Achilles tendinopathy: new insights in cause of pain, diagnosis and management

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Chapter 6

The plantaris tendon and a potential role in midportion Achilles tendinopathy: an observational anatomical study

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ABSTRACT

The source of pain and the background to the pain mechanisms associated with midportion Achilles tendinopathy have not yet been clarified. Intratendinous degenerative changes are most often addressed when present. However, it is questionable if degeneration of the tendon itself is the main cause of pain. Pain is often most prominent on the medial side, 2-7 cm from the insertion onto the calcaneus. The medial location of the pain has been explained to be caused by enhanced stress on the calcaneal tendon due to hyperpronation. However, on this medial side the plantaris tendon is also located. It has been postulated that the plantaris tendon might play a role in these medially located symptoms. To our knowledge, the exact anatomy and relationship between plantaris- and calcaneal tendon at the level of complaints have not been anatomically assessed. This was the purpose of our study. One-hundred and seven lower extremities were dissected. After opening the superficial fascia and paratendon, the plantaris tendon was bluntly released from the calcaneal tendon moving distally. Incidence of the plantaris tendon, its course, site of insertion and possible connections were documented. When with manual force the plantaris tendon could not be released, it was defined as a 'connection' with the calcaneal tendon. In all specimens a plantaris tendon was identified. Nine different sites of insertion were found, mostly medial and fan-shaped onto the calcaneus. In 11 specimens (10%) firm connections were found at the level of the calcaneal tendon midportion. Clinical and histological studies are needed to confirm the role of the plantaris tendon in midportion Achilles tendinopathy.

INTRODUCTION

Midportion Achilles tendinopathy is an entity that is generally difficult to treat. Peritendinous and intratendinous changes seem to co-exist in the majority of patients[29]. The source of pain and the background to the pain mechanisms associated with midportion Achilles tendinopathy have not yet been clarified[17]. Therefore, a wide range of conservative and surgical treatments is available, addressing different possible contributing properties of the tendon and its surrounding tissues. Why surgery promotes healing of the Achilles tendon is still not understood[22]. Intratendinous degenerative changes are most often addressed when present. However, it is questionable if degeneration of the tendon itself is the main cause of pain, since intratendinous changes are found in up to 34% of people *without* complaints[8,12,14,15]. Recently a long-term follow-up study was published revealing persistent structural abnormalities and thickening of the tendon 13 years after intra-tendon surgery for midportion Achilles tendinopathy, whereas all patients were satisfied with the results and went back to calcaneal tendon loading activities without restrictions[1].

Pain is the main symptom that leads a patient to seek medical help. It is often most prominent at 2-7 cm from the insertion onto the calcaneus on the medial side[26]. Most ultrasonographic midportion disorders (91-100%) are found in this medial segment of the tendon[7,10]. It has been proposed that the medial pain is caused by enhanced stress on the calcaneal tendon due to hyperpronation. However, on this medial side the plantaris tendon is also located. It is enclosed in a paratendon collectively with the calcaneal tendon. Steenstra and co-workers described that during Achilles tendoscopy for patients with symptomatic Achilles tendinopathy, the plantaris tendon was fixed to the Achilles tendon at the level of complaints. Where in a normal situation the plantaris tendon can glide in relation to the Achilles tendon, it was postulated that the plantaris tendon plays a role in these medially located symptoms[28].

To our knowledge, the exact anatomy and relationship between the anatomical structures at the level of midportion calcaneal tendon complaints have not been assessed. This was the purpose of our study.

METHODS

Specimens

One hundred and seven lower extremities were obtained from donors. During their lives the donors signed informed consent for the use of their bodies for scientific or educational purposes. Twenty six were fresh-frozen (– 20^0) and thawed at room temperature for dissection. Eighty-one had been fixated in formalin. Sixty-two were male legs, 37 female and of 8 this information was not available. History was unknown. Mean age was 84 years (SD±9.3).

Fifty-three left (49.5%)-, and 54 (50.5%) right lower legs were dissected. Of 22 specimens both legs were available (n=44), 63 were unilateral.

Anatomical dissection

Dissection was done by two observers. A longitudinal incision though the skin and subcutaneous tissue was made from the condylus medialis femoris to the medial distal 1/3 of the calcaneus, after which it was lengthened perpendicularly to the lateral side of the calcaneus. After opening the superficial fascia and paratendon, the midportion of the calcaneal tendon was inspected. Distally the plantaris tendon was not always visible; when searched for proximally after bluntly releasing the fascia between the medial belly of the gastrocnemius muscle and the soleus muscle, it could always be identified. After this it was released by hand from the calcaneal tendon moving distally (Figure 1).

When with maximum manual pulling force the plantaris tendon could not be released from the calcaneal tendon, it was defined as an attachment to the calcaneal tendon. Location of the attachment in relation to the insertion of the calcaneal tendon was measured with a millimetre precise ruler.

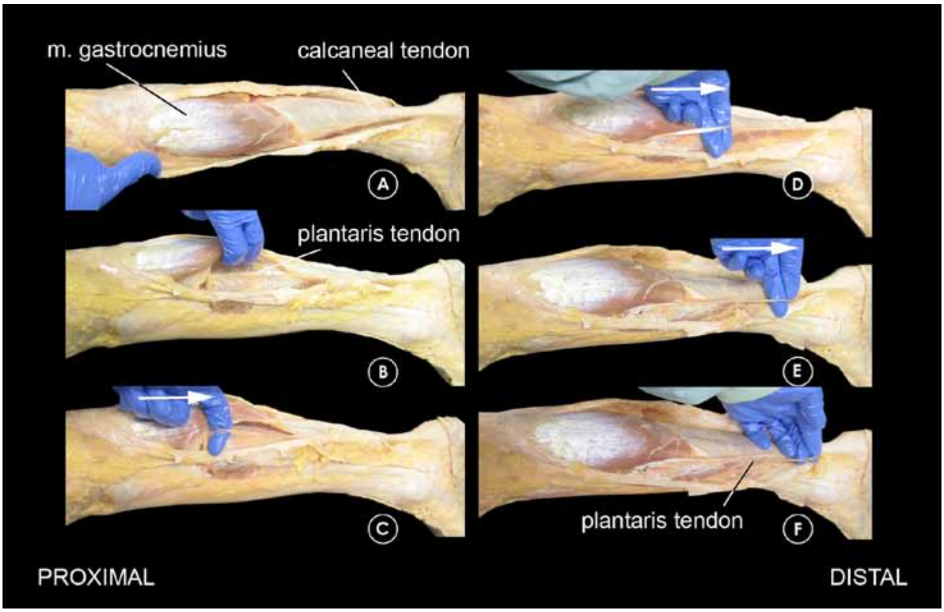

Figure 1. Technique of identification of plantaris tendon **(A)** The skin, subcutaneous layers, superficial fascia and paratendon are dissected. **(B)** The plantaris tendon is identified proximally between the medial head of the gastrocnemius muscle and the soleus muscle. **(C,D,E,F)** With the index finger, the tendon is released to its distal insertion. Then the insertion is carefully exposed

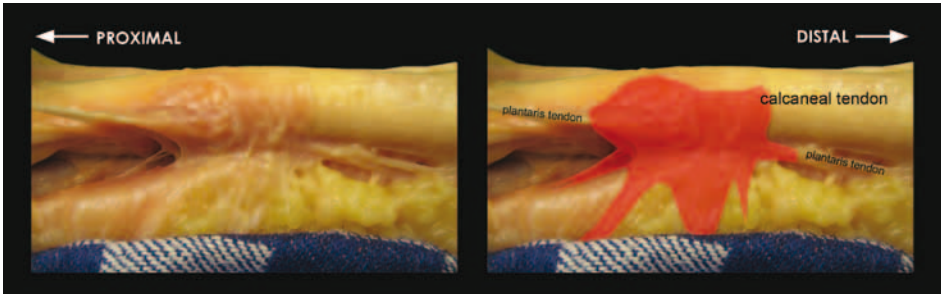

Figure 2. A firm attachment between the calcaneal - and plantaris tendons at the midportion level of the Achilles tendon. This type was named 'retinaculum-like'

The calcaneal tendon, incidence of the plantaris tendon, their relationships and the site of the midportion calcaneal tendon and of the insertion of the plantaris tendon onto the calcaneus were documented.

RESULTS

One- hundred and seven lower legs were dissected.

In 96 specimens the calcaneal tendon and plantaris tendon run separately and can glide in relation with each other. In the other 11 specimens we found a firm attachment of the plantaris tendon to the calcaneal tendon; in 6 of 26 fresh frozen specimens (23%), and in 5 of 81 formalin fixated specimens. In 3 specimens the plantaris- and calcaneal tendon were held together by a retinaculum- like structure, transversally constricting the calcaneal and plantaris tendon 32-88 millimetres (mm) proximal to the insertion (Figure 2); in 3 specimens the plantaris tendon inserted on the midportion of the calcaneal tendon at 20- 65 mm proximal to the calcaneal insertion of the calcaneal tendon; two inserted into the deep fascia; 2 adhered onto the anteromedial- and one onto the anterior side of the calcaneal tendon by cords of solid tissue but inserted into the calcaneus. The macroscopic image of a retinaculum-like structure made us consider this as being prone to pathology (Figure 2). Four of 11 attachments were in legs of which the other side was also available; however, none of the connections were bilateral.

In all specimens a plantaris tendon was identified (100%).

We found 9 different sites of insertion of the plantaris tendon, which are described and depicted in figure 3. In only 14% of 22 paired legs (3 pairs) site of insertion on the left leg was identical to that of the right.

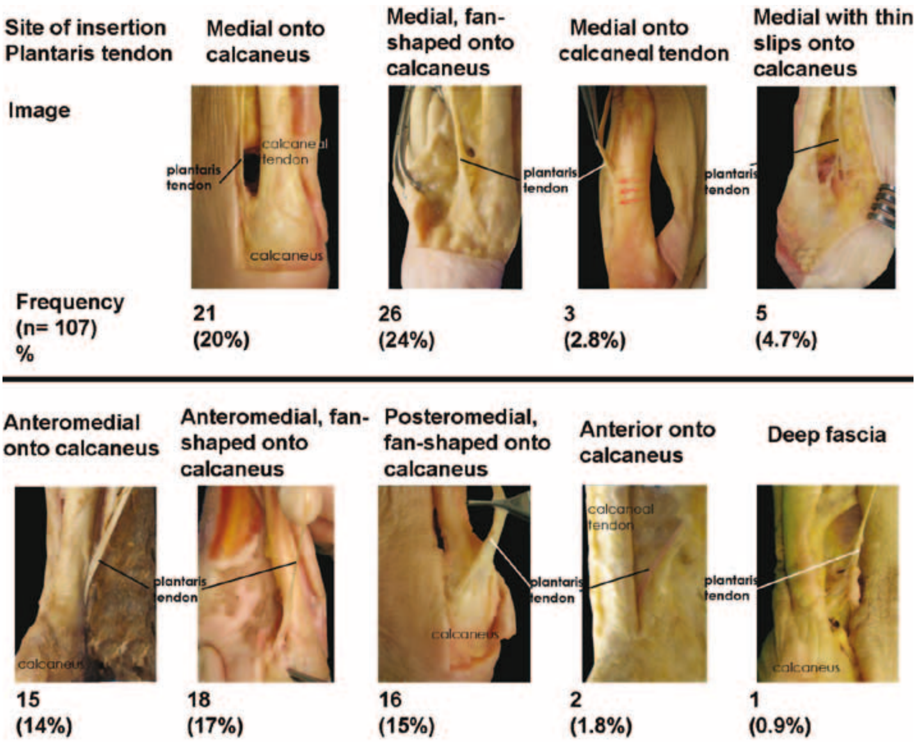

Figure 3. Sites of insertion of the plantaris tendon

DISCUSSION

In 11 specimens a firm connection between calcaneal - and plantaris tendon was found, at the level of the midportion of the calcaneal tendon. This corresponds to the level at which complaints in patients with midportion Achilles tendinopathy are present. In 3 other specimens (2.8%) the plantaris tendon inserted into the calcaneal tendon. This variance has been described before[6]. On the contrary, the firm connections (10%) between the plantaris- and calcaneal tendon have not been described before. We however found connections in 10% of our specimens. How then can we explain these findings? One way could be that these connections are congenital or an anatomical variation. Another explanation could be that these connections have developed later in life. We do not have a history of our specimens and thus we do not know whether they were symptomatic or not. Degenerative changes in the calcaneal tendon have been found in up to 34% of subjects without complaints[1,8,12,14,15]. If peritendinous adhesions occur secondary to intratendinous changes, this can offer an explanation for the connections and adhesions that we found. Development later on in life seems to be the most likely explanation of this high percentage of a firm connection between the plantaris- and calcaneal tendon at the midportion level.

Now could these connections between calcaneal-and plantaris tendon explain the medial pain in midportion Achilles tendinopathy? We aimed to theorize this by applying anatomical and pathophysiological evidence.

The calcaneal tendon consists of the fibers of two muscle units in the superficial compartment of the posterior leg: the gastrocnemius muscle (medial and lateral head) and the soleus muscle. The gastrocnemius muscle crosses the knee and ankle joints (ankle and subtalar); originating from the posterior surface of condylus medialis and -lateralis femoris and inserting onto the calcaneus. The soleus muscle lies anterior to the gastrocnemius muscle and originates from each side of the anterior aponeurosis attached to the tibia and fibula, and from the posterior surfaces of the head of the fibula and its proximal quarter, as well as the middle third of the medial border of the tibia. The soleus muscle only crosses the 2 ankle joints. Distally, both the gastrocnemius and soleus muscles form an aponeurosis, from each of which a tendon originates. At about the level where the soleus contributes fibers to the calcaneal tendon, rotation of the tendon begins and becomes more marked in the distal 5-6 cm. The gastrocnemius fibers rotate to lateral and the soleus fibers are positioned medial to the insertion[20]. This anatomical observation means that the medial portion of the calcaneal tendon, where pain is often most prominent, is bi-articular since it consists of fibers originating from the soleus muscle (Figure 4). The calcaneal tendon is involved in plantarflexion, whereas according to its anatomical course, the tri-articular plantaris tendon also contributes

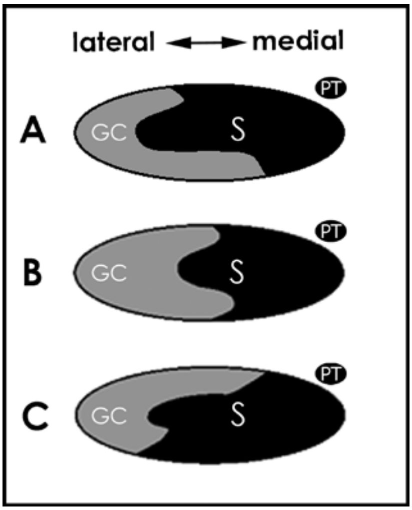

Figure 4. Degree of rotation and position of the gastrocnemius-soleus complex at the midportion of the calcaneal tendon. (GC= gastrocnemius; S= soleus.) The most common (52%) position is depicted in **(A)**, **(B)** occurs in 35%, and **(C)** in 13%. In all situations, the soleus fibres are positioned medially. The location of the plantaris tendon is shown (PT) (Illustration as adapted from Cummins and co-workers[4])

to ankle inversion. These opposite forces result in an intermittent small change of position between calcaneal - and plantaris tendon which occurs with every step.

Unlike other tendons in the leg, the Achilles tendon lacks a synovial sheath. Instead, it has a paratendon, which is an array of thin, fibrous tissue containing blood vessels[23]. In patients with symptomatic Achilles tendinopathy, enhanced neurovascular growth from the paratendon into the calcaneal tendon in an attempt to repair the tendon proper is seen. Also myofibroblasts responsible for the formation of permanent scarring and the shrinkage of peritendinous tissue have been shown. The plantaris tendon runs with the calcaneal tendon inside a collective paratendon. With the development of scarring and shrinkage of peritendinous tissue, the calcaneal - and plantaris tendon will adhere. The opposite movements between plantaris- and calcaneal tendon will result in traction to the firm peritendinous tissue that connects both tendons and the level of the tendinopathy. This tissue has recently been described to be richly innervated by neonerves which may be involved in causing pain[2,24]. Pain then aggravates with movement, given the fact that the traction forces occur with every step with an average of 5,000 - 12,500 steps/ day[30,31].

There are 2 drawbacks to our study. Histological examination would have provided us with more information on the nature of the connections, and is necessary to gain more relevant data for conclusions concerning a potential role in midportion Achilles tendinopathy. Another drawback is the fact that age and former lifestyle of our specimens did not match with the group of active 30 to 50 year-olds in which midportion Achilles tendinopathy most often occurs.

The consequences of formalin fixation are yet unknown. It may alter the properties of soft tissue structures, making blunt division of calcaneal- and plantaris tendons easier, consequently missing possible connections. We found 23% of connections in fresh-frozen but only 6% in formalin- fixated specimens. Larger numbers of specimens may be needed to substantiate this finding. Dissection of exclusively fresh frozen specimens might have been beneficial since this may be the closest we can get to *in vivo* tissue texture.

A strinking finding was that, as opposed to the widely accepted rule that in a large sample of patients a number of plantaris muscles/tendons is missing, in *all our 107 specimens* a plantaris tendon was identified. According to previous anatomical studies with large numbers of specimens, the plantaris tendon is absent in a number of cases (7-20%)[5,6,9,11,19,25]. Daseler found in 542 pairs of legs that in 9 the right plantaris tendon was absent, and in 21 the left. Moreover, in 31 *pairs* the plantaris muscle could not be identified. Harvey and co-workers noted the absence of plantaris in 18.2% of 658 lower limb dissections[13].

These earlier findings of absence in anatomical studies could be attributable to the technique of dissection. In our 5 cases where the tendon inserted into the calcaneal tendon, anterior to the tendon on the calcaneus and in the crural fascia (4.6%), the plantaris tendon could not be identified distally (Figure 3). We started our dissection between the gastrocnemius and soleus muscles (Figure 1), and identified a plantaris tendon in all our specimens. Unfortunately only two studies specified their dissection techniques. Freeman and co-workers (13% absence) specifically aim for the muscle belly dissecting the proximal dorsal compartment of the lower leg; Harvey (18.2% absence) mentions not dissecting the lower legs all the way to proximal[13]. With our relatively large group of specimens, we not only contradict earlier findings of its absence, but also raise implications for daily practise. The plantaris tendon is often used for grafting because it can be sacrificed without markable deficit, and is of adequate length and thickness for most applications[3,16,18,27]. It is often excised from distally. In this case it will be missed in a substantial number of cases. We advise to retrieve it more proximally (e.g. with a tendon stripper). Using ultrasound- or MR- imaging prior to surgery to pre-assess its course may be helpful.

Another discrepancy with the existing knowledge was the mid-course of the plantaris tendon in the posterior compartment of the lower leg.

According to Sobotta Anatomy[21], the plantaris tendon instantly crosses the posterior side of the calf, to run medial with the calcaneal tendon until its insertion (Figure 5). In our observations the plantaris tendon along its course gradually crosses the calf between the gastrocnemius and the soleus muscle.

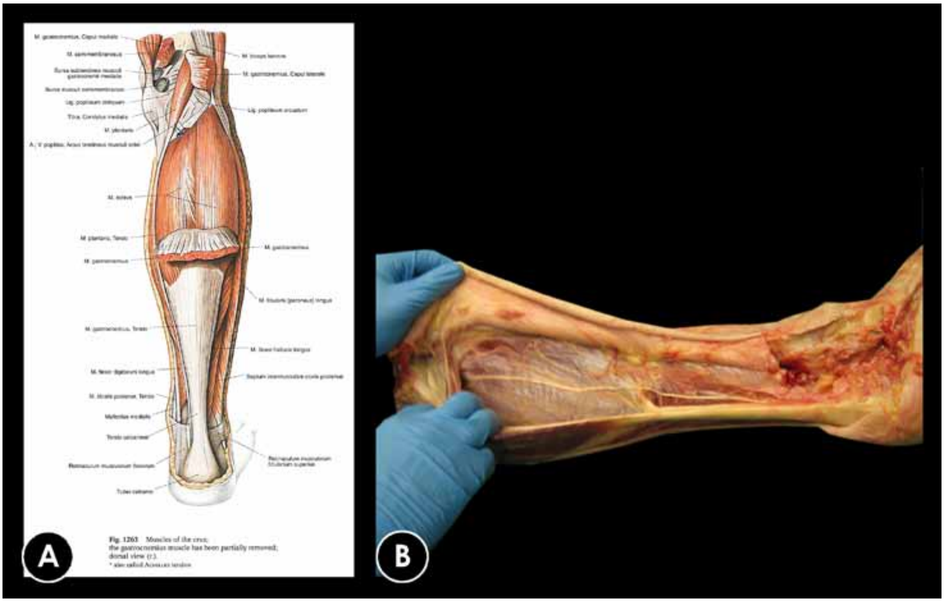

Figure 5. (A) Anatomical course of the plantaris tendon according to Sobotta Anatomy; **(B)** course found during 107 dissections

With this study we can theorize but not confirm that the plantaris tendon plays a role in complaints in patients with midportion Achilles tendinopathy. However, we do know more about the course and insertion of the plantaris tendon. Interesting and unexpected findings were the firm connections between plantaris- and calcaneal tendon at the level of in midportion of the calcaneal tendon in 10% of specimens. Clinical studies on the outcome of surgically removing plantaris tendons and thereby severing adhesions and accompanying enhanced neurovascular growth from the paratendon at the medial side of the calcaneal tendon may provide us with more evidence on the relation between the plantaris tendon and symptomatic midportion Achilles tendinopathy.

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