

## ANATOMY OF THE COMMON CALCANEAL TENDON IN RAT (*RATTUS NORWEGICUS*)

***Paweł Szaro<sup>1,2</sup>, Grzegorz Witkowski<sup>1</sup>, Bogdan Ciszek<sup>1</sup>***

<sup>1</sup> Department of Clinical and Descriptive Anatomy

<sup>2</sup> I Department of Clinical Radiology  
Medical University of Warsaw

Key words: tendon, rat, common calcaneal tendon, rotation, fascicles.

### Abstract

The aim of the study was to describe anatomy of the common calcaneal tendon in rat (*Rattus norvegicus*) and to correlate individual parts of the tendon with the muscles that act with the aid of them.

Ten pelvic extremities of adult rats were fixed in 10% of formaldehyde and were dissected layer-by-layer method with microsurgical instruments under the operating microscope (4 and 10 fold magnification). The fascicles of the soleus muscle and the lateral head of the gastrocnemius muscle compose the deepest layer of the tendon. The fascicle of the medial head of the gastrocnemius muscle is located more superficially. The strong tendon of the plantaris muscle covers the fascicles listed above. The common calcaneal tendon in rat is composed of twisted fascicles attaching on the tuber calcanei. Fascicles of the following muscles: gastrocnemius and soleus are twisted along the long axis of the common calcaneal tendon, which is additionally strengthened from behind by the plantaris tendon.

A detailed knowledge of anatomy of the common calcaneal tendon in rats provides a better understanding of pathology of the tendon. Conclusions are often extrapolated to the human calcaneal tendon.

### ANATOMIA ŚCIĘGNA PIĘTOWEGO WSPÓLNEGO U SZCZURA (*RATTUS NORWEGICUS*)

***Paweł Szaro<sup>1,2</sup>, Grzegorz Witkowski<sup>1</sup>, Bogdan Ciszek<sup>1</sup>***

<sup>1</sup> Zakład Anatomii Prawidłowej i Klinicznej

<sup>2</sup> I Zakład Radiologii Klinicznej  
Warszawski Uniwersytet Medyczny

Słowa kluczowe: ścięgno, szczur, ścięgno piętowe wspólne, rotacja, pęczki.

## Abstrakt

Celem pracy było zbadanie budowy ścięgna piętowego wspólnego u szczura (*Rattus norvegicus*) oraz powiązanie części ścięgna z odpowiednimi mięśniami.

Metodą warstwową z użyciem narzędzi mikrochirurgicznych pod mikroskopem operacyjnym (powiększenie 4x i 10x) preparowano dziesięć kończyn miednicznych dorosłych szczurów utrwalonych w 10% formalinie. Najgłębszą warstwę ścięgna tworzą pęczki ścięgniste mięśni: płaszczkowatego oraz głowy bocznej mięśnia brzuchatego łydki. Bardziej powierzchownie znajduje się pęczek od głowy przysrodkowej mięśnia brzuchatego łydki. Wymienione pęczki pokryte są przez silne ścięgno mięśnia podeszowego.

Ścięgno piętowe wspólne szczura składa się ze zrotowanych pęczków przyczepiających się na guzie piętowym. Pęczki ścięgniste mięśnia brzuchatego łydki i mięśnia płaszczkowatego ulegają rotacji wokół osi długiej ścięgna piętowego wspólnego, dodatkowo od tyłu wzmocnione są przez ścięgno mięśnia podeszwowego.

Dokładna znajomość budowy ścięgna piętowego wspólnego u szczura pomoże lepiej zrozumieć procesy związane z jego patologią. Wnioski z nich często ekstrapolowane są bezpośrednio na człowieka.

## Introduction

Rats belong to the semiplantigrade animals (SIKORSKA-PIWOWSKA 1984) and in scientific research are animal model for tendon related researches. Studies concerning injection of the corticosteroids to the tendon or the impact of stimuli on the tendon (ALMEIDA et al. 2009) as well as the effect of drugs (e.g. ciprofloxacin) on the tendon structure were conducted. There are no detailed data on the structure of the common calcaneal tendon of rat in the available literature. Neither are there further details regarding a comparison of the rat tendon with its human analogue, Achilles tendon. According to PARSONS (1894) the anatomy of the beavers' common calcaneal tendon is similar to that seen in other rodents. The common calcaneal tendon in wood rat (*Phloeomys cumingi*), which is tree-living (aboreal) and ground-living (nonaboreal) animal, is composed of the fused tendons of the gastrocnemius muscle, soleus muscle and plantaris muscle (BRAZIER 1926). There is an inaccuracy regarding the nomenclature of the muscles in rat. Some authors distinguish in rats the flexor digitorum superficialis muscle (ETTEMA et al. 2006, THOMAS et al. 2009) while other authors identify this muscle as the plantaris muscle (DEGENS et al. 2009, ISHIHARA et al. 1998). Such differences may result from the type of locomotion (SIKORSKA-PIWOWSKA 1984). The plantaris muscle is present in plantigrade animals (e.g. bear), while in digitigrades animals the flexor digitorum superficialis muscle is distinguished (eg. dog). Rats are digitigrade and plantigrade animals. In our study we used name "plantaris muscle" since this term is most commonly used in the literature referring to this tendon.

## **The aim of the study**

The aim of the study was to describe internal anatomy of the common calcaneal tendon in rat. In our research the individual parts of the tendon were correlated with muscles that act with the aid of them.

## **Material and Method**

Specimens of adult rats, fixed in 10% formaldehyde solution, came from the collection of the Department of Descriptive and Clinical Anatomy at Medical University of Warsaw.

Ten pelvic limbs (5 right and 5 left) of rats were dissected under surgical microscope (4 and 10 fold magnification was used) with layer-by-layer method. Initially the skin was removed, then the fascia was dissected and eventually the individual parts of the common calcaneal tendon were analyzed with their correlation with the muscles that act with the aid of them. Finally, the tendons fibres (tendon fascicles), which are a direct continuation of the tendon, were dissected. Photographic documentation was made at each stage of the study.

## **Results**

The triceps surae muscle in rat is composed of the gastrocnemius muscle and the soleus muscle (Figure 1, Figure 2). The common calcaneal tendon is covered by the plantaris tendon at the level of the tuber calcanei (Figure 3). Tendinous fibres of the plantaris tendon are located superficially and they cover the lower part of the common calcaneal tendon which is mostly composed of the fascicles from the gastrocnemius muscle. At the level of the tuber calcanei, the plantaris tendon covers it, becomes a little wider and partially attaches to it (Figure 2).

In the superior part of rats' leg the biceps femoris muscle covers the triceps surae muscle. In the inferior part it is located superficially (Figure 1).

During the dissection of the common calcaneal tendon we observed that the tendon fibres are loosely connected one to another and their separation during a gentle dissection was relatively easy. The fusion between the individual parts of the common calcaneal tendon that occurred just above the tuber calcanei was distinctly stronger.

The most superficial fibres in the common calcaneal tendon were those coming from the plantaris tendon (Figure 3). Tendinous fibres from the gastrocnemius are located deeper than the fibres coming from the plantaris



Fig. 1. The common calcaneal tendon in rat (left side), posterolateral aspect: 1 – the medial head of the gastrocnemius muscle; 1a – the fascicle from the medial head of the gastrocnemius muscle; 2 – the lateral head of the gastrocnemius muscle; 2a – the fascicle from the lateral head of the gastrocnemius muscle; 3 – the plantaris muscle; 4a – the plantaris tendon; 5 – the tuber calcanei

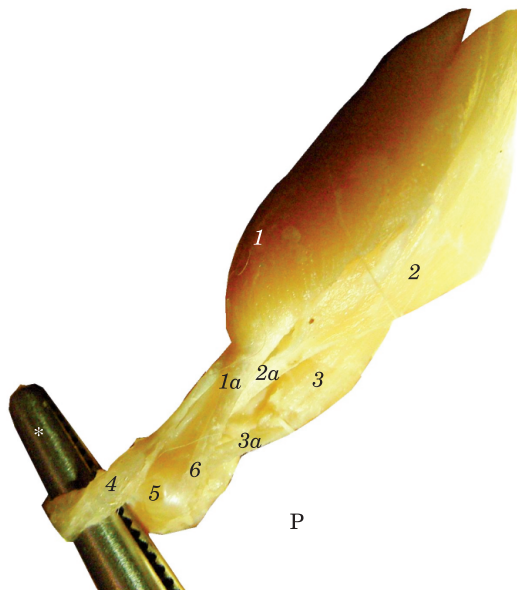


Fig. 2. The right common calcaneal tendon in rat, posterior aspect: 1 – the medial head of the gastrocnemius muscle; 1a – the fascicle from the medial head of the gastrocnemius muscle; 2 – the lateral head of the gastrocnemius muscle; 2a – the fascicle from the lateral head of the gastrocnemius muscle; 3 – the soleus muscle; 4 – the plantaris tendon; 5 – the tuber calcanei; 6 – the level of the connection between the fascicles of the triceps surae muscle, the common calcaneal tendon

tendon (Figure 4). Considering the two heads of the gastrocnemius, the medial one sends more superficial fibres lying beneath the fibres from the plantaris tendon. The deepest layer of the common calcaneal tendon is formed by tendineous fibres from the soleus muscle and from the lateral head of the gastrocnemius muscle (Figure 5).

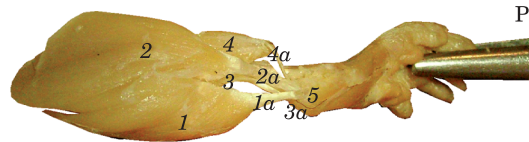


Fig. 3. The right common calcaneal tendon in rat. Posterior aspect: 1 – the medial head of the gastrocnemius muscle; 1a – the fascicle from the medial head of the gastrocnemius muscle; 2 – the lateral head of the gastrocnemius muscle; 2a – the fascicle from the lateral head of the gastrocnemius muscle; 3 – the plantaris muscle; 3a – the fascicle from the plantaris muscle; 4 – the soleus muscle; 4a – the fascicle from the soleus muscle

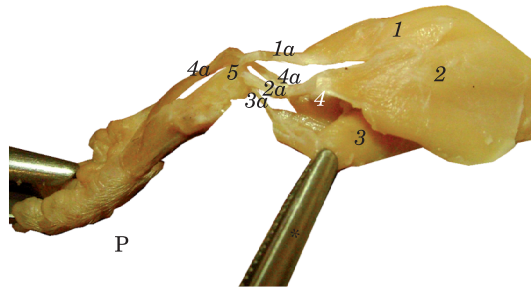


Fig. 4. The common calcaneal tendon in rat (right side). Posterolateral aspect: 1 – the medial head of the gastrocnemius muscle; 1a – the fascicle from the medial head of the gastrocnemius muscle; 2 – the lateral head of the gastrocnemius muscle; 2a – the fascicle from the lateral head of the gastrocnemius muscle; 3 – the soleus muscle; 3a – the fascicle from the soleus muscle; 4 – the plantaris muscle; 4a – the fascicle from the plantaris muscle; 5 – the tuber calcanei

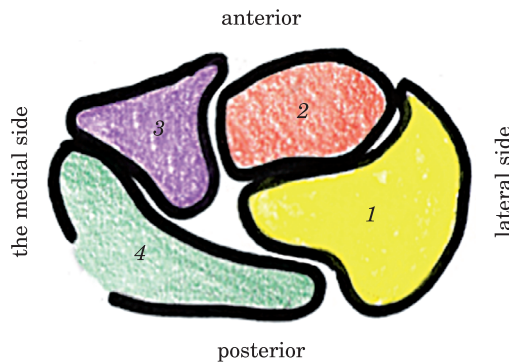


Fig. 5. The transverse cross section of the common calcaneal tendon in rat: 1 – the fascicle from the medial head of the gastrocnemius muscle; 2 – the fascicle from the lateral head of the gastrocnemius muscle; 3 – the fascicle from the soleus muscle; 4 – the plantaris tendon

## Discussion

The tendons that we examined in the study came from the adult rats in which the ultimate structure of the tendon, as well as its attachment, was developed (MURATA et al. 2000, RUFAl et al. 1992). In our material tendons fibres of the common calcaneal tendon come from the gastrocnemius muscle, the soleus muscle and the plantaris muscle, which is in accordance with observation made by other authors (BRAZIER 1926). This conception is also in accordance with the generally accepted scheme or pattern of the anatomy of the common calcaneal tendon in animals (KRYSIK 1981, KRYSIK et al. 2001, *Nomina Anatomica Veterinaria* 2005). As it was mentioned in the introduction, most of the research studies done on the common calcaneal tendon in rats are related to experimentally induced tendinitis or peritendinitis, rupture of the tendon, testing different terapeutical methods (eg. influence of drugs) and investigations of the tendon healing. The results of such researches (in which rats are used) are quite arbitrarily extrapolated to the human calcaneal tendon (SHAKIBAEI and STAHLMANN 2001). Differences in the internal structure of tendons and type of locomotion are not taken under consideration. The findings from the literature review confirm a lack of data on the internal structure of the common calcaneal tendon in rats and its comparison to the human analogue. There is information, given by BRAZIER (1926) who studied the anatomy of the wood rat that the fascicle of the medial head of the gastrocnemius muscle runs downwards and laterally. Nevertheless, as far as the lateral head of the gastrocnemius muscle is concerned similar report is not given which makes his description incomplete.

In our study we revealed that the common calcaneal tendon in rat is composed of twisted fascicles, which refers to the anatomy of the human calcaneal tendon (SZARO et al. 2009). However, there is a difference in number of tendons' components in both species. In humans the plantaris tendon is not a part of the Achilles tendon. In rats the plantaris tendon is relatively bigger and it contributes to the formation of the posterior part of the common calcaneal tendon. The fascicles of rats' common calcaneal tendon are loosely connected, as it was already mentioned, while tight junctions connect the fascicles of the human Achilles tendon. Comparing the common calcaneal tendon in rat and horse (SZARO et al. 2011) we can see that there is a tendency to multiply the fascicles in digitigrade animals such as horse (SIKORSKA-PIWOWSKA 1984). It helps to stabilize the autopodium in the digitigrade animals in the upright position. In the human Achilles tendon there are three fascicles participating in the formation of the tendon. They come from the medial and lateral heads of the gastrocnemius and from the soleus muscle. The common calcaneal tendon in the horse is composed of the five fascicles coming

from the two heads of the gastrocnemius muscle, the soleus muscle and from two calcaneal stripes derived from the muscles of the thigh (SZARO et al. 2011). As far as the number of the fascicles of the tendon is concerned, the common calcaneal tendon in the rat is more similar to the Achilles tendon in humans (representing the plantigrade locomotion) than to the analogue of this tendon in horses (which are digitigrade animals).

As it was mentioned in the results section the distinct connections between the fascicles of the common calcaneal tendon occur just above the tuber calcanei and this is where the tendon becomes “common” indeed, since it practically unifies the fascicles at this level and not above. A term “the calcaneal cord” which is used by some authors seems to be a very suitable and an alternative name for the common calcaneal tendon. This name emphasizes the fact that individual parts (or the fascicles) of the common calcaneal tendon form an integral structure. It has been proved in the current study but it was also previously reported in our study concerning the structure of the common calcaneal tendon in the horse (SZARO et al. 2011). Some authors believe that such observations (the fusion of the fascicles of the gastrocnemius, soleus and plantaris) can be the starting point for distinguishing the muscle complex called “guadriceps surae muscle” (BRAZIER 1926). However, such a term does not exist in the modern veterinary nomenclature (MILART 2002, *Nomina Anatomica Veterinaria* 2005).

## Conclusions

The common calcaneal tendon in rat is not a homogeneous structure but it is composed of the mutually rotated fascicles. Tendon fascicles connect the muscle bellies (which act with the aid of the tendon) with the tuber calcanei. Complexity of the internal structure of the common calcaneal tendon in rats is probably related to a type of locomotion.

Translated by GRZEGORZ WITKOWSKI, PAWEŁ SZARO, KATARZYNA WITKOWSKA-SKOWROŃSKA

Accepted for print 10.06.2012

## References

- DE ALMEIDA F.M., TOMIOSSO T.C., NAKAGAKI W.R., GOMES L., MATIELLO-ROSA S.M.G., PIMENTEL E.R. 2009. *Effects of passive stretching on the biochemical and biomechanical properties of calcaneal tendon of rats*. Connect. Tissue Res., 50: 279–284.
- DEGENS H., MORSE C.I., HOPMAN M.T.E. 2009. *Heterogeneity of capillary spacing in the hypertrophied plantaris muscle from young-adult and old rats*. Adv. Exp. Med. Biol., 645: 61–66.
- ETTEMA A., ZHAO C., AN K.N., AMADIO P. 2006. *Comparative anatomy of the subsynovial connective tissue in the carpal tunnel of the rat, rabbit, dog, baboon, and human*. Hand., 1: 78–84.

- HOWELL A.B., MAMMALOGISTS A.S. 1926. *Anatomy of the wood rat; comparative anatomy of the subgenera of the American wood rat*. The Williams & Wilkins Company, Baltimore.
- International Committee on Veterinary Gross Anatomical Nomenclature, n.d. *Nomina anatomica veterinaria*, 5th ed.
- ISHIHARA A., ROY R.R., OHIRA Y., IBATA Y., EDGERTON V.R. 1998. *Hypertrophy of rat plantaris muscle fibers after voluntary running with increasing loads*. J Appl. Physiol, 84: 2183–2189.
- KRYSIAK K. 1981. *Anatomia zwierząt. Aparat ruchowy*. PWN, Warszawa.
- KRYSIAK K., KOBRYŃCZUK F., KOBRYŃ H. 2008. *Anatomia zwierząt, t. 1*. PWN, Warszawa.
- MILART Z., 2002. *Anatomiczne mianownictwo weterynaryjne*. PWRIL, Warszawa.
- MURATA H., NISHIZONO H., MIYOSHI M. 2000. *Postnatal development of structure and arrangement of tendon cells. A scanning and transmission electron microscope study in the rat calcaneal tendon*. Okajimas Folia Anat. Jpn., 77: 77–86.
- PARSONS F.G. 1894. *On the Morphology of the Tendo-Achillis*. J. Anat. Physiol., 28: 414–418.
- RUFAL A., BENJAMIN M., RALPHS J.R. 1992. *Development and ageing of phenotypically distinct fibrocartilages associated with the rat Achilles tendon*. Anatomy and Embryology, 186: 611–618.
- SHAKIBAEI M., STAHLMANN R. 2001. *Ultrastructure of Achilles tendon from rats after treatment with fleroxacin*. Archives of Toxicology, 75: 97–102.
- SIKORSKA-PIWOWSKA Z. 1984. *Modele biologique de l'évolution de l'appareil locomoteur des Tetrapodes*. Zool. Poloniae, 31: 65–223.
- SZARO P., WITKOWSKI G., BARTYZEL B.J., CISZEK B. 2011. *Anatomy of the common calcaneal tendon in horse (Equus Caballus)*. 14: #04.
- SZARO P., WITKOWSKI G., ŚMIGIELSKI R., KRAJEWSKI P., CISZEK B. 2009. *Fascicles of the adult human Achilles tendon – an anatomical study*. Ann. Anat., 191: 586–593.
- THOMAS C.K., ESIPENKO V., XU X.M., MADSEN P.W., 3rd, GORDON T. 1999. *Innervation and properties of the rat FDSBQ muscle: an animal model to evaluate voluntary muscle strength after incomplete spinal cord injury*. Exp. Neurol., 158: 279–289.