

Unilateral Bicipital Plantaris Muscle: A Cadaveric Case Report

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ABSTRACT

The plantaris muscle, a vestigial structure in humans, is a muscle of the posterior superficial compartment of the leg. This study addresses unilaterally bicipital (bifurcated) muscle bellies of the plantaris in a 58-year-old male cadaver. The plantaris functions proprioceptively to provide the central nervous system with information about the position of the gastrocnemius muscle and soleus muscle. However, the significance of this muscle in knee flexion and ankle plantar flexion is thought to be insignificant. The tendon of the plantaris muscle can be used for tendon grafts. Surgeons should be aware of this anatomical variant when considering feasible graft options, specifically for flexor tendons, and consider the potential for significant loss of proprioceptive input in the posterior compartment of the leg from its use as a graft. Clinically, it plays a role in the differential diagnosis of various pathologies of the posterior leg such as Achilles tendinopathy and tennis leg syndrome. A bicipital plantaris muscle belly can impact pathological manifestations and should be considered when palpating the popliteal fossa and Achilles tendon.

Keywords: Tendon graft; Vestigial; Tennis leg

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INTRODUCTION

The plantaris muscle (PM) is a leg muscle, found in the posterior superficial compartment, the tendon of which passes between the soleus and gastrocnemius. During the 4th week of embryonic development, it forms within limb buds from lateral plate mesoderm. This muscle is considered vestigial, although it has retained considerable proprioceptive function [1]. The PM originates from the posterior femur above the lateral condyle or supracondylar line; and inserts into the calcaneal tuberosity medial to the Achilles tendon. The PM shows a high degree of morphological variability at both its origin [2] and insertion [3] sites. Duplication, absence, and eight types of distal attachments of the PM has been documented in previous cases [4]. The tendon of the PM is

clinically significant due to its usage as a graft and potential involvement in tendinopathy of the Achilles tendon.

CASE DESCRIPTION

A 58-year-old male cadaver was observed to have a bicipital PM in the left leg during a routine dissection by one of the authors at *The Edward Via College of Osteopathic Medicine*. Both PMs emerged from the oblique popliteal ligament. The muscle bellies were well demarcated, with the medial muscle belly (PM-1) wider at origin than the lateral muscle belly (PM-2) (Figure 1).

The tendons of both PMs (PT-1 and PT-2) coursed distally to insert on the calcaneus, both in proximity to the Achilles (Not shown). PT-1

inserted medial to the Achilles, while PT-2 coursed between the soleus and gastrocnemius muscles to join the Achilles tendon (Figure 2). This is a variant of normal PT insertion, thus designated as the ectopic plantaris, PT-2.

According to Waśniewska-Włodarczyk et al. [4], PT-1 is more medially implanted than PT-2 and

better fits into Type 1 of the eight-fold classification system of the PM in fetuses. It falls within Type A of the classification scheme proposed by Olewnik et al. [5]. It is assumed that PM-1 is normotopic and PM-2 is ectopic based on muscle belly breadth and insertion sites.



Figure 1: Proximal part of PM-1 and PM-2 inserting into the oblique popliteal ligament (OPL).

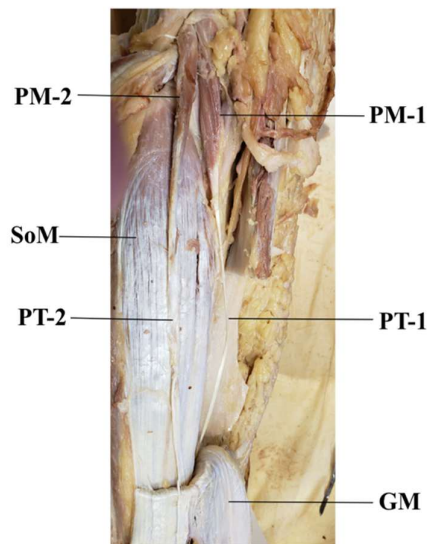


Figure 2: Two separate tendons (PT-1 and PT-2) of the plantaris muscle on the left lower limb.

DISCUSSION

Comparative Anatomy

The PM was first studied in the 19th century and variable morphologies have been documented since 1875. Traditionally, the human PM consists of a small, thin muscle belly with a long tendon. By contrast, the soleus muscle is more developed, with wider origin and insertion sites [6]. The soleus muscle has a vital role in walking, running, and maintaining balance. It has been hypothesized that the soleus may have evolved to perform functions of the PM muscle in bipedal species, including humans [7]. The relative muscle weight of the soleus is much greater than the PM in humans, whereas lighter in rats and primates [8]. Future electromyography studies on PM muscle activity during each phase of walking should be conducted to determine activity of the PM in humans.

Despite action with the gastrocnemius and soleus muscles, the PM is most notable for proprioceptive function due to its high density of muscle spindle fibers that provide information to the dorsal-column medial lemniscus pathway via type 2 afferent fibers predominantly. Despite primary proprioceptive function, non-isolated rupture of the PM has been noted as an etiology of “tennis leg”—a common clinical condition caused by muscle tears in the posterior superficial compartment of the leg from excessive eccentric load on the ankle while the knee is in an extended position [9]. The syndrome presents with a sudden, sharp pain at the time of injury, followed by swelling and tenderness within a few hours of injury. Although gastrocnemius muscle injury is most commonly the etiology of tennis leg syndrome, magnetic resonance imaging studies have noted PM tears occurring in association with gastrocnemius tears [10]. The involvement of a PM tear in the etiology of tennis leg could impact the clinical

manifestations due to proprioceptive loss, manifesting as impaired balance and stability. It is important to note that the variable origin sites of the PM could impact the potential for PM involvement in tennis leg. Variants similar to PM-2 may increase the likelihood of PM involvement by introducing an additional muscle belly that inserts in the same region as the lateral head of the gastrocnemius, thereby increasing the risk of involvement. Furthermore, the presence of an ectopic PM could contribute to the likelihood of this etiology and should be considered in a clinical setting. Additionally, future studies may provide insight into the role of an ectopic plantaris in this condition.

Clinical Significance - Grafts

The PM tendon has been used as auto- and allogeneous grafts due to its accessible bony insertion and high degree of tensile strength. Variants similar to PT-2 with insertion into the Achilles tendon are likely to have the needed tensile strength for grafts. Previous cadaveric studies determined that the PM tendon possesses enough bony stock insertion to be used in flexor tendon reconstruction procedures involving the digits, hand, and forearm [11]. In addition to accessibility, the PM tendon has been found to have a higher median elastic modulus than ankle ligaments, indicating the ability of the tendon to effectively load bear [12]. Furthermore, the PM has a mean length of 30 cm and a mean width of 4 cm, making it a viable option when multiple grafts are needed. Previous studies have documented anatomical procedures and usage of the PM tendon in ankle and hand injuries. Although the Brostrom-Gould approach is the “gold standard” for persistent lateral ankle instability, usage of grafts is an important alternative when there are absolute contraindications [13]. Santos et al. [14] reports two cases where the PM tendon was used in a two-

staged reconstruction of the flexor pollicis longus tendon with variable outcomes. Future research is needed to further assess the potential of the PM tendon in hand injuries and to investigate expected loss of proprioceptive input within the posterior superficial compartment of the leg from PM harvest.

CONCLUSION

Variations of the PM previously cited have noted variable origins, insertions, and additional muscle bellies. Despite ongoing debate among anatomists regarding the muscle's adaptations and significance, being aware of these variations is crucial for accurate palpation of the popliteal fossa and Achilles tendon. Variants similar to PT-2 that insert into the Achilles tendon may result in additional clinical manifestations of Achilles tendon rupture since the normotopic PT inserts medial to the tendon. Furthermore, non-isolated rupture of the PM can contribute to clinical manifestations of tennis leg due to its significant role in balance and stability via muscle spindle fibers. This proprioceptive loss highlights the importance of considering the role of the PM in both diagnosis and treatment. Nevertheless, PM tendon usage as a graft remains clinically significant. Surgeons should be aware of bicipital PM variants, particularly if they are involved in flexor tendon reconstruction procedures of the hand.

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CONFLICT OF INTEREST

None

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