The anatomical footprint of the Achilles tendon

A CADAVERIC STUDY

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We dissected 12 fresh-frozen leg specimens to identify the insertional footprint of each fascicle of the Achilles tendon on the calcaneum in relation to their corresponding muscles. A further ten embalmed specimens were examined to confirm an observation on the retrocalcaneal bursa. The superficial part of the insertion of the Achilles tendon is represented by fascicles from the medial head of the gastrocnemius muscle, which is inserted over the entire width of the inferior facet of the calcaneal tuberosity. In three specimens this insertion was in continuity with the plantar fascia in the form of periosteum. The deep part of the insertion of the Achilles tendon is made of fascicles from the soleus tendon, which insert on the medial aspect of the middle facet of the calcaneal tuberosity, while the fascicles of the lateral head of the gastrocnemius tendon insert on the lateral aspect of the middle facet of the calcaneal tuberosity. A bicameral retrocalcaneal bursa was present in 15 of the 22 examined specimens.

This new observation and description of the insertional footprint of the Achilles tendon and the retrocalcaneal bursa may allow a better understanding of the function of each muscular part of the gastrosoleus complex. This may have clinical relevance in the treatment of Achilles tendinopathies.

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The Achilles tendon is the largest in the body, made of the confluence of the medial and lateral heads of the gastrocnemius and soleus muscles. The tendon of the plantaris muscle, which forms part of the Achilles tendon, is found in only 65% of the population. As the Achilles tendon courses from proximal to distal, the fibres rotate, making the medial side more superficial or posterior and the lateral side deep or anterior towards its insertion on the calcaneum. In an anatomical study, Szaro et al described the fascicles of the human Achilles tendon in detail.

As a single structure, the insertion of the Achilles tendon on the calcaneum has been described previously, but to the best of our knowledge the insertional footprint of the different tendon fascicles has not been described. The aim of this cadaveric investigation was to identify this footprint in an anatomical study.

Materials and Methods

The study was conducted at a university hospital’s mortuary using 12 fresh-frozen leg specimens. Some additional observations were made from ten embalmed leg specimens at the anatomy department of the local university. The embalming fluid used to perfuse and fix the cadavers was a mixture of formaldehyde, methanol, phenol and water. The frozen specimens were thawed overnight before the dissection and there were four right and eight left legs from five men and seven women, with a mean age at death of 75.4 years (59 to 92). The ages and genders were unknown for the embalmed specimens, but there were four right and six left legs used.

In order to identify the footprint of the Achilles tendon in the fresh-frozen specimens, the triceps surae muscle was identified, elevated from its origin en masse and reflected distally after dissecting the anterior fat pad of Kager from the anterior surface of the Achilles tendon. Before the different fascicles were separated, the remaining fat pad was removed in order to examine the retrocalcaneal bursal side of the tendon (Fig. 1). Then using the layer-by-layer dissection technique described by Szaro et al, the different fascicles of the tendon were identified. Viewed with 3.5 x magnification loops and using a scalpel and forceps, the different fascicles were separated, starting proximally between the two heads of the gastrocnemius and identifying the tendons of the medial and lateral heads (Fig. 2).
tendon of the soleus muscle was then identified on the anterior aspect of the Achilles tendon and was separated from the gastrocnemius fascicles. Once the three main fascicles (medial head, lateral head and soleus) (Fig. 3) were identified, their insertional footprint on the calcaneum was dissected. The fascicles of the medial head were sharply dissected, first from its insertion, as they lay more superficial to the other fascicles, and its footprint was documented (Fig. 4a). The origin of the plantar fascia on the plantar aspect of the calcaneum was identified. The fascicle of the tendon of the medial head of the gastrocnemius was elevated, with periosteum when possible, and followed distally to see if it was in continuity with the plantar fascia (Fig. 4b). The insertion of the lateral head of gastrocnemius tendon fascicle was sharply dissected from its insertion and chased distally, followed by the soleus muscle tendon fascicle.

The insertion of the fascicles on to the calcaneum and their footprints were documented (Fig. 5). The attachment of each of these fascicles onto the posterior surface of the calcaneum was described in relation to the different facets of the calcaneal tuberosity (superior, middle and inferior), as reported by Kachlik et al.8

The ten embalmed specimens had already been dissected by anatomy demonstrators for teaching purposes. In all, the Achilles tendon was still attached to the calcaneal tuberosity but the fat pad had been removed previously. In these specimens we only assessed the retrocalcaneal bursae for their chambers, but did not detach the Achilles tendon from its insertion.
Results

In nine of the 12 fresh-frozen specimens and six of the ten embalmed specimens, the retrocalcaneal bursa had two distinct chambers. A small shallow medial chamber and a larger and deep lateral chamber were found separated by a small septum (Fig. 1a). The medial chamber is located anterior to the fascicles of the tendon of the soleus, whereas the lateral chamber is located anterior to the fascicles of the tendon of the lateral head of the gastrocnemius. In the remaining three frozen specimens the four embalmed specimens, the bursa had a single chamber with a mean width of 22.7 mm (19 to 29).

In all the 12 dissected frozen specimens, the insertional footprint of the Achilles tendon was similar. It can be divided into superficial and deep parts. The fascicles of the tendon of the medial head of the gastrocnemius inserted into the inferior facet across the whole width of the calcaneal tuberosity. This forms the superficial part of the footprint. The mean width of the footprint was 28.3 mm (24 to 34) and the mean length was 7.8 mm (6 to 10) (Fig. 6). In three specimens the fascicles of the tendon of the medial head of the gastrocnemius were continuous with the
plantar fascia via the periostium (Fig. 4b). These findings were in the two youngest cadavers (59 and 66 years of age) and from a 79-year-old cadaver. In the other nine frozen specimens, the periosteum was too friable to be dissected to demonstrate any continuity.

The deep part of the footprint is made by the fascicles of the tendons of the lateral heads of the gastrocnemius and soleus. The footprint of fascicles of the lateral head of the gastrocnemius was on the lateral part of the middle facet in all specimens. This footprint as shown in Figure 6 had a wide base, formed by the ridge separating the middle and inferior facets distally, with an apex proximally. The mean width of the base was 14.4 mm (12 to 19) and its mean height was 10 mm (7 to 12). The insertional footprint of the fascicles of soleus was in the medial part of the middle facet. It also had a wide base formed by the ridge separating the middle and inferior facets distally, and had an apex proximally. The mean width of the base was 18.2 mm (15 to 28) and the mean height was 15 mm (13 to 17) (Fig. 6).

Discussion

The Achilles tendon rotates as it courses distally, so that those fascicles arising from the medial head of the gastrocnemius form the posterior aspect of the tendon while the anterior part is formed by the fascicles of the tendons of the lateral head of the gastrocnemius and soleus muscles. Some variations in this arrangement have been described by Smigielski. He reported the anterior part of the tendon being formed by the fascicles from the tendon of the lateral head of the gastrocnemius, whereas the posterior part was formed by the fascicles of the medial head; the fascicles from the soleus muscle tendon lay between the fascicles of the gastrocnemius muscle. Szaro et al showed that the deep part of the tendon was formed by fascicles from both the lateral head and the soleus, while the superficial part of the tendon was formed by fascicles from the medial head of the gastrocnemius as well as the soleus. Our findings follow the distinctive pattern of the footprint of the fascicles of the three different tendons in all the frozen specimens makes it most likely that our description is accurate.

Previous studies have suggested that the Achilles tendon inserts into both the middle and the inferior facets of the calcaneal tuberosity. Other authors have suggested that the main insertion of the tendon is at the border which separates the middle and the inferior facets. Our study confirms that both middle and inferior facets are areas of attachment of the tendon. No study has described the different arrangement of the attachment of the tendon fascicles into these facets. We have demonstrated that the middle facet serves as the attachment for the fascicles of the tendons of both the soleus and of the lateral head of the gastrocnemius. The inferior facet serves as the insertion of the fascicles of the tendon of the medial head of the gastrocnemius (Fig. 6).

The relationship between the Achilles tendon and the plantar fascia has been reported before. Previous studies have revealed a partial continuity between the Achilles tendon and the plantar fascia. Kim et al and Snow et al both reported this observation, which was seen mainly in young specimens. Kim et al studied 60 human lower extremities and found that in 8% of the specimens there was a partially contiguous relationship between the plantar fascia and the Achilles tendon. Snow et al demonstrated in their anatomical study that as the foot ages, the number of fibres connecting the plantar fascia and the Achilles tendon appears to diminish. In the neonatal foot, they found a continuation of thick fibres, whereas the middle-aged foot had superficial periosteal fibres only connecting the tendon and fascia. They also demonstrated an insertion of fibres of the tendon and the fascia into the calcaneum, with the periosteum in between in elderly feet. Our finding that the footprint of fascicles of the tendon of the medial head of the gastrocnemius forms the superficial part of the Achilles tendon and is located over the width of the calcaneal tuberosity, suggests that this is the part of the tendon that has continuity with the plantar fascia, whereas fascicles from the lateral head of the gastrocnemius and soleus muscles have no continuity with the plantar fascia. We found true continuity in only three specimens, two of which were from the youngest donors. This might offer an anatomical basis for the early promising results of release of the medial head of the gastrocnemius for plantar fasciitis in patients with tightness of the gastrocnemius, which is clinically assessed by the Silfverskiöld test.

A bicameral retrocalcaneal bursa was present in 15 of the 22 specimens. Generally the soleus tendon formed the posterior wall of the smaller medial chamber, while the tendon of the lateral head of the gastrocnemius formed the posterior wall of the larger lateral chamber. The presence of two chambers in this bursa should be taken into account when debriding it arthroscopically in patients with recalcitrant bursitis.

If detachment of the Achilles tendon is required for a surgical procedure such as excision of a prominent superior calcaneal tuberosity, consideration should be given to its subsequent re-attachment with sutures to each part of the footprint in order to engage all the fascicles.

Our study has limitations, mainly as a result of the small number of samples. However, the consistency of this distinct pattern of the footprint of the fascicles of the three different tendons in all the frozen specimens makes it most likely that our description is accurate.

Our findings may allow a better understanding of the function of each muscular part of the gastrosoleus complex. This may have clinical relevance in the treatment of Achilles tendinopathies.
References