

## MORPHOLOGICAL STUDY OF ACHILLES TENDON

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### ABSTRACT

**Background:** The calcaneal tendon is the thickest and strongest tendon in the human body which is attached to the midpoint of the posterior surface of calcaneum. It is a frequent site of rupture, degenerative changes and inflammation.

**Aim:** To study the anatomical and morphological details of attachment of Achilles tendon.

**Materials and Methods:** The study was carried out on 70 adult cadaveric lower limbs in two Medical colleges. Various linear measurements were taken with the help of digital vernier caliper, accurate up to 0.01 mm.

**Results:** Presence of Achilles tendon in all cadaveric limbs was observed in the present study. Bursa between the tendon at insertion and calcaneus was seen in all specimens. Length of tendon of gastrocnemius was observed to vary between 16.5 cm to 29.5 cm. The width at musculotendinous junction with gastrocnemius was observed to vary between 3.42 cm to 6.84 cm. Other measurements taken were minimum width, thickness at insertion, length of gastrocnemius aponeurosis medially and laterally.

**Conclusion:** In the present study, variations in the morphology of Gastrocnemius were observed. Understanding these variations of the gastrocnemius tendon and aponeurosis will aid the surgeon in performing surgical procedures such as pedicle tendon flap for reconstructive surgery and arthroplasty, Endoscopic Gastrocnemius Recession (EGR), on the Achilles tendon and prevent iatrogenic complications. It is also useful to the Anatomists as it will help them integrate in their teaching the variations and thus better prepare the students for their clinical tenures/work/future.

**KEY WORDS:** Tendoachilles, Repair Of Ruptured Tendon, Reconstructive Surgery, Arthroplasty.

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### INTRODUCTION

Gastrocnemius is the most superficial muscle of the flexor group and forms the belly of the calf. It arises by two heads connected to the condyles of the femur by strong and long

tendons. The fleshy part of the muscle extends up to mid-calf. The muscle fibres of the larger medial head extend lower than those of the lateral head. As the muscle descends the muscle fibres begin to insert into a broad aponeurosis

that develops on its anterior surface; up to this point the muscular masses of the two heads remain separate. The aponeurosis gradually narrows and receives the tendon of soleus on its deep surface to form the calcaneal tendon [1]. The tendoachilles is considered to be the thickest and strongest tendon in the body, being the tendon by which calf muscles exert their force on the posterior part of the foot during the propulsive phase of many activities for example walking, running and jumping[2].

The tendon is wider at its lower end becoming thick and narrower as it descends until it becomes essentially round in cut section superior to calcaneum and its narrowest part is 4 cm above the insertion. It is inserted in the centre of the posterior surface of calcaneal tuberosity [3]. The variation of the insertion of Achilles tendon can contribute significantly to the mechanical stability and movements of the joints [4,5].

The calf muscle plantar flexes the foot at the ankle joint. Gastrocnemius acts as propelling force, working mainly on the ankle but also producing flexion of the knee joint. Soleus acts more as a postural muscle. This is because its lower attachment is a fixed point and prevents the leg from falling forwards under the influence of body weight, because the vertical projection from the centre of gravity of the body fall in front of ankle joint[2].

The large size of these two muscles is a human feature related to upright posture and bipedalism. These muscles help in lifting, propelling and accelerating the weight of the body when walking, running, jumping or standing on the toes[3].

As compared to humans and gibbons who have a long Achilles tendon, it is short or absent in apes. It provides elastic energy storage in hopping, walking and running[3].

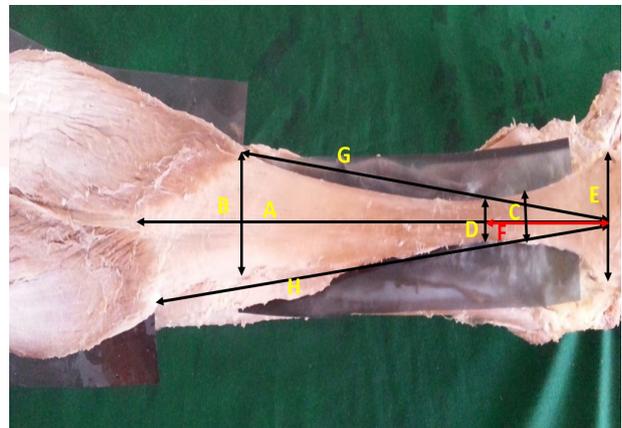
A complete tear of the gastrocnemius tendon is a disabling condition. An acute tear typically occurs in sedentary middle aged men engaged in episodic over activity resulting in forceful dorsiflexion of the foot[6]. It may also be chronic.

Present study was carried out with an aim to study the anatomical and morphological details, of the gastrocnemius aponeurosis and that of the tendoachilles.

## MATERIALS AND METHODS

The study was carried out on seventy adult cadaveric lower limbs from Departments of Anatomy of two Medical colleges. The cadavers were in the age group of 50-80 yrs. Various linear measurements were taken with the help of digital vernier caliper accurate up to 0.01 mm. We measured the length of the tendon of gastrocnemius and that of soleus. The width of the achilles tendon was measured at three levels, at its junction with gastrocnemius, at its junction with Soleus and at the level of its insertion. The minimum width of the tendon was measured and the distance of this from the insertion was noted. The thickness of the tendon was noted at its insertion. We also measured the length of aponeurosis of gastrocnemius, length of medial and lateral borders of the aponeurosis of gastrocnemius. The results were tabulated and statistically studied for mean and standard deviation using the SPSS, version 22 software.

**Fig.1:** Showing the method of taking various measurements.



- (a) Length of tendon of gastrocnemius ,
- (b) Width at the musculotendinous junction with gastrocnemius
- (c) Width at 4cms from insertion
- (d) Minimum width of tendon
- (e) Width of tendon at insertion
- (f) Distance of minimum width from insertion
- (g) Length of gastrocnemius aponeurosis at medial border
- (h) Length of gastrocnemius aponeurosis at lateral border

**RESULTS**

**Table 1:**  
Morphometrical parameters of Achillis tendon.

	MEASUREMENTS TAKEN	RANGE (cm)	MEAN +SD (cm)
1	Length of tendon at junction with gastrocnemius	16.5--29.5	21.30 ± 2.9
2	Width of tendon at junction with gastrocnemius	3.42 - 6.84	4.93 ± 0.76
3	Width of tendon at insertion	2.51 - 4.5	3.5 ± 0.54
4	Width of tendon at 4cm	1.2 - 2.0	1.49 ± 0.24
5	Minimum width of tendon	1.0 - 1.82	1.30 ± 0.16
6	Distance of minimum width from insertion	4.0 - 8.14	5.16 ± 0.91
7	Thickness of tendon at insertion	0.49 - 1.14	0.82 ± 0.22
8	Length of gastrocnemius aponeurosis in the midline	4 - 29.5	19.56 ± 5.88
9	Length of Gastrocnemius aponeurosis medially	13.1 - 28.5	21.86 ± 3.05
10	Length of Gastrocnemius aponeurosis laterally	15.0 - 32.7	24.10 ± 2.95

**Table 2:** Comparison of the Measurements taken in the present study with measurements available from various studies.

	MEASUREMENTS (cm)	Present study (Cadaveric)	Ghany Hassan Ollo [7] (Cadaveric)	P. Kharate & K.C. Larsen[12] (usg)	Pang & Yang [8] (usg)	R A F de Mello [13] (usg)
1	Length of tendon at junction with gastrocnemius	21.30 ± 2.9	22.18 ± 3.12		11.77 ± 2.37	
2	Width of tendon at junction with gastrocnemius	4.93 ± 0.76	6.62 ± 0.52			
3	Width of tendon at 4cm	1.49 ± 0.24	2.55 ± 0.34			
4	Minimum width of tendon	1.30 ± 0.16				
5	Width of tendon at insertion	3.5 ± 0.54				
6	Distance of minimum width from insertion	5.16 ± 0.91				
7	Thickness of tendon at insertion	0.82 ± 0.21		0.37 ± 0.06	0.51 ± 0.06	0.55 ± 0.06
8	Length of Gastrocnemius aponeurosis medially	21.86 ± 3.05				
9	Length of Gastrocnemius aponeurosis laterally	24.1 ± 2.95				

Study of seventy adult cadaveric lower limbs showed presence of Achilles tendon in all the cadaveric limbs. Bursa between tendon at insertion and calcaneus was present in all the specimen.

The mean length of the tendon of gastrocnemius was 21.30 ± 2.9 cm (16.5 - 29.5 cm) and that of soleus was 7.5 ± 7.08 cm (4.5 – 10 cm). The width of the Achilles tendon was observed as 4.93 ± 0.76 cm (3.42 - 6.84 cm) at musculotendinous junction with gastrocnemius and 1.16 ± 0.34 cm at musculotendinous junction with soleus.

At insertion the width of the tendon was 3.5 ± 0.54 cm. (2.51- 4.5 cm). Minimum width was observed as 1.30 ± 0.16 cm (1.0 - 1.82 cm) and its average distance from insertion was 5.16 ± 0.91 cm (4.0 – 8.14 cm). We also noted the width of the tendon at 4cm from the insertion and it was 1.49 ± 0.24 cm. (1.2 -2 cm). Mean thickness at insertion was 0.82 ± 0.21 cm (0.49 - 1.14 cm).

Length of gastrocnemius aponeurosis was 19.56 ± 5.88 cm (4 -29.5 cm) in the midline, 21.86 ± 3.05 cm (13.1 -28.5 cm) on its medial side and

24.10 ± 2.95 cm (15.0 – 32.7 cm) on the lateral side (Table no.1)

**DISCUSSION**

The calcaneal tendon is the thickest and strongest tendon in the human body which is attached to the midpoint of the posterior surface of the calcaneus. The mid substance of the tendon is relative avascular and is a frequently susceptibility to rupture, degenerative changes (tenosinovitis) and inflammation (paratendinitis) [1].

Singh et al[3] reported a case where the lateral and medial heads of gastrocnemius were fleshy in its entire length till its insertion, thus total absence of tendinous portion. In the present study we did not find such variation.

Abdel-Ghany and Ollo[7], in their cadaveric study, observed the mean length of gastrocnemius tendon as 22.18 ± 3.12 cm, while it was 21.30 ± 2.9 cm in the present study. Pang and Ying[8] reported the mean length as 11.77 ± 2.37 cm in their ultrasonographic study of achilles tendon.

Abdel- Ghany and Ollo[7] observed the mean

width at its junction with gastrocnemius muscle as  $6.62 \pm 0.52$  cm while it was less in the present study i.e.  $4.93 \pm 0.76$  cm. They observed the width as  $2.88 \pm 0.32$  cm at its junction with soleus while we observed it as  $1.16 \pm 0.34$  cm. At insertion the width was  $2.55 \pm 0.34$  cm in the study done by Ghany- Hassan and Ollo[7], while in the present study it was  $3.5 \pm 0.54$  cm. The variation in the differences in population height could account for the differences in tendon thickness[11].

Mean thickness of the Achilles tendon at insertion was observed as  $0.82 \pm 0.21$  cm. Pang and Ying[8] reported mean thickness as  $0.51 \pm 0.06$  cm. Kharate and Larsen[12] reported it as  $0.37 \pm 0.06$  cm, RAF de Mello[13] reported it as  $0.55 \pm 0.06$  cm. The difference can be explained as the methods of study were different. All these three studies were done by ultrasonography while we studied the cadavers. (Table no.2) Detailed knowledge of anatomic variation of the Soleus muscle at its insertion point onto the tendoachillis has clinical implications when repairing the tendon following rupture. It also helps in the planning of reconstructive surgery using soleus muscle flap[10]. Length from the musculotendinous junction of soleus to its insertion was  $7.62 \pm 1.71$  cm in the study conducted by Ghany-hassan and Ollo[7], while it was observed as  $7.5 \pm 7.08$  cm in the present study. Balius et al.[9] in their MRI study of soleus observed it as  $6.42 \pm 2.18$ cm(range 3.3 – 11.8)and Pitchler et al.[10] noted the range from 2.54 to 7.62 cm.

In some cases the gastrocnemius muscle inserts superficially, onto the tendon of the soleus; though in most cases, the distal end of gastrocnemius aponeurosis extends for a variable distance as a thin, tendinous sheet void of muscular attachments. Surgeons performing a gastrocnemius recession may target the exposed inferior portion of the aponeurosis that is not directly covered by muscle[14]. Barford and Pers[15] first described use of the lateral belly of the gastrocnemius muscle, after detaching it from its lower insertion to cover the eroded condyles and the gaping knee while the medial gastrocnemius muscle flap plasty was first described by Ger[16].

In the present study we found that the mean

length of the medial border of the gastrocnemius aponeurosis was  $21.86 \pm 3.05$  cm and on the lateral side it was  $24.10 \pm 2.95$  cm. In pathological conditions of the foot and ankle, Gastrocnemius muscle plays a vital role. Conditions such as gastrocnemius equinus are treated by the Endoscopic gastrocnemius recession (EGR)[17]. The morphology of the conjoint junction of the tendons of gastrocnemius and soleus and the location of the gastrocnemius tendon relative to bony landmarks would help in incision planning for open or endoscopic division of tendon[18]. A detailed understanding of the variations in the gastrocnemius aponeurosis as well as of the morphological aspects of triceps surae will help the surgeon to choose the appropriate recession technique. It will also help in accurately performing the procedure and avoiding complications like sural nerve injuries [17].

Due to the increasing number of implantation of knee endoprotheses and the associated number of soft tissue damages, a standardized procedure for the treatment of these complications is necessary. In the case of deep soft tissue damages with fistulae reaching the prosthesis or exposing the prosthesis, the gastrocnemius muscle flap is a good method for secure coverage of the prosthesis with well-perfused tissue[19]. Detail anatomical and morphological knowledge of gastrocnemius can be useful to surgeons in planning of the surgery.

## CONCLUSION

Understanding the variations in morphology of the achilles tendon and aponeurosis of gastrocnemius muscle, will be useful to the Anatomists as it will help them integrate the variations in their routine teaching and thus help them to prepare the students better for their clinical tenures.

This knowledge will aid the surgeon in choosing the recession technique, planning the incision, performing surgical procedures such as repair of a ruptured tendon, pedicle muscle flap for reconstructive surgery and arthroplasty, Endoscopic Gastrocnemius Recession surgery. It will prevent iatrogenic complications like nerve injuries.

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**Conflicts of Interests: None**

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