7.9%).

Patterns of muscular slips, belonging to the psoas or the iliacus, or even an accessory muscle described in this study may cause tension of the FN and therefore should be suspected in patients with referred pain to the hip and knee joints and to the lumbar dermatomes. The description of a split iliacus might also be found in the articles about the FN with an abnormal course. In slip muscle pattern, however, other authors reported this splitting without any additional information about the FN.

The crus and their fascia overlap the psoas and appear to be continuous with this muscle until they come more anterior and blend with the anterior longitudinal ligament. As the psoas descends, its inferomedial fascia becomes thick at its inferior portion and is continuous with the pelvic floor fascia. Some authors mentioned that this splitting was accompanied by an abnormal course of the FN, which passed between the two layers.[8,30,33]

Both in the sheet muscle and the slip pattern, the compression onto the FN may change depending on the density of the muscular bundles. In our opinion, the FN was located under dense muscle mass such as the sheet muscle pattern because slip muscle pattern was exposed to muscle compression lesser. In sheet pattern, morphologically, both the psoas origin and iliacus origin types would be more prone to intramuscular compression while in slip patterns which were thinner at the bottom of the FN, were divided into two branches of the slips at duplicate shape. Even the vertical course muscle branch could pass bottom the FN as oblique course slip pattern (Fig. 5).

4.1. Add limitation of the study

Since this study was carried out with the cadaver, evaluation of leg or feet pain with muscular slips in individuals was out of the question. This was the limiting point of the study. This report describes slips that occurred in 5% of specimens; half due to a psoas slip and half to an iliacus slip. These important variations may lead to an explanation about deviation of bundles and the migration of FN along the process of muscle coursing. No clinical finding is pathognomonic for femoral neuropathy. Similar findings of absent or diminished patellar reflex, quadriceps weakness or wasting, weakness in hip flexion and adduction as well as sensory symptoms such as pain in the iliac fossa, inguinal region and anterior thigh may also indicate radiculopathy, plexopathy, or combined lesions of the femoral and obturator nerve.[27,35]

Our study provided detailed analysis of the accessory muscle of two distinct types that we thought to be causing femoral neuropathy. In the specimens of Pattern 1, the existence of the accessory muscle either resulting from psoas or from iliacus, the compression to the nerve may be more obvious as the muscle covers the FN like a sheet (Figs. 1–3). There may be more compression to the nerves.

In Pattern 2, compression to the muscle can be observed frequently as the FN proceeds lengthwise (Fig. 5) or oblique (Figs. 4 and 5) despite not being covered like a sheet. In Pattern 2 samples similar to the fibromuscular circle structure were identified (Figs. 4 and 5). In Fig. 5 slip from iliacus was bifurcationed to psoas and iliacus, respectively after passing over FN.

Physicians should be aware of the pathogenesis of this complication. It is necessary to monitor the position of the retractor, making sure that the retractor is away from the psoas and not compressing it during surgery.

5. Conclusions

Accessory psoas-iliacus muscle patterns described in this study might cause tension on the FN resulting in referred pain to the hip and knee joints and to the lumbar dermatome L4. Recognition of these variations in normal anatomy may be useful to the clinician when treating the patient with refractory leg pain.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jor.2018.12.009.

References

1. Al-Ajmi A, Rousseff RT, Khuraibet AJ. Iatrogenic femoral neuropathy: two cases and literature update. *J Clin Neuromuscul Dis.* 2010;12:66–75 (December (2)).
2. Bair MR, Gross MT, Cooke JR, Hill CH. Differential diagnosis and intervention of proximal median nerve entrapment: a resident's case problem. *J Orthop Sports Phys Ther.* 2016;46:800–808 (September (9)).
3. Touray ST, de Leeuw MA, Zuurmond WW, Perez RS. Psoas compartment block for lower extremity surgery: a meta-analysis. *Br J Anaesth.* 2008;101:750–760 (Dec (6)).
4. Busis NA. Femoral and obturator neuropathies. *Neurol Clin.* 1999;17:633–653 (Aug (3)).
5. Bono V, La Bella V, Spataro R. Bilateral iatrogenic femoral neuropathy. *J Clin Neurol.* 2015;1 11:398–399 (October (4)).
6. Chambers S, Berg AJ, Lupu A, Jennings A. Iliacus haematoma causing femoral nerve palsy: an unusual trampolining injury. *BMJ Case Rep.* 2015. https://doi.org/10.1136/bcr-2014-208758 July 27. pii: bcr2014208758.
7. Lee AC, Drake DB, DeGeorge Jr BR. Medical student and primary care physician perception of the surgical management of upper- and lower-extremity peripheral nerve entrapment. *Ann Plast Surg.* 2016;76:524–531 (May (5)).
8. Stafford MA, Peng P, Hill DA. Sciatica: a review of history, epidemiology, pathogensis, and the role of epidural steroid injection in management. *Br J Anaesth.* 2007:461–473 (October 99).
9. Yang W, Guo Z, Yu Y, Xu J, et al. Pain relief and health-related quality-of-life improvement after microsurgical decompression of entrapped peripheral nerves in patients with painful diabetic peripheral neuropathy. *J Foot Ankle Surg.* 2016;55:1185–1189 (November - December 6)).
10. Anloague PA, Huijbregts P. Anatomical variation of the lumbar plexus: a descriptive anatomy study with proposed clinical implications. *J Man Manip Ther.* 2009;17(4):107–114.
11. Arazińska A, Polguj M, Wojciechowski A, Trębiński Ł, Stefańczyk L. Median arcuate ligament syndrome - predictor of ischemic complications? *Clin Anat.* 2016;29:1025–1030 (November 8)).
12. Astik RB, Dave UH. Anatomical variations in formation and branching pattern of the femoral nerve in iliac fossa: a study of 64 human lumbar plexuses. *People's J Sci Res.* 2011;4(2):14–19.
13. Battaglia PJ, Scali F, Enix DE. Co-presentation of unilateral femoral and bilateral sciatic nerve variants in one cadaver: a case report with clinical implications. *Chiropr Man Ther.* 2012;20:34 October 1.
14. Duparc F, Coquerel D, Ozeel J, Noyon M, Gerometta A, Michot C. Anatomical basis of the suprascapular nerve entrapment and clinical relevance of the supraspinatus fascia. *Surg Radiol Anat.* 2010;32:277–284 March (3).
15. Elzinga KE, Curran MW, Morhart MJ, Chan KM, et al. Open anterior release of the superior transverse scapular ligament for decompression of the suprascapular nerve during brachial plexus surgery. *J Hand Surg Am.* 2016;41:e211–e215 July (7).
16. Herma T, Baca V, Yershov D, Kachlik D. A case of a duplicated superficial branch of radial nerve and a two-bellied brachioradialis muscle presenting a potential entrapment syndrome. *Surg Radiol Anat.* 2017;39:451–454 April (4).
17. Kokubo R, Kim K, Isu T, Morimoto D, et al. The impact of tarsal tunnel syndrome on cold sensation in the pedal extremities. *World Neurosurg.* 2016;92:249–254 August.
18. Tatu L, Parratte B, Vuillier F, Diop M, Monnier G. Descriptive anatomy of the femoral portion of the iliopsoas muscle. Anatomical basis of anterior snapping of the hip. *Surg Radiol Anat.* 2001;23(6):371–374.
19. Cho KJ, Kang S, Ko S, Baek J, et al. Neurovascular compression caused by popliteus muscle enlargement without discrete trauma. *Ann Rehabil Med.* 2016;40:545–550 June (3).
20. Polster JM, Elgabaly M, Lee H, Klika A, et al. MRI and gross anatomy of the iliopsoas tendon complex. *Skeletal Radiol.* 2008;37:55–58 January (1).
21. Jelev L, Shivarov V, Surchev L. Bilateral variations of the psoas major and the iliacus muscles and presence of an undescribed variant muscle-accessory iliopsoas muscle. *Ann Anat.* 2005;187:281–286 July (3).
22. Rao TR, Vanishree, Kanyan PS, Rao S. Bilateral variation of iliacus muscle and splitting of femoral nerve. *Neuroanatomy.* 2008;7:72–75.
23. Singh V, Shon WY, Lakhotia D, Kim JH, Kim TW. A rare case of femoral neuropathy associated with ilio-psoas bursitis after 10 years of total hip arthroplasty. *Open Orthop J.* 2015 26:270–273 June 9.
24. Spratt JD, Logan BM, Abrahams PH. Variant slips of psoas and iliacus muscles, with splitting of the femoral nerve. *Clin Anat.* 1996;9(6):401–404.
25. Srikanteswara PK, Cheluvaiah JD, Agadi JB, Nagaraj K. The relationship between nerve conduction study and clinical grading of carpal tunnel syndrome. *J Clin Diagn Res.* 2016;10:13–18 July (7).
26. Suri P, Rainville J, Katz JN, Jouve C, et al. The accuracy of the physical examination for the diagnosis of midlumbar and low lumbar nerve root impingement. *Spine (Phila Pa 1976).* 2011;36:63–73 January (1).
27. Martin HD, Khoury A, Schröder R, Palmer IJ. Ischiofemoral impingement and hamstring syndrome as causes of posterior hip pain: where do we go next? *Clin Sports Med.* 2016;35:469–486 July (3).
28. Moon HB, Nam KY, Kwon BS, Park JW, et al. Leg weakness caused by bilateral piriformis syndrome: a case report. *Ann Rehabil Med.* 2015;39:1042–1046 December (6).

29. Smoll NR. Variations of the piriformis and sciatic nerve with clinical consequence: a review. *Clin Anat.* 2010;23:8–17 January (1).
30. Vázquez MT, Murillo J, Maranillo E, Parkin IG, et al. Femoral nerve entrapment: a new insight. *Clin Anat.* 2007;20:175–179 March (2).
31. Padua L, Coraci D, Erra C, Doneddu PE, et al. Prolonged phone-call posture causes changes of ulnar motor nerve conduction across elbow. *Clin Neurophysiol.* 2016;127:2728–2732 August 8.
32. Illig KA, Donahue D, Duncan A, Freischlag J, et al. Reporting standards of the Society for Vascular Surgery for thoracic outlet syndrome. *J Vasc Surg.* 2016;64:e23–e35 September 3.
33. Fabrizio PA. Anatomic variation of the iliacus and psoas major muscles. *Int J Anat Var.* 2011;4:28–30.
34. Khan YS, Khan TK. A rare case of bilateral high division of sciatic nerve (of different types) with unilateral divided piriformis and unusual high origin of genicular branch of common fibular nerve. *Int J Anat Var.* 2011;4:63–66.
35. Franklin AD, Cierny GB, Luckett TR. Interventional and multimodal pain rehabilitation in a child with meralgia paresthetica. *J Clin Anesth.* 2016;33:456–459 September.