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A three-headed piriformis muscle: an anatomical case study and narrative review of literature

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The piriformis muscle (PM) is found in the gluteal region, exiting the pelvis through the greater sciatic foramen and dividing it into the suprapiriform and infrapiriform foramina. The piriformis works as part of the hip external rotator muscle group, and is responsible for rotation of the femur upon hip extension and abduction of the femur during flexion of the hip joint. The aim of the present report is to describe a very rare case of the primary three-headed PM. To the best knowledge of the authors, the said variant has not yet been described in the existing literature.

The 71-year-old male formalin-fixed cadaver was subjected to routine dissection. After careful removal of the connecting tissue, three separate, primary heads of the PM were identified. The lower head of the PM arose from the middle part of the sacral bone; 87.56 mm long and 9.73 mm wide. The medial head was attached to the internal part of the posterior inferior iliac spine; 121.6 mm long and 20.97 mm wide. The upper head was attached to the external part of the posterior inferior iliac spine; 78.89 mm long and 23.94 mm wide. All heads converged into a common tendon which inserted onto the greater trochanter.

The clinical importance of this work comes down to the fact that the aberrant PM may be the reason behind the piriformis syndrome and its associated symptoms. Moreover, knowledge regarding the variant anatomy of the PM is of immense importance to, e.g. anaesthesiologists performing computed tomography- or ultrasound-guided sciatic nerve injection for local anaesthesia, radiologists interpreting imaging studies, and surgeons, especially during posterior approaches to the hip and pelvis. (Folia Morphol 2023; 82, 4: 969–974)

Key words: piriformis muscle, piriformis syndrome, sciatic nerve, anatomy

INTRODUCTION

The piriformis muscle (PM) is located in the gluteal region of the pelvis, posteriorly from the hip joint, passes through the greater sciatic foramen thus dividing it into two topographic areas: the suprapiriform and infrapiriform foramina [5, 7]. The muscle is a part

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of the hip external rotator muscle group, consisting namely of: the piriformis, quadratus femoris, obturator internus, obturator externus, gemellus inferior and superior. The piriformis is responsible for rotation of the femur upon hip extension and abduction of the femur during flexion of the hip joint.

The possible proximal attachment points for the PM are: the anterior surface of the lateral process of the sacral bone, the spinal region of the gluteal muscles, the gluteal surface of the iliac bone, the capsule of the sacroiliac joint or sacrotuberous ligament [5]. The distal attachment of the piriformis is the superomedial surface of the greater trochanter of the femur [23]. The piriformis muscle is innervated by the nerve to piriformis which can originate from the L5-S2 ventral rami, S1-S2 ventral rami or S1-S3 ventral rami [9].

The term "piriformis syndrome" was first introduced by Robinson in 1947 [18]. The condition was defined as a type of sciatica caused by an abnormal state of PM and probably resulted from a trauma to this region. According to Hopayian and Danielyan [8], the leading symptoms of the said condition involve: pain radiating to the ipsilateral leg (70%), external tenderness found close to the greater sciatic notch (61%), pain located in the gluteal region (56%), and aggravation of pain while sitting (40%). Noteworthy, the piriformis syndrome may be confused with sciatica, what in turn may lead to inappropriate treatment [6]. Moreover, the female-to-male ratio regarding the piriformis syndrome was 75:61 and the mean age of patients was 43 years [8].

The piriformis syndrome may exist in correlation with the abnormal structure of the PM or its spatial relation with the sciatic nerve (SN), whereby the SN is compressed by the PM [12]. The variants of this muscle need to be taken into account while performing procedures such as computed tomography- or ultrasound-guided SN injection for local anaesthesia, interpreting medical imaging studies by radiologists, and in surgical posterior approaches to the hip and pelvis.

The aim of the present report is to describe a very rare case of the previously unreported primary (i.e. undivided by a nerve or a vessel) three-headed piriformis muscle. Measurements of the width and length of each head were taken and included in the following article.

CASE REPORT

The 71-year-old male formalin-fixed cadaver was subjected to routine dissection at the Department of Anatomy, Jagiellonian University Medical College. The donor's height was 180 cm, and weight 107 kg. The process was performed by 3 authors (T.K., W.C., P.J.), under close supervision of more senior prosectors (M.P.Z., J.A.W.). The skin, adipose tissue and fascia were removed from the gluteal region on the right lower extremity. As the next step, the gluteus maximus was gently sectioned and after careful removal of the connecting tissue, three separate, primary heads of the PM were identified. Every measurement of the described muscle was made 3 times, using an electronic calliper and then the average was calculated (Fig. 1).

The lower head of the PM arised from the middle part of the sacral bone. It was 87.56 mm long and 9.73 mm wide. The medial head, which was the longest, was attached to the internal part of the posterior inferior iliac spine. It was 121.6 mm long and 20.97 mm wide. The upper head, which was the widest head, was attached to the external part of the posterior inferior iliac spine. It was 78.89 mm long and 23.94 mm wide. All heads converged into a common tendon which inserted onto the greater trochanter as classically depicted in anatomical textbooks. Unfortunately, the authors were not able to identify neither the nerve branches nor blood vessels supplying the heads. To the best of our understanding, they arose from the inferior gluteal vessels and nerves, though they were inadvertently not preserved with the transposition of the gluteus maximus to uncover the subgluteal space.

Undivided SN, posterior femoral cutaneous nerve, inferior gluteal nerve with inferior gluteal artery and vein were visible leaving the lesser pelvis underneath the lower head of the PM. The superior gluteal nerve, artery and vein exited through the suprapiriform foramen over the upper head of the PM. The authors have observed neither signs of potential nerve entrapment nor nerve or vascular compression in the dissected area. The contralateral subgluteal space did not exhibit any anatomical variants. No visible pathology was observed on either lower extremity. Regrettably, the donor's medical records indicating any possible clinical involvement were not available to the authors.

Ethical concern

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and

Figure 1. Posterior view of the gluteal region, following removal of the gluteus maximus muscle; 1 — lower head of the piriformis muscle; 2 — medial head of the piriformis muscle; 3 — upper head of the piriformis muscle; 4 — gluteus maximus muscle; 5 — sciatic nerve.

its later amendments or comparable ethical standards. The material used for this research was obtained from a body donation programme.

DISCUSSION

Anatomical aberrances in the gluteal region are a frequent finding. The present study aimed to introduce the primary three-headed PM and discuss its embryological basis, as well as, emphasize the clinical significance of this finding. To the best knowledge of the authors, the said variant has not yet been described in the literature. Overall, the PM and the SN tend to be aberrant in 16.9% of cases [20].

Embryological considerations

When it comes to the prenatal development, the PM is situated close to the coccygeus muscle, gluteus maximus and pudendal nerve at approximately 9 weeks of gestation. The SN runs between the PM and the obturator internus. Moreover, an aponeurosis is visible between the coccygeus muscle and the PM or gluteus maximus at the 20th gestational week [16]. The PM tendon resembles a condensation of fibres between the 6th and 15th week of gestation. About the 15th week, the PM tendon merges with the gluteus medius tendon. Additionally, the PM tendon forms its final insertion in the later development (after the 15th week) [14].

Sulak et al. [21] characterised the relationship between the PM and the SN in fetuses. Two hundred SNs of 200 human fetuses (between 9th and 40th gestational weeks) were included in the study. Based on gestational ages, the fetuses were categorised into four groups: 9–12 weeks, 13–25 weeks, 26–37 weeks, and 38–40 weeks. Then, some measurements were made, three of them regarded the distance between the SN and intergluteal sulcus, greater trochanter and ischial tuberosity. All of the distances rose with gestational age. There was a statistically significant difference between the age groups ($p < 0.05$) [21].

Another measurement involved the connection between the bifurcation levels of the SN and the popliteal fossa (PF) [21]. The SN was separated: into the tibial nerve (TN) and common peroneal nerve (CPN) in the PF, into the terminal branch of SN above the PF, or at the level of PM in 88.5%, 9.5% and 2%, respectively. Furthermore, the SN exited the lesser pelvis underneath the PM in 98% of the cases, while the remaining variants included the CPN piercing the PM and the CPN exiting above the PM [21]. The data suggests that the bifurcation levels of SN in fetuses are lower than in adults. In the latter group, that division happens most often when the SN is located in the posterior compartment of the thigh [1].

Similarly to the aforementioned case, Kurtoglu et al. [11] reported that the level of the SN splitting

in fetuses is found in 97.5% of cases in the PF. The bifurcation was located above the upper border of the PF only in one leg from 40 dissected. The fetuses incorporated in the said study were between 20th and 36th gestational weeks [11].

PM variations described in the literature

Żytkowski et al. [26] highlighted that the concept of norm regarding the human body has evolved throughout history. The anatomical norm and abnormality do not have strict boundaries and thus determining whether a certain feature is a variant or not can pose a challenge. With almost every established anatomical structure comes its variation, which does not necessarily impair body functions [26]. The most frequent variants of the PM and its surrounding structures are described hereafter.

The PM is inherently associated with the SN. Tomaszewski et al. [23] presented a modified system of classification of the PM and SN, which regarded the relationship between the SN and PM and the way the SN exited the pelvis. According to that system, the PM described in the present study appears to be type A, which is also the most common type, with a pooled prevalence estimate of 85.2% [23].

Nevertheless, PM comprising primarily three heads has never been reported in the literature before. Natsis et al. [15] described a case with three muscle bellies of the PM that were formed due to the passage of the CPN and the TN through between the bellies. However, the case described herein points towards a three-headed PM that was not divided by the neurovascular entities passing right through it. Arifoglu et al. [2] reported a case of double PM existing alongside double superior gemellus muscle. The SN divided within the pelvis and the CPN was present between the lower and upper PM, while the tibial nerve was located under the lower PM.

What is more, a fusion between the PM and gluteus maximus muscle is also a possibility. Arora et al. [3] encountered a muscle merging proximally with the gluteus maximus muscle and distally with the PM. That particular anomaly may impinge on the SN and present clinically in the form of pain in the gluteal region.

Bifid PM is another variation, classified as type B, D, or E, depending on the SN bifurcation [23]. Thompson and Visagie [22] described a case where a 12-year-old girl had a bifid PM identified 4 months after surgery. The surgical procedure was performed due to osteoid osteoma located in the acetabular roof of the right leg. In this instance, two heads of PM were pierced by the CPN and the TN passed below the PM, which corresponds to type B of PM [22]. Such an anomaly resulted in the iatrogenic injury of the CPN, therefore, taking those variations into account while operating on a patient is undoubtedly of utmost importance.

Similar to the above-mentioned case, Wun-Schen [25] depicted a bipartite PM. Notwithstanding, it was the SN that came between the two heads of the PM. Moreover, the entrapment of the SN gave symptoms such as sciatica, and numbness in the area innervated by the CPN. Having corrected the position of the PM, the pain was relieved [25].

Last but not least, the PM may also be absent altogether in the gluteal region. Brenner et al. [4] reported such a case of unilateral absence of PM, the inferior gluteal artery was also missing ipsilaterally. Possibilities of the disappearance included fusion with another muscle, involution due to medical intervention, and true aplasia, with the latter being indicated by the authors as the most probable cause.

Clinical significance of the PM

In addition to the aforementioned clinical information regarding the piriformis syndrome, the said condition may be treated by a novel method, introduced by Tubbs et al. [24], which proved to be attainable in a cadaveric study thus far. The technique was performed on 5 adult cadavers and included the exposure of the PM in the proximity of the greater sciatic foramen. What is more, in order to achieve that an incision was performed near the pubic tubercle and then underlying adductor muscles, as well as deeper obturator muscles, were split. Subsequently, a laparoscope was inserted into the emergent canal and the SN was identified. As a result, the PM was cut which relieved the compression of the SN. Neither the SN nor neuromuscular bundles were damaged during the procedure [24].

The PM is also involved in certain invasive procedures. Ozisik et al. [17] described a computed tomography-guided injection into the PM. The group which received that form of treatment consisted of 10 patients. What is more, one of the patients had right PM hypertrophy found on the magnetic resonance imaging. When it comes to the technique, an 18G needle was placed in the PM and the insertion was confirmed with the computed tomography. The

methylprednisolone (Depo-Medrol 40 mg/1 vial) and bupivacaine (Marcaine 1 amp) were applied to the muscular tissue [17]. Concerning the PM features, such a precise diagnostic process resulted in the good recovery of 9 patients.

Thorough knowledge regarding the PM's anatomical variations is also essential in ultrasound-guided injection. Santamato et al. [19] illustrated the usage of botulinum toxin in the treatment of the piriformis syndrome. The injection process comprises three stages: placing the linear transducer on the line connecting the projections of the greater trochanter and the ischial tuberosity, then identifying the PM by using the probe and consequently, inserting the needle underneath the close ultrasound surveillance. As a result, the patient's symptoms were alleviated [19].

Furthermore, McLawhorn et al. [13] reported anatomical outcomes of direct anterior approach total hip arthroplasty, for instance, the violation of the PM. During the direct anterior approach an incision on the front of the hip is made, and then muscles are moved instead of detaching the tendons so as to replace the joint. Promptly after the procedure, 75% (24 out of 32) of the PM tendons were found to be intact, whereas a 1-year follow-up showed that only 1 patient out of 32 had PM tendon damaged. In addition, 22% of hips manifested moderate atrophy of the PM [13].

Limitations of the study

The principal limitation of the present study is lack of patient's medical records. Without those, it is impossible to determine whether the patient felt any discomfort or pain due to the existence of the three-headed PM. Furthermore, the anatomical variant of the PM should be taken into consideration in a differential diagnosis concerning pain localized in the gluteal region of unknown origin.

CONCLUSIONS

This study presented a case of the primary three-headed PM with discussion of its possible embryological basis. To the best knowledge of the authors, the said variant has not yet been described in the literature. The clinical importance of this work comes down to the fact that the aberrant PM may be the reason behind the piriformis syndrome and its associated symptoms. Moreover, knowledge regarding the variant anatomy of the PM is of immense importance to, e.g. anaesthesiologists, performing computed tomography- or ultrasound-guided SN injection for local anaesthesia.

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Conflict of interest: None declared

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