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CASE REPORT

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Never undescribed before, four-headed plantaris muscle

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The plantaris is a small muscle of the superficial posterior compartment of the leg. It originates at the lateral supracondylar line of the femur and the knee joint capsule, from where it continues distally, forming a long and slender tendon distally attached to the calcaneal tuberosity.
During standard anatomical dissection a four-headed plantaris muscle was found, and all of its heads connected to each other as a single muscle belly passing into tendinous structure, which was distally attached as a standard plantaris muscle. The first head originated from the popliteal surface of the femur. The second one originated from distal Kaplan fibre. The third and fourth heads were proximally attached to the lateral femoral epicondyle.
Knowledge about morphological variations is necessary because of its potential clinical significance, which means not only neurovascular compressions, but also surgical procedures. (Folia Morphol 2024; 83, 4: 942–946)

Keywords: plantaris muscle, plantaris tendon, anatomical variations

INTRODUCTION

The posterior compartment of the leg is divided into 2 groups: the superficial one including the plantaris muscle (PM), the gastrocnemius muscle (GM), and the soleus muscle (SM); and the deep one consisting of the popliteus, flexor digitorum longus, flexor hallucis longus, and tibialis posterior muscle. The PM usually originates from the knee joint capsule, the lateral condyle, and the popliteal surface of the femur. Its distal attachment in most cases is located on the calcaneal tuberosity. This muscle is innervated by the tibial nerve and receives vascular supply from the posterior tibial artery [1].

The function of the PM depends on the alignment of the foot, because when the foot is fixed, the PM supports flexion of the knee. In turn, when the foot is not fixed, it supports plantar flexion. This muscle also takes part in walking or climbing [18].

The PM demonstrates considerable morphological variability in both origin and insertion attachments. In rare cases, an accessory PM is present. More frequently, a different number of additional heads is observed. Also, some PMs are fused with another muscle [11].

As is commonly known, morphological variations may be associated with some clinical implication. For example, an unusual course or accessory head of the PM can lead to neural compression, the symptoms of which may be similar to sciatica [12].

During standard anatomical dissection a four-headed plantaris muscle was found, and all of its heads connected to each other as a single muscle belly passing into the tendinous structure, which was distally attached as a standard plantaris muscle. The first head originated from the popliteal surface of the femur. The second one was originated from distal Kaplan fibre. The third and fourth heads were

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Table 1. Morphometric measurements of four-headed PM.

	1st muscle belly	2nd muscle belly	3rd muscle belly	4th muscle belly
PA width	3.65 mm	7.53 mm	11.24 mm	8.55 mm
Length	56.03 mm	57.84 mm	53.67 mm	58.88 mm
DA width	2.67 mm	4.57 mm	7.55 mm	5.10 mm

DA — distal attachment at the point of fusion with other heads; PA — proximal attachment; PM — plantaris muscle.

proximally attached to the lateral femoral epicondyle [9]. Knowledge about morphological variations is necessary because of their potential clinical significance.

CASE REPORT

An male cadaver, 76 years old at death, donated to science, was subjected to routine anatomical dissection for research and teaching purposes at the Department of Anatomical Dissection and Donation, Medical University of Lodz, Poland. The left lower limb was subjected to traditional anatomical dissection [10, 15], and morphological variations of the PM were recorded.

The anatomical dissection started with removal of the skin from the popliteal and shin area up to the GM. The lateral and medial heads of the GM were carefully separated. The next step was to gradually remove the medial head of the GM. In turn the lateral head of the GM was cut at the myotendinous junction point and deflected. After that, the PM was completely cleansed. The four-headed PM was found during this process, and all its heads connected to each other as a single muscle belly passing into the plantaris tendon, which was distally attached to the calcaneal tuberosity.

The first head originated from the popliteal surface of the femur. Its proximal attachment was 3.65 mm wide, and its distal part at the point of fusion with the second head was 2.67 mm wide. This belly was 56.03 mm long. The second head originated from distal Kaplan fibres, and at this point was 7.53 mm wide. Its length was 57.84 mm, and its distal part at the point of fusion with the first head was 4.57 mm wide. The third head originated from the lateral femoral epicondyle. The width of its proximal attachment was 11.24 mm, the width of the distal part (at the point of fusion with other heads) was 7.55 mm, and its length was 53.67 mm. The fourth head originated also from the lateral femoral epicondyle. It was 8.55 mm wide in its proximal attachment, 5.10 mm wide in its distal part at the point of fusion with other heads, and its length was 58.88 mm.

These measurements were collected using a Mitutoyo Corporation electronic caliper (Kawasaki-shi, Kanagawa, Japan). Each measurement was repeated twice with an accuracy of up to 0.01 mm. When dissecting the lower limb, no other morphological variabilities were found. The morphometric measurements are given in Table 1.

DISCUSSION

As it mentioned above, the PM is characterised by various morphological variabilities in both origin and insertion. To explain such variations, it is necessary to analyse embryonic development. In the case of differentiation of the common flexor mass into distinct muscles, it starts in 11 mm foetuses. This flexor mass is completely divided in a 14 mm embryo into a superficial layer (including the PM, GM, and SM) and the deep one including the flexor digitorum longus, flexor hallucis longus, popliteus, and tibialis posterior muscles. Proximal attachment of the PM develops after dividing the GM mass into 2 heads, and it splits off from the lateral head of the GM [3] Inappropriate embryological development may result in morphological variations of the muscular or tendinous PM parts.

Olewnik et al. [11, 13, 14] created not only classification of the PM's proximal part, but also of its distal attachment. Looking for something similar to the present case, the classification of the PM's origin was checked. Olewnik et al. [13] distinguished 6 types of PM origin. Interestingly, the PM was absent in almost 10% of cases. Type I was divided into 2 subtypes and was characterised by proximal attachment to the lateral head of the GM, lateral femoral condyle, knee joint capsule (Subtype Ia), and to the popliteal surface of the femur (Subtype Ib). Type II was characterised by proximal attachment located on the knee joint capsule and to the lateral head of the GM and as a common junction to the lateral femoral condyle. Type III was similar, but there was no connection with the GM. Type IV originated from the lateral femoral condyle,

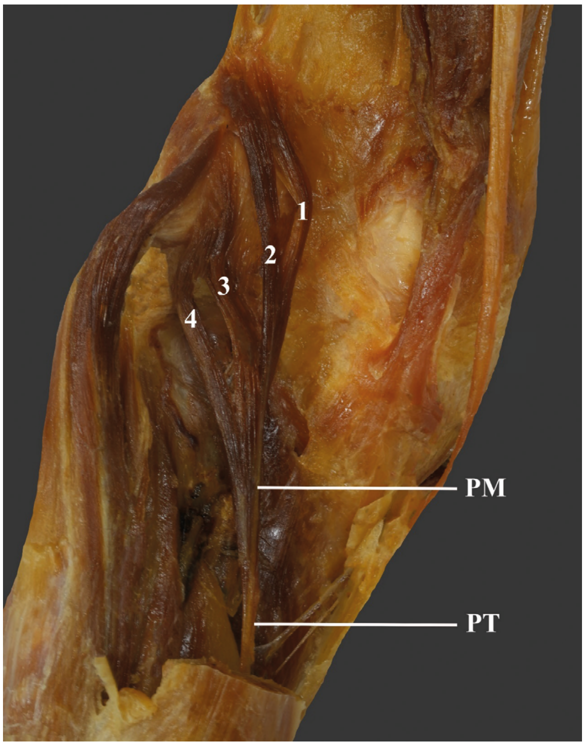

Figure 1. 1 — 1st head of the plantaris muscle; 2 — 2nd head of the plantaris muscle, 3 — 3rd head of the plantaris muscle, 4 — 4th head of the plantaris muscle; PM — plantaris muscle, PT — plantaris tendon.

the knee joint capsule, and the iliotibial band. Proximal attachment of Type V was located only on the lateral femoral condyle. They also distinguished Type VI, which was called "rare cases". This group contains the double PM (standard PM originating from the lateral femoral condyle, knee joint capsule, and iliotibial band and additional PM originating from the iliotibial band) and bifurcated PM (the lateral head of the PM originating from the lateral head of the GM, and medial head originating from the knee capsule) [11].

In the present case, there were 4 distinct heads fused with each other into a single muscular mass passing into the tendinous structure distally attached to the calcaneal tuberosity. The origin of these heads varied – the first head was attached to the popliteal surface of the femur, the second to the distal Kaplan fibres, and the third and fourth to the lateral femoral condyle. There was no connection with lateral head of the GM or with the knee joint capsule. Even though in Olewnik et al. [11] a classification type with 3 or more heads was not included, the present case may be classified as a Type VI because this type included all "rare cases".

Waśniewska et al. [19] carried out a similar study, but on human foetuses. PM was classified according to Olewnik et al. [11] classification, and the first 5 types were the same. There was only one difference — Type VI — which in Waśniewska et al.'s [19] classification was described as a PM originating from the lateral femoral condyle and the iliotibial band, instead of bifurcated or doubled PM observed in the adult population [11]. Interestingly, the PM was absent in 21.3% of cases [20].

A similar case was described by Maślanka et al. [9]. A three-headed PM was found, and the first head was proximally fused with the distal Kaplan fibres and to the lateral femoral condyle. The second and third heads were proximally attached to the lateral femoral condyle and the knee join capsule. Maślanka et al. [9] also classified this case as Type VI according to Olewnik et al. [11]. In the available literature there is also another description of a three-headed PM [16], in which the first head was attached to the lateral femoral condyle and the posterior femoral surface, the second one to the lateral femoral condyle and lateral head of the GM, and the last one from the lateral head of the GM. Interestingly, the tendon of the first head was fused with the tendon of the second head, and subsequently this common tendinous structure was fused with the third head's tendon [16].

In the available literature a PM with one additional head is significantly more frequent, called a bifurcated PM [5–7, 11, 17, 20].

As is commonly known, the presence of additional heads or accessory muscles in some cases may be related to neurovascular compression [21]. Bifurcated, or three- or four-headed PM may cause compression of the tibial nerve and symptoms similar to those seen in sciatica.

However, in the present case, there is a more important clinical implication. As mentioned above, the second head originated from distal Kaplan fibres, and this is a connection between the iliotibial band and the distal part of the femur. Kaplan fibres take part in stabilisation of the knee region due to proprioception and mechanical features [2]. Another function of this structure is increasing the mechanical resistance of the anterior cruciate ligament [4]. Because in the present case, the second head of the PM is connected to the distal Kaplan fibres, it may lead to inappropriate proprioception. The main reason for this is possible tensioning of distal Kaplan fibres while the PM contracts or stretches. Anterolateral and rotatory instability in the knee may be a result of it. It is believed that such a pathology may be important, especially for patients with anterior cruciate ligament rupture [8].

Concluding, knowledge about the PM's anatomy and its morphological variations is clinically important, not only in neurovascular aspects, but also during surgical operations, for example reconstruction of the anterior cruciate ligament.

CONCLUSIONS

Although, the PM's morphological variations are commonly known, there are also undescribed anatomical cases. A specific course or morphology of the accessory head or standard PM may result in neurovascular compression or other pathologies like disorders of proprioception of the iliotibial band. Knowledge about morphological variabilities of PM is also required during surgical procedures like anterior cruciate ligament reconstruction.

ARTICLE INFORMATION AND DECLARATIONS

Ethics statement

The cadavers were the property of the Department of Anatomical Dissection and Donation, Medical University of Lodz. Informed consent was obtained from all participants before they died.

Authors' contributions

Nicol Zielinska — project development, data collection and management, data analysis, and manuscript writing.

Krystian Maślanka — data collection and analysis and manuscript editing.

Andrzej Węgiel — data collection and analysis and manuscript editing.

Konrad Kurtys — data collection, analysis, and manuscript writing.

Łukasz Olewnik — numerous consultations, observations, and suggestions related to the paper. Data analysis and manuscript editing.

All authors have read and approved the manuscript

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Conflict of interest

The authors declare that they have no competing interests.

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