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CASE REPORT

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The co-occurrence of a previously unreported double-headed accessory psoas major with an unusually positioned accessory iliacus muscle: case report

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ABSTRACT

The iliopsoas muscle complex traditionally consists of the iliacus muscle and psoas major, occasionally including the psoas minor. These elements were distinguished based on their shared function and common distal attachment. Although accessory structures have been previously reported within the complex, they are rare. This study reports an unusual observation of the co-occurrence of two additional muscles within the iliopsoas muscle complex during dissection: and accessory iliacus muscle and a four-headed accessory psoas major, whose anatomical position and morphological features indicate a high possibility of femoral nerve compression.

Keywords: accessory iliacus muscle, accessory psoas major, anatomical variations, femoral nerve compression, iliopsoas muscle complex, iliopsoas tendon release, snapping hip syndrome

INTRODUCTION

The iliopsoas muscle complex is composed of the psoas major, iliacus muscle and the psoas minor, the latter being the most variable. These components perform a common function, i.e. strong hip flexion, and form a common distal attachment to the lesser trochanter of the femur.

Of the described muscles, the most variable is the psoas minor. Its demonstrates considerable differences in prevalence [9, 15, 25], multiple alternative insertion sites [28], double-headed morphology [23] or accessory muscle [11].

The remaining components also demonstrate some variation, albeit not as frequently. Accessory slips of the psoas major and iliacus muscle in particular are relatively common and have previously been classified by Aleksandrova et al. [1]. Some reports of variable morphology [10, 21] or additional muscles also exist [5, 10, 22, 29, 30, 33].

Knowledge about the diversity of the muscles of the posterior abdominal wall is important in clinical practice. The presence of additional structures or an atypical course may result in compression of the neural structures of the lumbosacral plexus, which is anatomically related to the iliopsoas muscle complex.

This study reports the unusual co-occurrence of an atypically-positioned accessory iliacus muscle and a previously-undescribed accessory double-headed psoas major, whose position and morphological features indicate the possibility of femoral nerve (FN) compression.

CASE REPORT

A 78-year-old male cadaver underwent routine anatomical dissection for research and teaching purposes at the Department of Anatomical Dissection and Donation, Medical University of Lodz, Poland. Before the dissection, the cadaver was preserved according to the standard hard-fixed procedure in a 10% formalin solution [3, 24].

The dissection was performed according to the standard protocol. The cadaver was placed in the supine position on the dissecting table. The intestines were separated from the greater omentum, mesentery and fatty tissue to provide visibility of the right posterior abdominal wall structures. Thus it was possible to distinguish the structures of lumbar plexus

and the iliacus muscle and psoas major. After removing the latter, the occurrence of two additional muscular structures was noted.

The first head of the accessory psoas major originated via three muscular bands. The first band originated from the superior margin of the L4 transverse process, the second band from the transverse process of the L5 vertebrae and the third band from the iliolumbal ligament. All bands merged together and formed the first head, that descended downwards under the FN trunk. The second head descended downwards from the inferior margin of the L4 transverse process and split FN into two branches: one located anterior to the second head and one posterior. The branches of the FN joined together and formed a nerve trunk. Described heads of the accessory psoas major muscle merged together at the level of the inguinal ligament, where the tendon was formed. The tendon descended downwards medially to the tendon of the iliacus muscle and laterally to the accessory iliacus muscle and inserted onto the lesser trochanter of the femur. All parts of described muscle, including its tendon and insertion were positioned posterior to the regular psoas major, which was extracted during dissection.

The accessory iliacus muscle originated medially, from the iliopubic eminence, pubic crest and along arcuate line. It produced a muscular belly that descended downwards medially to the accessory psoas major tendon and inserted onto the lesser trochanter of the femur (Fig. 1–3).

Both additional structures were subjected to detailed morphometric measurements and photographic documentation. All the measurements were taken three times with an accuracy up to 0.1 mm using an electronic caliper (Mitutoyo Corporation, Kawasaki-shi, Kanagawa, Japan). Arithmetic average was drawn from those measurements and presented accordingly in Tables 1 and 2.

Table 1. Morphometric measurements of individual parts of accessory psoas major.

Structure	**Measurement [mm]**
First head	
Proximal attachment	
Width	10.87
Thickness	3.86
Length	130.82
Second head	

Proximal attachment	
Width	8.38
Thickness	1.56
Length	144.93
Third head	
Proximal attachment	
Width	4.38
Thickness	1.40
Length before junction with the fourth head	37.33
Fourth head	
Proximal attachment	
Width	2.40
Thickness	0.38
Length before junction with third head	30.31
Length of conjoined third and fourth head	74.05
Musculotendinous junction	
Width	9.44
Thickness	3.83
Tendon length	88.14
Distal attachment	
Width	16.24
Thickness	2.11
Diameter of the femoral nerve at the junction between first and second head	4.40

Table 2. Morphometric measurements of individual parts of accessory iliacus muscle.

Structure	**Measurement [mm]**
Proximal attachment (starting point)	
Width	11.44
Thickness	5.53
Proximal attachment (distal point)	
Width	10.20
Thickness	9.68
Proximal attachment length	55.15
Muscle length	153.94
Musculotendinous junction (starting point)	
Width	4.69
Thickness	3.27
Musculotendinous junction (distal point)	
Width	2.43
Thickness	3.86
Musculotendinous junction length	62.56
Tendon length	79.14
Distal attachment	
Width	3.58
Thickness	6.29

DISCUSSION

As mentioned previously, even though anatomical variations of the psoas major and iliacus muscle are not as common as those of the psoas minor, they have nevertheless been recorded and include additional muscular structures. It is also worth noting that such accessory structures are usually connected with some kind of neurovascular compression [34].

The accessory muscular slips associated with both described muscles have been organised into a ten-fold classification by Aleksandrova et al. [1] based on literature searches and dissection. In addition, Unat et al. [31] distinguish a sheet muscle pattern and a slip muscle pattern for the accessory slips covering the FN.

Other compound additional structures are associated with the iliopsoas muscle complex, such as descriptions of the psoas quartus and psoas tertius. The latter is usually described as arising from the twelfth rib and first lumbar vertebra transverse process and inserts onto lesser trochanter of the femur [5, 12]. The psoas quartus might arise [20] from the third lumbar vertebra transverse process and the quadratus lumborum, and fuse with the psoas major and iliacus muscle via muscular fibers at the level of inguinal ligament, according to Tubbs et al. [29]. Alternatively, it may originate solely from the anteromedial surface of the quadratus lumborum muscle and fuse with the psoas major tendon at the inguinal ligament level, as noted by Wong et al. [33]. In addition, [3]it may originate as a slip from the quadratus lumborum muscle and fifth lumbar vertebra transverse process and fuse with other psoas tendons at the inguinal ligament level, as presented by Clarkson and Rainy [5].

However, the accessory psoas major observed in the present study has a different morphology to those noted in previous studies. This is the first report of a four-headed, completely separate accessory muscle that splits and restricts the FN between heads.

The accessory iliacus muscle is a rather known variation. It is usually described as a slim slip arising from the middle-third of the iliac crest inner lip. This slip is distinguishable from the iliacus muscle mass and inserts onto the lesser trochanter of the femur [28]. Other variation were also described. Pośnik et al. [20] reported a case of a double-headed accessory iliacus muscle composed of superficial and deep heads Iliacus minor is a muscle that arise from the anterior inferior iliac spine of the ilium and insert onto the anterior trochanteric

line[18]. Ilio-capularis is a variation that originate from the anterior trochanteric line and insert onto the ilio-femoral ligament [2]. Additionally, some authors introduce variations as iliacus minimus or iliacus minor in order to describe additional muscular bands of IM that originate from the iliolumbar ligament or ala ossis sacri [1, 26].

Interestingly, the iliopsoas tendon is also variable, being present as a single, double, or a triple band [19]. Philippon et al. [19] classified the iliopsoas tendon as follows: Type 1 — a single tendon generated by fusion of iliacus muscle and psoas major, Type 2 — a double banded tendon composed of iliacus muscle and psoas major tendons separately and Type 3 – a triple-banded tendon composed of a medially-located psoas major tendon, an intermediate iliacus muscle tendon and an accessory iliacus muscle tendon in the most lateral position.

The accessory iliacus muscle observed in this study also differs from previous reports. Position of variation from this report does not align with the classification by Philippon et al. [19]. While the accessory iliacus tendon was described as the most lateral element inserting onto lesser trochanter of the femur in the classification, it was positioned most medially in the present case. It is also important to note that in the present study, four muscles were found to insert onto the lesser trochanter of the femur: regular iliacus muscle (most laterally), accessory iliacus muscle (most medially), regular psoas major (between iliac muscles, anterior to the accessory psoas major) and accessory psoas major (between iliac muscles, posterior to the regular psoas major). The Philippon et al. classification [19] does not include a four-banded insertion of the iliopsoas muscle complex.

It can be assumed, that variations presented in this study might result from the unknown disturbance of the embryological development. As for right now, there are no detailed studies regarding the development of the structures forming the iliopsoas muscle complex. It is known, that the iliopsoas musculotendinous unit (IPMU) is derived from the paraxial mesoderm [32]. Bardeen shown psoas muscle cut away from the lumbar plexus of the 7 weeks embryo of 20 mm in length [4], and according to Warmbrunn et al. [32] after 8 weeks of embryological development, when the embryo is 30 mm in length, the musculature of the iliopsoas muscle complex is already formed. Bergman et al. [28] suggested, that most variations from the described complex might result from the aggressive ingrowths of the FN through the developing muscles. Such a theory might explain the existence of accessory psoas muscle reported in this study, due to its close relation to the FN, however further studies regarding embryological development of the IPMU are required to confirm those suspicions.

Our findings has clinical significance as the configuration may increase the chance of compressive and entrapment peripheral neuropathies of the femoral nerve (FN). The critical zone for FN entrapment is assumed to be the fibro-muscular ring, bounded superficially by the inguinal ligament [13, 27]. However, additional muscular bands of iliopsoas muscle complex components, especially those that split the FN, have also been implicated in causing FN compression [1, 6, 31]. As such, the presented case, where the FN was split by the second head, and the inferior part of the split nerve was restricted between second and third head, appears to have a high risk of compression. Moreover, such compression could possibly be aggravated during accessory muscle constriction, which would occur during muscle function; however, since the accessory muscle was a part of the iliopsoas muscle complex, it is possible that it could aid hip flexion.

The arrangement may have clinical consequences that would result directly from disrupting the innervation of the structures supplied by FN: *viz.* the pectineus, iliacus and sartorius muscles (participating in hip movement) and the quadriceps components (participating in knee straightening and hip joint stabilization) [14]. Additionally, the FN is connected with sensory innervation of the anterior and medial parts of the thigh [14]. Therefore, compression of the FN at such high point of its course could impair hip flexion, hip stabilisation and knee straightening, and result in numbness, tingling or paraesthesia. However, further studies are required to confirm this.

Retroperitoneal endoscopic surgery is a known method applied to anterior interbody fusion for disc herniation, anterior decompression, and interbody fusion for burst fracture and discectomy for extreme lateral disc herniation [8, 17]. Moro et al. [16] presented an anatomical study in order to decline number of the postoperative complications after the described procedure. The study by Moro et al. [16] let surgeons dissect the psoas muscle at L4-L5 level and above, due to thorough consideration of the relationship between the psoas major and lumbar plexus, however, variations of the psoas major muscle were not regarded. In this study, we described an accessory psoas muscle, that was closely related to the nervous structures of the lumbar plexus. Morphological variation of this kind might not be detected during pre-surgical imaging studies, since visualization of the iliopsoas muscle complex variation may be complicated [22]. If the change is detected during operation, it may prolong the procedure, or cause avoided complications, such as lumbar plexus nerves palsy.

The unusual number and arrangement of tendons within the studied iliopsoas muscle complex also might be clinically significant. Snapping hip syndrome, manifested by

unexpected, tender and audible snapping of the hip, occurs usually when the hip changes from flexion-abduction-external rotation to the neutral position [7]. During this movement, the medial part of the iliacus is restricted by the iliacus muscle and iliopsoas tendons. The condition is treated by iliopsoas tendon release, with incomplete release resulting in recurrence. Such possibility seems probable when more than one tendon is present [19]. As the iliopsoas muscle complex in the present study comprised four components inserting onto the lesser trochanter of the femur, it may have been characterised by a high probability of interference with such procedure.

CONCLUSIONS

The study presents an unusual co-occurrence of four-headed accessory psoas major and accessory iliacus muscle found during dissection. Such co-occurrences of two additional muscular structures within the iliopsoas muscle complex are rare, and no four-headed accessory psoas have been described in the literature. In addition, the anatomical position and morphological features of the muscles indicate a high possibility of associated clinical complications; as such, it may of interest to clinicians, who should take such variations into consideration while choosing diagnosis and further treatment.

ARTICLE INFORMATION AND DECLARATIONS

Ethics statement

The cadavers belonged to the Department of Anatomical Dissection and Donation, Medical University of Lodz.

Authors' contributions

Marta Pośnik — project development, data collection and management, data analysis and manuscript writing. Nicol Zielinska — data analysis and manuscript editing. Konrad Kurtys — manuscript editing. Krzysztof Koptas — manuscript editing. Łukasz Olewnik — data analysis and management, manuscript editing.

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Conflict of interest

The authors declare that they have no competing interests.

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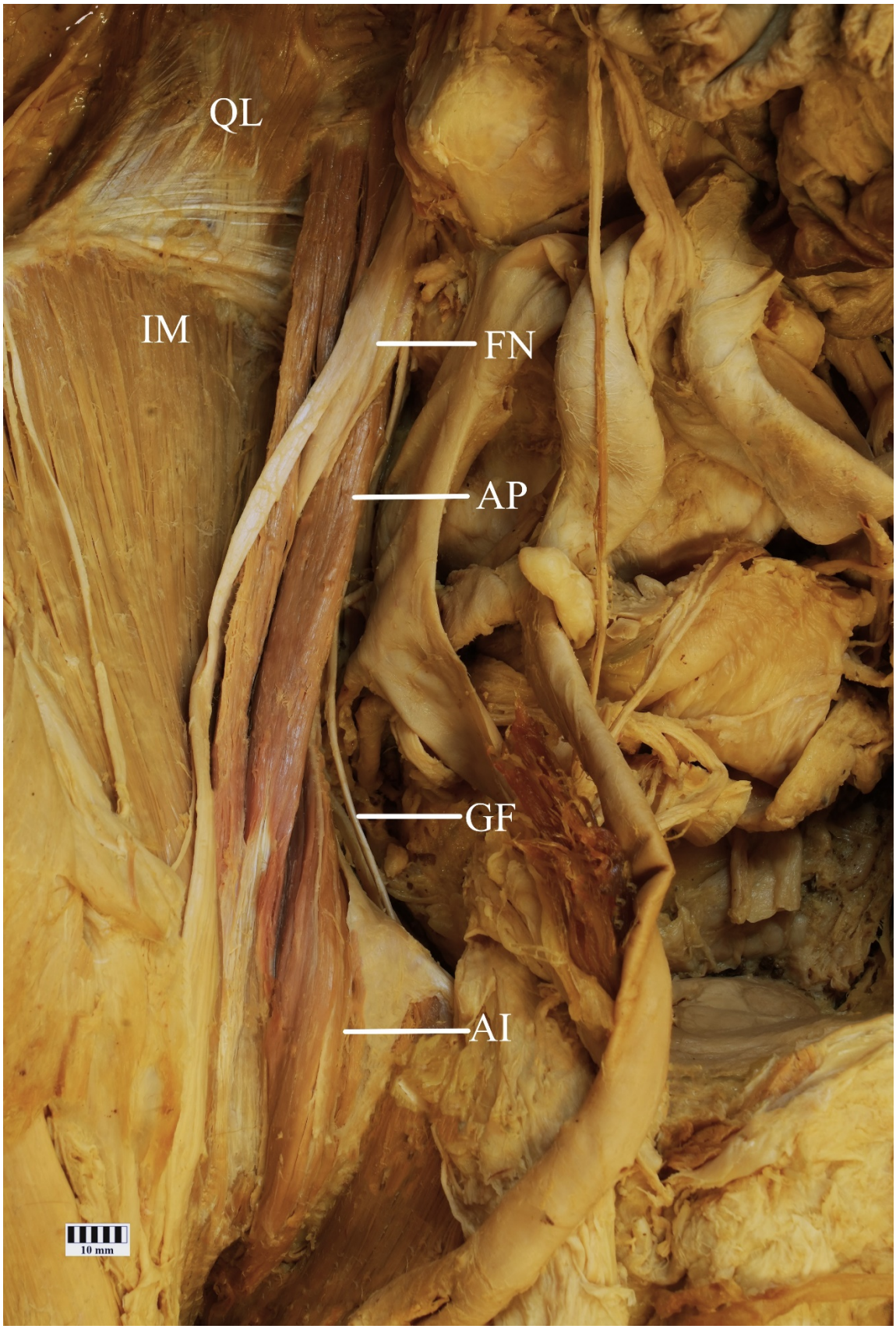
QL
IM
FN
AP
GF
AI
10 mm

Figure 1. Posterior abdominal wall after dissection. AI — accessory iliacus muscle; AP — accessory psoas muscle; FN — femoral nerve; GF — genitofemoral nerve; IM —iliacus muscle; QL — quadratus lumborum muscle.

Figure 2. Accessory psoas muscle after extraction. B1, B2, B3 bands of first head origin FN femoral nerve FH first head SH second head AT accessory psoas muscle tendon. FH — first head of the accessory psoas muscle; FN — femoral nerve; SH — second head of the accessory psoas muscle.

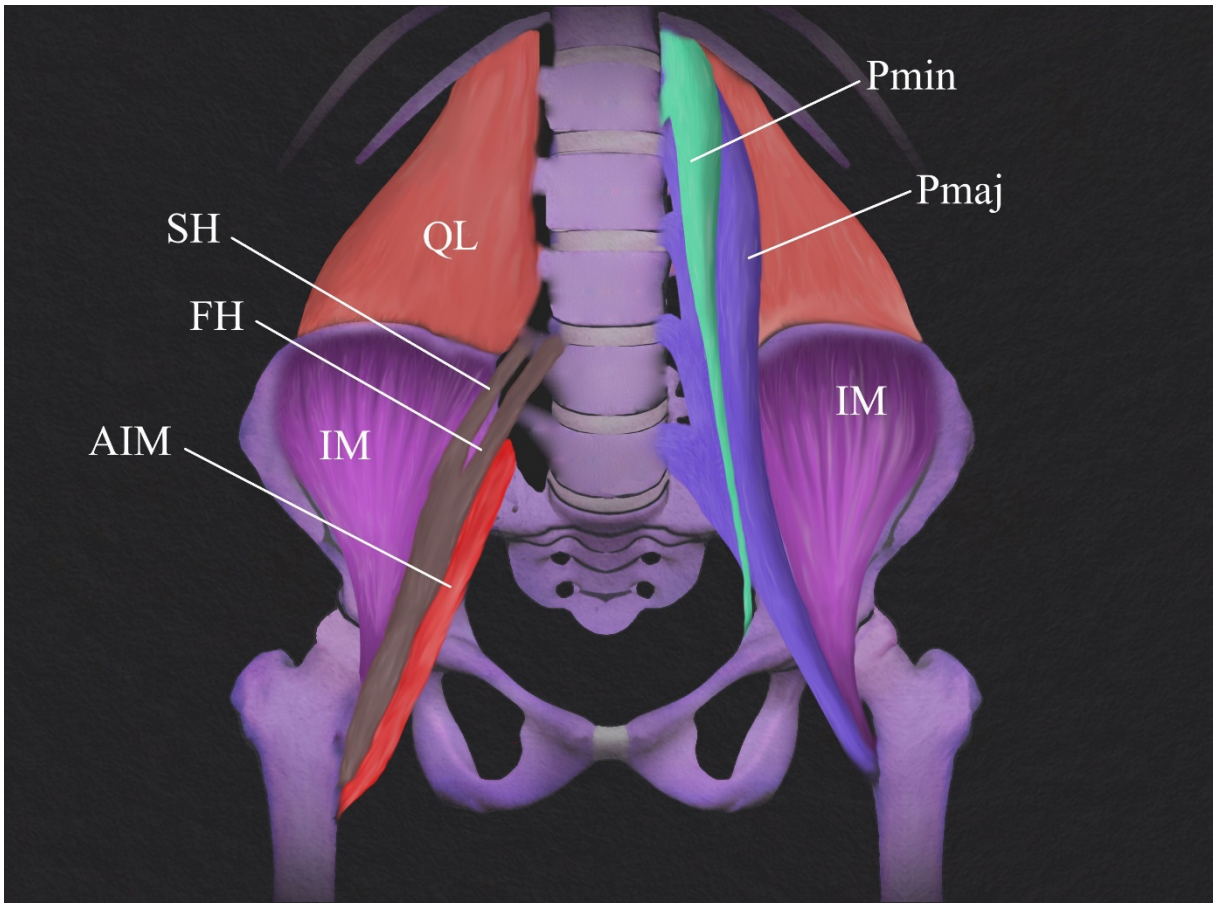

Figure 3. Schematic presentation of anatomical variability presented in this study. FH — first head of the accessory psoas muscle (second and third bands of origin were not visible from the presented perspective); IM — iliacus muscle; AIM — accessory iliacus muscle; Pmaj — psoas major muscle; Pmin — psoas minor muscle; SH — second head of the accessory psoas muscle; QL — quadratus lumborum muscle.