ONLINE FIRST

ISSN: 0015-5659

e-ISSN: 1644-3284

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Authors: Nicol Zielinska, Krystian Maślanka, Andrzej Węgiel, Konrad Kurtys, Łukasz Olewnik

DOI: 10.5603/fm.98753

Article type: Case report

Submitted: 2023-12-31

Accepted: 2024-02-29

Published online: 2024-04-26

CASE REPORT

Never undescribed four — headed plantaris muscle

Nicol Zielinska, Krystian Maślanka, Andrzej Węgiel, Konrad Kurtys, Łukasz Olewnik

Department of Anatomical Dissection and Donation, Medical University of Lodz, Łódź, Poland

Address for correspondence: Łukasz Olewnik Department of Anatomical Dissection and Donation, Medical University of Lodz, Łódź, Poland, email: lukasz.olewnik@umed.lodz.pl

ABSTRACT

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 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 was originated from distal Kaplan fiber. In turn, 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.

Keywords: plantaris muscle, planteris tendon, anatomical variations

INTRODUCTION

The posterior compartment of the leg is divided into two 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 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 tibial nerve, and receives vascular supply from posterior tibial artery [1].

Function of the PM depends of 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 take parts in walking or start climbing [18].

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

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

During standard anatomical dissection 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 was originated from distal Kaplan fiber. In turn, the third and fourth heads were proximally attached to the lateral femoral epicondyle[9] . Knowledge about morphological variations is necessary because of their potential clinical significance.

CASE REPORT

An 76-year-old at death male cadaver 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 from removing 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 one, 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 of its heads connected to each other as a single muscle belly passing into 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 fibers 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, 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 two times 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.

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
LENGHT	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 others heads; PA — proximal attachment

DISCUSSION

As it mentioned above, the PM is characterized by various morphological variabilities, in both origin and insertion. To explain such variations, it is necessary to analyze embryonic development. In case of differentiation of the common flexor mass into distinct muscles it starts in 11 mm fetuses. This flexor mass is completely divided in a 14 mm embryo into 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 GM mass into two heads, and splits off from the lateral head of the GM [3] Inappropriate embryological development may results in morphological variations of the muscular or tendinous PM parts.

Olewnik et al. [11, 13, 14] created not only classification of PM's proximal part, but also about its distal attachment. Looking for something similar to the present case the classification of PM's origin were checked. Olewnik et al. [13] distinguished six types of PM's origin. What is interesting the PM was absent in almost 10% of cases. Type I was divided into two subtypes and was characterized by proximal attachment to the lateral head of the GM, lateral femoral condyle, knee joint capsule (Subtype Ia) and also to the popliteal surface of the femur (Subtype Ib). Type II was characterized 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 lateral femoral condyle, 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 four distinct heads fused with each other into single muscular mass passing into tendinous structure distally attached to the calcaneal tuberosity. The origin of these heads was various – 1st head were attached to the popliteal surface of the femur, 2nd to the distal Kaplan fibers, and 3rd and 4th to the lateral femoral condyle. There was no

connection with lateral head of the GM, and with knee joint capsule. Despite the fact that in Olewnik et al. [11] classification type with three 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 fetuses. PM was classified according to Olewnik et al. [11] classification, and first five types were the same. There was only one difference — Type VI — which in Waśniewska et al. [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 adult population [11]. What is interesting the PM was absent in 21.3% cases [20].

Similar case to the present one, was described by Maślanka et al. [9]. Three-headed PM was found, and the first head was proximally fused with the distal Kaplan fibers 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 to Type VI according to Olewnik et al. [11] classification. In the available literature there is also another description of three-headed PM [16], and the first head was attached to the lateral femoral condyle and 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. What is interesting, the tendon of first head was fused with the tendon of second head, and after that this common tendinous structure was fused with the third head’s tendon [16].

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

As is commonly known, 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 like in sciatica.

However, in the present case, there is more important clinical implication. As it mentioned above, the second head was originated from distal Kaplan fibers, and this is a connection between iliotibial band and distal part of the femur. Kaplan fibers take part in stabilization of the knee region thanks to proprioception and mechanical features [2]. Another function of this structure is increasing the mechanical resistance of the anterior cruciate ligament [4]. The fact that in the present case, the second head of the PM is connected with the distal Kaplan fibers, it may lead to inappropriate proprioception. The main reason of it is possible tensioning of distal Kaplan fibers while PM contracts or stretches. Anterolateral and rotatory instability in

the knee may be a result of it. It is believed, that such pathology may be important, especially for patients with anterior cruciate ligament rupture [8].

Concluding, knowledge about 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. Specific course or morphology of accessory head or standard PM may result in neurovascular compression or other pathologies like disorders of proprioception of iliotibial band. Knowledge about morphological variabilities of PM is also required during surgical procedures like anterior cruciate ligament reconstruction**.**

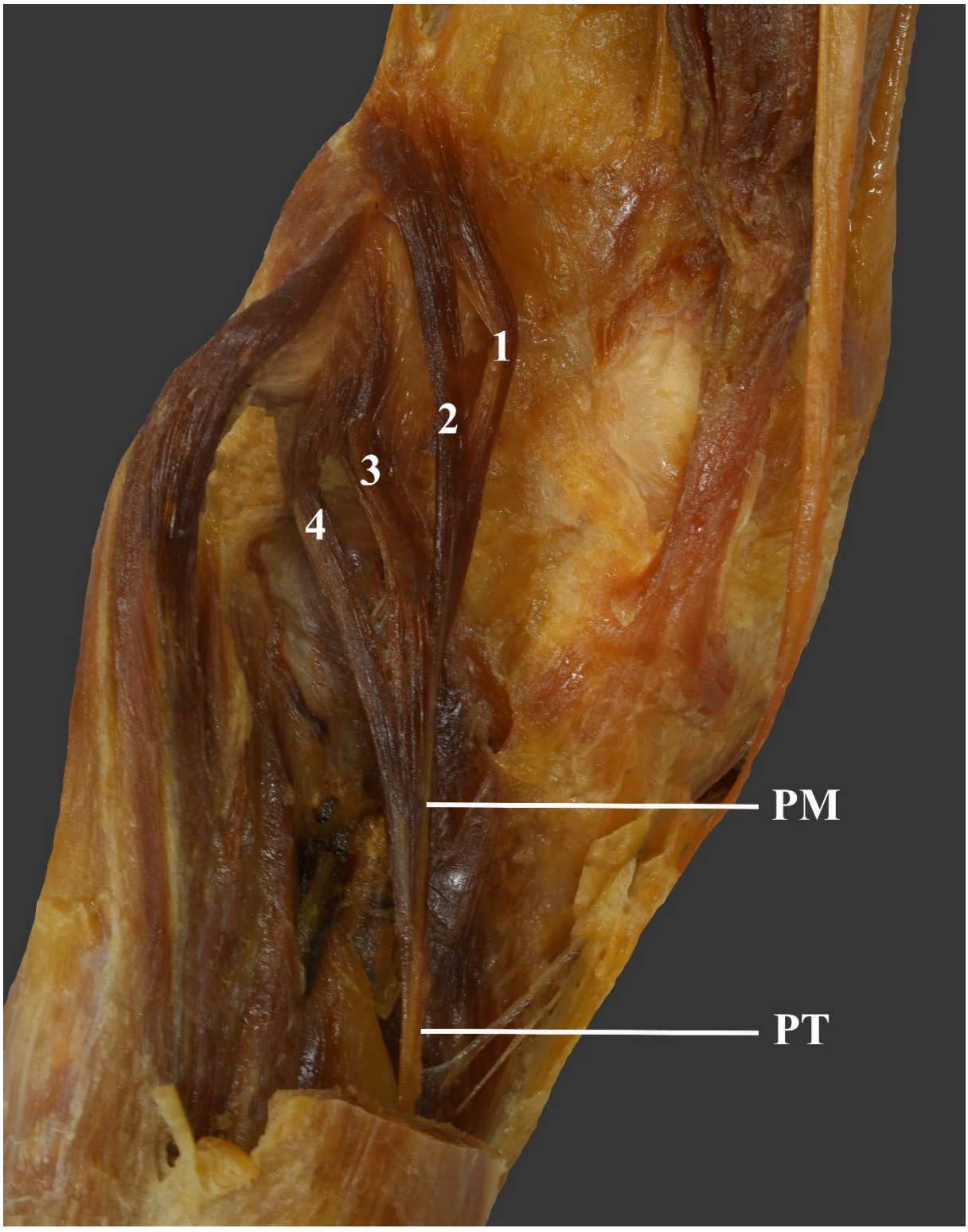

Figure 1. 1 — 1st head of the plantaris muscle; 2 — 2nd head of the plantaris muscle, 3 — 3rd head of the plantaris muscle, 4 — 4th head of the plantaris muscle; PM — plantaris muscle, PT — plantaris tendon

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

Funding

The authors have no financial or personal relationship with any third party whose interests could be influenced positively or negatively by the article's content. This research received no specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of interest: The authors declare that they have no competing interests.

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