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CASE REPORT

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Very rare arrangement of the pes anserinus: potential clinical significance

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The pes anserinus superficialis is composed of the semitendinosus, gracilis and sartorius tendons. Normally, they all insert to the medial side of the tibial tuberosity, and the first two are attached superiorly and medially to the tendon of the sartorius muscle. During anatomical dissection, a new pattern of arrangement of tendons creating the pes anserinus was found. The pes anserinus comprised three tendons; the semitendinosus tendon was located superiorly to the gracilis tendon, and they both had distal attachments on the medial side of the tibial tuberosity. This seemed like the normal type, but the tendon of the sartorius muscle created an additional superficial layer, its proximal part lying just below the gracilis tendon and covering the semitendinosus tendon and a small part of the gracilis tendon. After crossing the semitendinosus tendon it is attached to the crural fascia significantly below the tibial tuberosity. Good knowledge of the morphological variations of the pes anserinus superficialis is necessary during surgical procedures in the knee region, especially anterior ligament reconstruction.
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Keywords: pes anserinus, superficialis, semitendinosus, gracilis, sartorius, autograft, anterior cruciate ligament reconstruction, hamstring tendon graft, patellar tendon graft

INTRODUCTION

The pes anserinus comprises two parts, the pes anserinus superficialis (PAS) and the pes anserinus profundus. The PAS is created by tendons of the sartorius (ST), gracilis (GT), and semitendinosus (STT) muscles. Normally, the STT and GT are located inferiorly and medially to the ST, but they all have distal attachments on the medial side of the tibial tuberosity [12].

The main function of the muscles constituting the PAS is flexion and external rotation of the knee joint. Moreover, this structure is responsible for stabilizing the knee, especially during rotatory movements [10].

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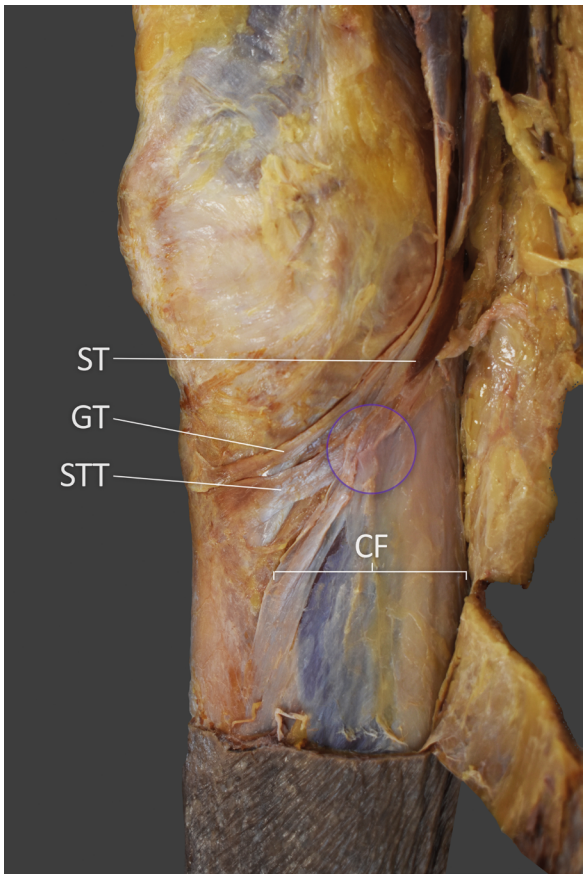

Figure 1. A very rare case of the sartorius muscle; ST — sartorius tendon; GT — gracilis tendon; STT — semitendinous tendon; CF — crural fascia (deep fascia of the leg). The purple circle indicate connection between the ST and CF.

The PAS shows several morphological variations. The literature contains descriptions of PASs with one or two accessory bands from the STT, or one accessory band from the GT, or one accessory band from the ST, in different combinations. The shape and location of insertion of the PAS can also vary [12].

The PAS can be used as a graft during reconstruction of the anterior cruciate ligament (ACL) [3]. Good knowledge of its morphological characteristics and variability is therefore useful during this procedure [12]. The tibial tuberosity helps to locate the PAS clearly [11]. However, the accessory tendons seem to be a major problem during operations [11].

During anatomical dissection a new pattern of arrangement of tendons constituting the PAS was found. This PAS comprised three tendons; the GT was located superiorly to the STT and the distal attachments of both were located on the medial side of the tibial tuberosity. This seemed like the normal arrangement, but the sartorius muscle tendon created an additional superficial layer in its proximal part, just below the GT and covering the STT and small part of the GT. After crossing the STT, the ST was distally attached to the crural fascia significantly below the tibial tuberosity.

CASE REPORT

An 83-year-old female cadaver was dissected routinely for research and teaching purposes at the Department of Anatomical Dissection and Donation, Medical University of Lodz, Poland. The right lower limb was subjected to traditional anatomical dissection [11, 12] and a morphological variant of the PAS was found. The proximal course of the sartorius, semitendinosus, and gracilis muscles was normal. The sartorius originated from the anterior superior iliac spine, the gracilis from the pubis and ischium, and the semitendinosus from the ischial tuberosity. The interesting morphological variation was in their distal attachment (pes anserinus).

The ST created a superficial layer of which the proximal part was located just below the GT and covering the STT and a small part of the GT. The myotendinous junction of the sartorius was 5.32 mm wide and 0.43 mm thick. The ST was 79.92 mm long. After crossing the STT, the ST was distally attached to the crural fascia significantly below tibial tuberosity. At the point of the insertion it was 3.47 mm wide and 0.23 mm thick.

The GT was attached, as normal, to the medial part of the tibial tuberosity. At this point the tendon was 6.13 mm wide and 0.52 mm thick. The STT was attached to the same location, but just below the insertion of the GT, and it was covered by the ST. In its distal attachment the STT was 9.12 mm wide and 0.81 mm thick (Fig. 1).

An electronic calliper (Mitutoyo Corporation, Kawasaki-shi, Kanagawa, Japan) was used for these measurements. Each measurement was repeated twice with an accuracy of up to 0.1 mm.

No other morphological variabilities were found during dissection of the lower limb. Table 1 shows the morphometric measurements.

DISCUSSION

The PAS shows several morphological variations. Normally, it is composed of three tendons: the ST (which is located laterally and superiorly to the rest), the GT (inserting medially to the ST and superiorly to the STT), and the STT (the element of the PAS located

Table 1. Morphometric measurements

	Sartorius tendon	Gracilis tendon	Semitendinosus tendon
INSERTION	Crural fascia	Medial part of the TT	Medial part of the TT
WIDTH (DA)	3.47 mm	6.13 mm	9.12 mm
THICKNESS (DA)	0.23 mm	0.52 mm	0.81 mm

DA — distal attachment; TT — tibial tuberosity

most inferiorly). However, this arrangement can vary among the population [12].

Olewnik et al. [12] distinguished six types of PAS on the basis of the distribution of tendons. The first type showed the standard arrangement and occurred in 52.9%. In the second type the ST and GT were normal and one additional tendon arose from the STT. The frequency of this type was 31.4%. The third type (8.8%) had normal ST and GT with two accessory tendons from the STT. There was also a PAS with normal ST, one additional tendon from the GT and two from the STT, but this variation was the rarest (1% of the studied population). Another type (2% of studied population) had normal ST and GT, but one additional tendon from the STT. The final type, with frequency 3.9%, had one additional tendinous structure arising from both the GT and the ST, and two accessory tendons from the STT [12].

Olewnik et al. [12] also analysed the shape and insertion of the PAS and distinguished three types. In the first, the PAS had a short tendinous extension of the elongated muscle belly. In the second, called 'band-shaped', there was a distal attachment less than twice as wide as the tendon above. The last type, 'fan-shaped', had an insertion at least twice as wide as the tendon above [12].

There are alternative accounts of PAS variations. For example, there was an interesting case [11] with a normal PAS inserted to the tibia but an accessory slip arising from the STT. This structure was divided into two small tendons, the first attached to the tibia and the second to the fascia of the soleus muscle [2]. Rivizi et al. [13] found a case with an additional attachment of the STT and GT to the crural fascia. La Prade et al. [8] found a PAS divided into two layers; the ST was located superficially to the deep layer created by both the GT and the STT. A similar type was described by Lee et al. [9].

Snoeck et al. [14] carried out a study about GT and STT paratenons and other surrounding fascial connections. What is interesting GT and STT expansions were connected with the crural fascia in 100% of studied lower limbs. Moreover, these expansions were the edges of the paratenon tunnel. GT and STT paratenons were attached to the sartorius fascia, to the semimembranosus and the fascia lata. GT and STT are surrounded by a fascial structure whose edges diverge from the direction of the tendon to overlap. After that they are attached to the crural fascia [14].

The present case describes the new PAS variant. Although there were no additional tendons, the structures were arranged totally differently from those described earlier. The distal attachment of the ST had long tendon, the proximal part of the first layer being located just below the GT and covering the STT and a small part of the GT. After crossing the STT it inserted to the crural fascia, significantly below the GT and STT insertion. Normally, the ST attaches to the tibia, superiorly and medially to the other structures constituting the PAS.

Good knowledge of such morphological variations can be useful during surgery in the knee region, especially when the PAS is used for autografts [12]. The ST and GT are commonly grafted not only for the reconstructing the ACL, but also for the posterior cruciate, medial patellofemoral, and fibular collateral ligaments [12], medial knee reinforcement, and reconstruction of the patellar retinaculum (after patellar subluxation) [1]. Moreover, if the patellar tendon ruptures, these two tendons can also be used to repair the injury.

Patients after such a procedure report decreased anterior knee pain and better stabilization [4]. Recovery after a hamstring tendon graft (using STT and GT) is faster than after a bone-patellar tendon-bone graft [2]. However, the method seems more difficult because accessory tendons of the SM, the GT, or the STT, and morphological variations of their arrangement, are all common [12].

The present case, which has not been described previously, exemplifies this point. Even the latest classification created by Olewnik et al. [12] did not include a similar type of PAS. An interesting course of the ST (superficial layer with distal attachment to the

crural fascia) could cause confusion among surgeons or orthopedists during operations, increasing the operation time and making side effects more likely.

When there are such variants, most of the ST should be removed before the GT harvest. Only then is it possible to use GT and STT grafts during, for example, ACL reconstruction. There is also another option, which seems easier and could facilitate this procedure. In the present case, only the ST (rather than the GT) and STT should be used for reconstructing some knee ligaments. This method avoids the additional step or removing the ST, potentially shortening the duration of surgery.

Interestingly, the PAS regenerates after harvesting, though with altered anatomical and histological features that are not normally clinically visible [3]. Although the PAS is regenerated and normalized on magnetic resonance imaging images, histological examination reveals an irregular course of collagen fibres, increased angiogenesis, and proliferation of fibroblasts. This could explain why the PAS is more susceptible to injury after it is used for ACL reconstruction [3]. However, it is important to remember that the PAS will not regenerate in some cases; this is one of the disadvantages or risks of such a procedure [7].

CONCLUSIONS

The PAS is morphologically variable, and various types have already been classified. However, the present case shows a totally new and undescribed type of the PAS arrangement. Good knowledge of the morphological variations of this structure is useful during surgical procedures, not only in ACL reconstruction, but also during reconstruction of the posterior cruciate, medial patellofemoral, or fibular collateral ligament.

Ethical approval and consent to participate

The study protocol was accepted by the Bioethics Committee of the Medical University of Lodz. The cadavers were the property of the Department of Anatomical Dissection and Donation, Medical University of Lodz. Informed consents were obtained from all participants before they died.

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Conflict of interest: None declared

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