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## Research Article

### An unusual variation of an additional plantaris originating from the soleus – a histological examination

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#### Abstract

The plantaris muscle belongs to the posterior superficial crural muscles. It is placed between the gastrocnemius and soleus. Its origin usually is from the inferior part of the lateral supracondylar line of the femur at a position a little superior to the origin of the lateral head of gastrocnemius. It is composed of a small fusiform belly and a long thin tendon, which runs along the leg in lower medial direction alongside the medial border of the tendo calcaneus and inserts into the posterior part of the calcaneus. The material was taken from the Department of Anatomy and morphology by Sofia's Medical University. Some histological sections from the beginning of the additional muscle belly of the plantaris originating from the soleus were taken. Permanent histological preparations were obtained. This study describes macroscopic and microscopic results of unusual variation of the plantaris merged with the tendon of the main belly and inserted into the tendo Achilles. The presence of an additional plantaris muscle originating from the soleus, as seen in this case, may be of academic interest as the standard text book, as well in cases of an unexplained pain in lower leg and during surgical procedures in the lower limb.

**Keywords:** Muscles of the lower leg, plantaris muscle, histology, tennis leg, surgery.

#### Introduction

The plantaris muscle belongs to the group of posterior crural muscles. This group is subdivided into two subgroups - superficial and deep. The plantaris is one of the superficial muscles. It is considered as a vestigial structure and placed between the gastrocnemius and soleus. It arises from the inferior part of the lateral supracondylar line of the femur at a position a little superior to the origin of the lateral head of gastrocnemius. Sometimes the plantaris may arise from the oblique popliteal ligament. It is composed of a small fusiform belly and a long thin tendon. The tendon runs along the leg in lower medial direction alongside the medial border of the tendon Achilles and inserts into the

posterior part of the calcaneus. Occasionally the tendon of the plantaris inserts into the tendo calcaneus. Sometimes the plantaris is double. In 7-10% of the human population the muscle is absent. But according sonographic investigations the plantaris muscle is absent in 7–20% of limbs (Simpson et al., 2003). Very rarely its tendon is lost in the fascia of the leg.

The functions of the plantaris are to support plantar flexion in the ankle joint and flexion in the knee joint. It is considered as an unimportant muscle. It mainly acts with gastrocnemius. The plantaris may also provide proprioceptive feedback information to the central

nervous system regarding the position of the foot (Moore et al., 2008).

It is clear that the plantaris has minimal motor function and it is important to mention that its long tendon can readily be harvested for reconstruction elsewhere in the human body.

The first part of this variation was observed macroscopically in the left lower limb from a cadaver that the additional muscle belly of the plantaris merged with the tendon of the main belly and inserted into the tendo Achilles and described by Kalniev et al. (2014). Due to this our first observation, the aim of this paper is to analyze and describe histological data for this rare and interesting phenomenon.

## Material and methods

### Experimental material

The material for this study was collected in the period 1995 - 2013. This work is collaboration between the Department of Anatomy and Histology, Department of Forensic Medicine and Deontology from Sofia's Medical, and Institute of Microbiology, Bulgarian Academy of Sciences.

During routine dissection in the section hall of the Department of Anatomy and Histology we came across a very interesting variation of the additional plantaris originating from the soleus. The additional muscle belly of the plantaris (actually a tendon) merged with the tendon of the main belly and inserted into the tendo Achilles.

As a material for the present study were used left lower limb from human cadaveric materials. The material was taken during a routine autopsy from the Department of Anatomy and morphology, in accordance to the ethical principles applying by the Sofia's Medical University.

### Macroscopic observations

The unusual anatomical variation was photographed using a Nikon Coolpix 995 camera with a 3,34 Megapixels. We take some histological sections from the beginning of the additional muscle belly of the plantaris originating from the soleus. The fixation was carried out by glutaraldehyde and formaldehyde.

### Microscopic observations

Permanent histological preparations were obtained after appropriate procedures. They have been colored by Nissl's method. Light microscopy was performed.

Experimental muscle tissues were placed in a solution of 4% neutral formalin solution and after a stay of five days was proceed to dehydration of tissue debris in the ascending series of alcohols, followed by lightening in cedar oil. Samples were embedded in paraffin, and then serial sections were prepared with a thickness of 20 µm. A part of the serial paraffin sections, after installation on slides were stained by the classic Nissl's method. By staining adjacent sections were provided successively monitoring the structure of the muscles.

Sections were processed for light microscopic as follows:

1. Washing the cuts in xylene with increasing content of ethyl alcohol up to 96%.
2. Transfer of the sections for 3 minutes in a 0.5-1% solution of celloidin in equal parts of absolute ethanol and ether.
3. Placing the slices in a vertical position, so the redundant celoidine solution flows out of the slide glass, and then were transferred for 2 minutes in 80% alcohol, followed by treatment with 70% and 50% alcohol for 2 minutes each.
4. Finally, the sections were rinsed in distilled water and then placed horizontally in a bath of 2.5% feriamoniumsulfat for 18-24 hours.

## Results and discussion

The plantaris muscle belongs to the posterior superficial muscles of the calf. Normally its origin is from the inferior part of the lateral supracondylar line of the femur at a position a little superior to the origin of the lateral head of gastrocnemius. It usually is composed of a small fusiform belly and a long thin tendon. This tendon runs along the calf in lower medial direction alongside the medial border of the tendo Achilles and inserts into the posterior part of the calcaneus, separately or by merger with the tendo calcaneus. This variation of the additional plantaris originating from the soleus was observed in the lower limb from a cadaver (Figure 1 and Figure 2).

They are data showing some variations of the normal anatomy of plantaris in human, as well in American Bear. Small literature data concerning the variations of the plantaris were found in the literature. It has been suggested that the plantaris is a vestigial remnant of human's quadrupedal ancestry. It is believed that the muscle originally attached to the plantar aponeurosis as seen in the American Bear and that the distal attachment has migrated proximally with the onset of bipedalism. It

has been considered that the plantaris muscle was earlier attached to the plantar aponeurosis of the foot but with normal evolutionary process of erect posture, the insertion of the muscle got shifted to a higher position (Daseler et al., 1943). The plantaris muscle is known to exhibit variations. Standard textbook of anatomy has reported the fact, that the muscle may be sometimes absent or it may be double (Standring, 2005).

The double plantaris occurred in some cases. It is important to mention that in these cases there is an additional medial head beside the original lateral head. The additional medial head may arise proximally from the medial condyle of the femur (Kwintar et al., 2010) or may arise from the oblique popliteal ligament (Sharadkumar et al., 2012). It continues in a short tendon that fused distally with the tendon of the lateral plantaris muscle.

In our case we observed a variation which did not have any data in the literature. But the common in this unusual variation and variations described in the literature is the fact that irrespective of different variations, finally the plantaris has a common tendon that inserts into the posterior part of the calcaneus separately or by merger with the tendo Achilles.

The next step of our examinations was a histological analysis of the additional muscle belly which originates from the soleus. (Figure 3 and 4).

Moreover we did a histological examination of the additional muscle belly originating from the soleus. It is interesting to mention that the histological examination showed that the additional belly originates as a usual muscle structure with own fascial sheath and finally continues as a tendon like other muscles.

The motor function of the plantaris as whole is so minimal that its long tendon can readily be harvested for reconstruction elsewhere with little function. Although the plantaris does have little importance, there are injuries that can occur. It can be damaged in an tendon calcaneus rupture. But it has been a source of controversy in the literature (Mennen, 1983, Severance et al., 1983). Tennis leg is a commonly known injury (Delgado et al., 2002). It is a result of eccentric loading placed on the ankle while the knee is extended, and occurs while running or jumping. It may cause a direct trauma to the calf area. Pain and swelling are common in the injury. This pain usually becomes more severe after resting or the next day (Gecha et al., 1988). Accompanying the pain may be swelling that may

extend down to the ankle and foot. Any attempt at active or passive dorsiflexion, and resisted plantarflexion with elicit severe pain (Gecha et al., 1988, Toulipolous et al., 1999).

To diagnose tennis leg a physical examination is used first. Palpation of the muscle belly is possible in the popliteal fossa as well as along the medial aspect of the common tendon of the triceps surae group. With the patient prone and the leg flexed to approximately 90 degrees, the distal hand of the practitioner covers the heel while the forearm is applied against the plantar aspect of the foot, allowing a simultaneous resistance to plantarflexion of the foot and flexion of the knee. The muscle is palpated in the popliteal fossa, medial and superior to the lateral head of the gastrocnemius muscle. Its tendinous portion can be palpated along the medial aspect of the Achilles tendon into its calcaneal insertion (Tixa, 2003). Sonography is a reliable method to diagnose and stage tears involving the myotendinous junction of the medial gastrocnemius and plantaris muscles ("tennis leg") (Bianchi et al., 1998, Delgado et al., 2002). It is sometimes removed to treat its inflammation.

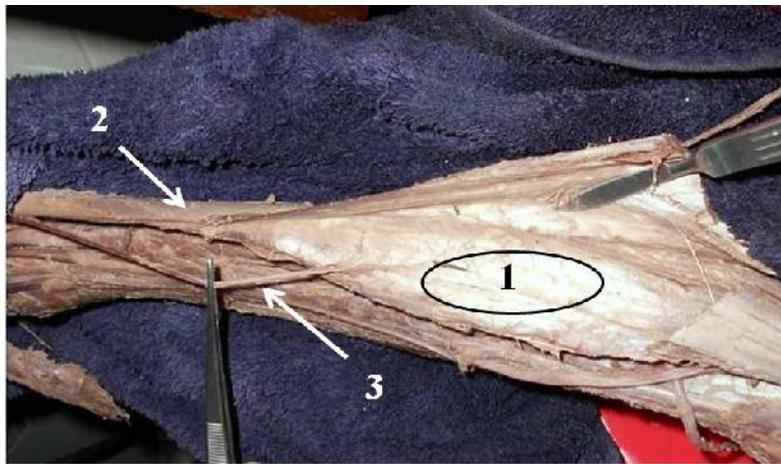
Often dismissed as a small, vestigial muscle, injury of the plantaris muscle should actually be included in differential considerations of the painful calf. Injury to the plantaris muscle may occur at the myotendinous junction with or without an associated hematoma, or partial tear of the medial head of the gastrocnemius or soleus (Andreo, 2007).

However, the presence of variations should remind physicians that this unpredictable anatomy requires careful examination in cases of unexplained lower leg pain. Irrespective of the normal histology of the additional belly the question arises whether a lifetime the man had a pain in lower leg. Clinically, the plantaris muscle is primarily of concern in the differential diagnosis of lower extremity pain as its rupture is indistinguishable from deep vein thrombosis without the assistance of high resolution ultrasound or MRI (Lopez et al., 2009). As is seen sonography is a reliable, accessible, and relatively inexpensive diagnostic modality for musculoskeletal imaging (Torriani et al., 2003).

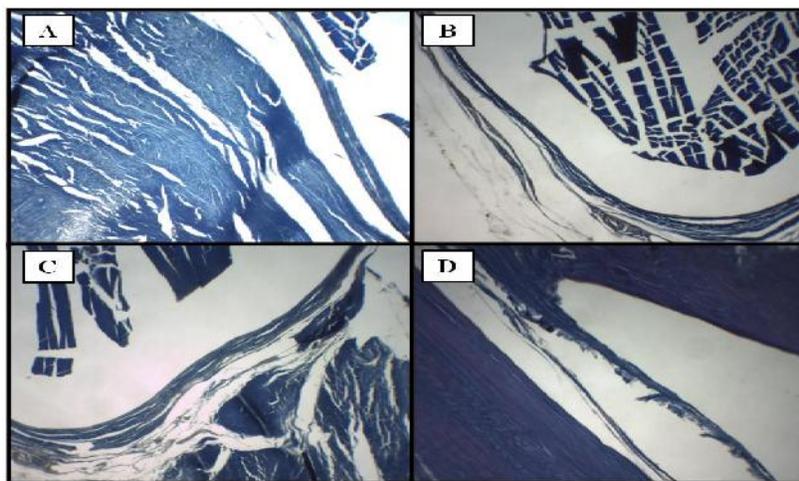
The plantaris is mainly used by surgeons for tendon grafts needed in other areas of the body. Topographical anatomy of the plantaris muscle is important for any surgery. In the presence of other flexors like gastrocnemius and soleus muscles, the removal of



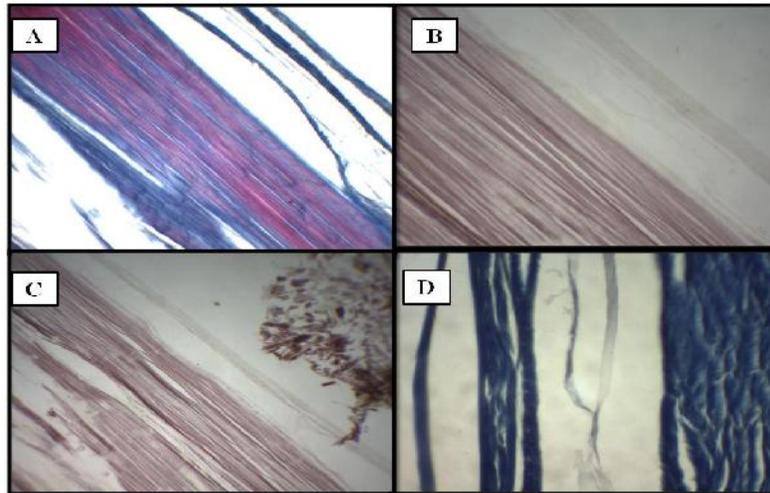
**Figure 1.** The origin of the main belly of plantaris was beginning from the inferior part of the lateral supracondylar line a little superior to the origin of the lateral head of gastrocnemius. The medial head of gastrocnemius was cut.



**Figure 2.** The long tendon of the main belly merges with the additional belly (actually a tendon) originating from the soleus. The substitution with the merger is caught with the upper tweezers.



**Figure 3.** **A.** Two tendons merged into a long tendon runs along the calf in lower medial direction alongside the medial border of the tendo Achilles. **B.** The beginning of the additional belly – a classic view of a striated muscle tissue. **C.** In a transverse section is visible, that the additional muscle belly has own fascial sheath. **D.** This own fascial sheath separates the additional belly of the plantaris from the soleus. Staining by AZAN;  $\times 100$ .



**Figure 4.** **A.** In a longitudinal section, the own fascial sheath covered the additional muscle belly is clearly visible. **B.** The fibers of the additional muscle belly are arranged parallel to one another and form a fusiform belly. **C.** The parallel arranged muscle fibers and a fascial sheath. **D.** The beginning of a musculotendinous connection (which is slightly torn). Staining by silver impregnation; – 150.

plantaris muscle may not have an effect on the normal limb function. The tendon of the plantaris muscle is considered as an extremely tensile structure and has been used successfully for flexor tendon replacement in hand and even for atrioventricular valve repair (Shuhaiber et al., 2003).

In conclusion, the presence of an additional plantaris muscle originating from the soleus as seen in this case may be of academic interest as the standard text book. It is very important to consider that the histological examination showed that the additional belly originates as a usual muscle structure has own fascial sheath and continues as a tendon like other muscles. This fact suggests that if in his lifetime the man with above described variation had an unexplained pain in calf it can be explained with the presence of the additional muscle belly. Maybe an unexplained pain in lower leg in some patients is due to the existence of a double plantaris muscle or the existence of an additional tendon originating from the soleus. It may also be of surgical interest to surgeons and clinical interest to clinicians diagnosing muscle tears in the leg. The existence of an additional tendon originating from the soleus as in our case could be important for anatomists, and orthopedic surgeons.

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