



A bilateral gastrocnemius tertius coexisting with a unilateral two-headed plantaris muscle

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Abstract: The current cadaveric report aims to present a coexistence of two uncommon variants of the posterior leg compartment. The variations were detected, during classical dissection in an 84-year-old donated male cadaver. On the left lower limb, the gastrocnemius muscle was identified as having a third head that was attached to the lateral head. This variant is known as gastrocnemius tertius muscle and was bilaterally identified. The left-sided plantaris muscle had two distinct heads that fused into a common tendon that was inserted into the calcaneal tuberosity. Knowledge of these variants is important, due to their close relationship with the popliteal neurovascular bundle. Clinicians should be aware, to avoid pitfalls and take them into account in their differential diagnosis.

Key words: Gastrocnemius muscle, Plantaris muscle, Anatomic variation, Popliteal artery entrapment syndrome

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Introduction

The superficial surface of the posterior compartment of the leg encompasses the gastrocnemius (GM), the soleus (SM), and the plantaris muscle (PM), which form the calcaneal (or the Achilles) tendon and are inserted into the calcaneus. The two-headed GM consists of a lateral head (LH) that originates from the lateral femoral epicondyle, and a medial head (MH) that arises from the medial femoral epicondyle. Both heads are inserted into the calcaneus. The PM is a small muscle that typically originates from the lateral supracondylar line of the femur and the knee joint capsule and inserts distally to the calcaneal tuberosity medial side. The three muscles' main action is the plantar flexion of the ankle, with the PM having an insignificant contribution to it (0.7% of plantar flexion power) compared to GM and SM [1]. The

GM's most studied variant is the presence of a third head, the so-called "gastrocnemius tertius (GT)", a variant that has an adequate clinical interest, due to the atypical muscle's proximity to the popliteal vessels [2]. In the current case, two variant muscles of the posterior compartment of the leg were identified; a bilateral GT variant coexisted with a unilateral two-headed PM. The embryological background and clinical implications of these variants are further discussed.

Case Report

The dissection of an 84-year-old donated male cadaver was performed, at the Dissection Hall of the Anatomy Department of the School of Medicine of the National and Kapodistrian University of Athens. The body was donated through the "Body Donation Program" after written informed consent. Skin and superficial fascia of the lower limb were dissected, all muscles of the posterior thigh compartment were exposed from their proximal to their distal attachment, and meticulous dissection of the popliteal fossa was performed. The muscles were carefully examined for a typical or variant attachment, morphology, and innervation. Lower limbs were free of any physical deformity or trauma.

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Fig. 1. (A) The gastrocnemius tertius (GT) variant. On the left lower limb, the GT had a thin tendinous insertion (asterisks) into the calcaneus (Achilles) tendon (AT). (B) The GT variant. On the right lower limb, the GT fused with the lateral head (LH). MH, medial head; CFN, common fibular nerve; TN, tibial nerve.

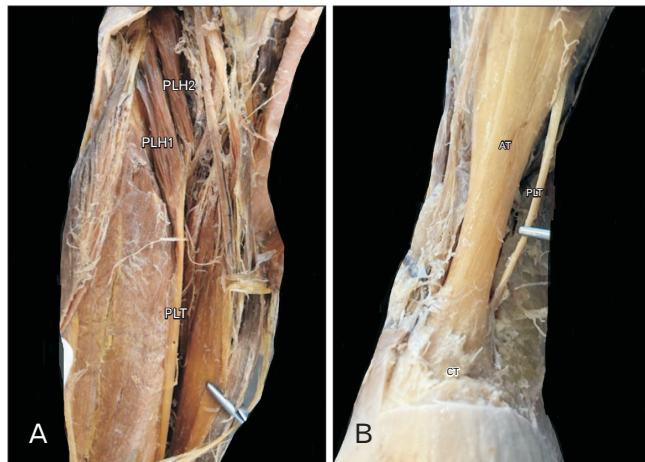


Fig. 2. (A) The plantaris muscle variant. On the left lower limb, the plantaris muscular part consisted of two heads (PLH1, PLH2). (B) The plantaris muscle variant. On the left lower limb, the tendinous insertion of the muscle (PLT), at the calcaneal tuberosity (CT) medially to the Achilles tendon (AT).

An electronic digital caliper was used for all measurements (Mitutoyo Corporation), and each measurement was performed twice with an accuracy of up to 0.1 mm.

On the left lower limb, the GT was identified along with a two-headed PM. The GT originated from the posterior surface of the femur and is located laterally to the popliteal artery (PA) and vein (PV) and the tibial nerve (TN). The GT formed a distinct tendon that was inserted into the calcaneal

Table 1. Morphometric measurements of the gastrocnemius tertius and plantaris muscle variants

Parameters	GT length	GT width	PM (first head)	PM (second head)	PM (tendon)
Left side (mm)	117.2	21.8	100.7	95.8	310.9
Right side (mm)	162.1	28.9	-	-	-

GT, gastrocnemius tertius; PM, plantaris muscle.

tendon (Fig. 1A). After careful dissection of the GM third head, a variant PM was identified with two heads, which created a thin tendon (Fig. 2A), that further was inserted into the medial side of the calcaneal tendon (Fig. 2B).

On the right lower limb, the GT originated from the posterior surface of the femur and coursed laterally to the PA and PV and the TN (Fig. 1B). The variant head was fused with the LH of the GM. The right-sided PM was typical. The morphometric measurements (length and width) of GT and PM are summarized in Table 1.

Discussion

The developmental background of the posterior muscles of the leg

The lateral portion of the flexor plate of the leg gives rise to GM and SM, while the PM arises proximally to the SM and on the GM tibial side [3]. The superficial muscles of the posterior leg compartment (GM, SM, PM) are not well differentiated before the 2nd developmental month. These muscles' variants seem to occur due to separation problems of the original anlage into the three independent muscles (GM, SM, PM). The GM supernumerary head (3rd head) may be defined as a congenital muscle mass (or tendinous head), usually originating from the distal dorsal surface of the femur that joins the LH, MH, or both heads of GM [4].

Gastrocnemius muscle morphological variability

The most investigated variant of the GM, due to its clinical significance, is the presence of a third head, the so-called "GT". In the current case, a bilateral presence of a three-headed GM was identified. Bergman et al. [2] noted a prevalence of the GT, ranging between 2.9 and 5.5%. Koplak et al. [5] in their imaging study of 1,039 magnetic resonance images (MRI), identified a GT in 2% of their sample. In all cases, the 3rd head originated from the posterior distal femur and fused with the LH, while it coursed laterally to the popliteal vessels. Only a unique case of a bilateral appearance of a GT was identified [5]. The bilateral GT has been reported in the

case studies of Arefi et al. [6], Ishii et al. [7], and Yildirim et al. [8]. Arefi et al. [6] reported a similar case to the present one, while Ishii et al. [7] reported a quite smaller Gand hypoplastic GT (morphologically similar to the PM). Yildirim et al. [8] identified the coexistence of a bilateral GT with an accessory SM, similar to the coexistence of the GT with a unilateral two-headed PM, in the present case. Hence, the GT occurrence is considered relatively uncommon (2-5.5%), while its bilateral presence is considered even rarer and has been reported in only four published cases [5-8]. Except for the three-headed GM, there are extremely rare cases of quadriceps GM, as Koplak et al. [5] identified in a unique case of their sample (<0.01%).

Plantaris muscle morphological variability

Recently, the PM has gained a lot of clinical interest due to its value for the tendons' reconstruction in the hand and lateral ankle ligament reconstruction [1]. In the current report, a two-headed PM was identified with a distinct insertion medially to the calcaneal tendon. Olewnik et al. [9] in their morphological study of the PM in 142 adult lower limbs, classified the muscle's morphology into six types. Type I corresponded to the typical presentation of the muscle (48.4%), while in type II, the PM originated partially from the GM LH and partially from the knee joint capsule (25%). Type III was characterized by an origin from the lateral femoral condyle and the knee joint capsule (10.15%), while in type IV, the origin was from the lateral femoral condyle, the knee joint condyle, and the iliotibial band (6.25%). Type V PM originated only from the lateral femoral condyle (8.6%) and type VI included "rare cases" (1.6%). Type VI was further divided into type VIa (0.8%), which included a double PM with two distinct muscular and two tendinous parts, and type VIb (0.8%), which included a PM with two distinct muscular parts forming a single tendon. The present described PM morphological variant corresponded to Olewnik Type VIb (0.8%), a similar finding to Smędra et al. [10] who reported a unilateral PM with two heads that fused into a common tendon. Olewnik et al. [11] and Maślanka et al. [12] identified three-headed PMs. Except from its origin, Gonera et al. [1] in their systematic review of PM morphology created a classification system for its insertion. Gonera type I PM insertion refers to the calcaneal tuberosity with a course medial to the calcaneal tendon with an estimated prevalence between 24-48%. In the current case, the PM insertion corresponds to the Gonera type I.

Clinical significance

Implications may manifest concerning the presentation of a third-headed GM, mainly involving compression of the popliteal neurovascular bundle. PA entrapment and/or PV, and/or TN was first described by Hamming (1959) due to the appearance of a muscular congenital anomaly, the abnormal 3rd head of GM (as cited by Connell [13]). The third head may or may not cross the popliteal neurovascular bundle or some portion of the neurovascular bundle before insertion into GM or its tendon [4]. Koplak et al. [5] and Arefi et al. [6] pointed out the compression effect of the various components of the popliteal neurovascular bundle, presenting with the symptomatology of nerve entrapment, such as tibial or sciatic neuropathy. In cases of GM aberrant heads and their neural supply (TN thin branches), the available space in the popliteal fossa is decreased between adjacent structures, and vascular entrapment neuropathy of the TN may occur within the GM. Such chronic cases of neuropathy may also present with GM atrophy [14]. Differential diagnosis of entrapment neuropathy or vasculopathy cases includes a range of conditions, such as intraneural ganglion cyst affecting the sciatic nerve lower divisions, adventitial cyst in the PA, thrombophlebitic syndrome due to lower extremity deep vein thrombosis, synovial sarcoma in the knee joint, popliteal entrapment syndrome, posterior compartment syndrome in the lower leg, PA aneurysm, and Baker cyst [5, 6, 15]. It is important also to consider the GT variants among these clinical entities. In addition, PM variants have been implicated in Achilles tendon tendinopathy; hence, in recurrent cases, PM variants should also be considered [1]. Meticulous clinical examination and further imaging are essential for establishing the diagnosis.

In the current case, a bilateral three-headed GM coexisted with a unilateral two-headed PM. These two variants, independently, are considered rare, while their coexistence has not been reported. Especially, the GT variant could potentially cause compression to popliteal neurovascular structures. The coexistence of these variants should alert clinicians, to avoid pitfalls and iatrogenic lesions.

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Conflicts of Interest

No potential conflict of interest relevant to this article was reported.

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