

MORPHOMETRIC PROFILE OF ACHILLES TENDON IN MALE - A CADAVERIC STUDY

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ABSTRACT

The Achilles tendon is a conjoined tendon of gastrocnemius and soleus muscles and occasionally may have a small contribution from plantaris muscle. Despite being the strongest and thickest tendon in the body it is a frequent site of degenerative changes, inflammation and rupture. The main objective of this study was to measure and analyze the various parameters of Achilles tendon in cadavers. An observational, descriptive study was conducted from August 2021 to February 2022 in the Department of Human Anatomy of Nepal Medical College Teaching Hospital, Attarkhel, Gokarneshwor – 8, Kathmandu, Nepal which included forty lower limbs of twenty male cadavers. The various parameters recorded were (a) mean length of right Achilles tendon was 16.65 ± 1.72 cm, (b) mean proximal width of right Achilles tendon was 5.50 ± 1.07 cm, (c) mean proximal circumference of right Achilles tendon was 10.67 ± 2.20 cm, (d) mean distal width of right Achilles tendon was 2.22 ± 0.54 cm, (e) mean distal circumference of right Achilles tendon was 4.27 ± 0.67 cm, (f) mean length of left Achilles tendon was 16.35 ± 1.49 cm, (g) mean proximal width of left Achilles tendon was 5.25 ± 0.88 cm, (h) mean proximal circumference of left Achilles tendon was 10.57 ± 1.78 cm, (i) mean distal width of left Achilles tendon was 2.05 ± 0.27 cm and mean distal circumference of left Achilles tendon was 4.0 ± 0.42 cm. The present morphometric evaluation of Achilles tendon in cadavers can be of substantial help to clinicians before determining its pathological conditions and can also be of help to surgeons during the surgical repair and reconstruction of damaged tendon.

KEYWORDS

Achilles tendon, cadavers, calcaneus, musculotendinous

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INTRODUCTION

The Achilles tendon (AT) is the thickest and strongest tendon in the human body which is fifteen cm long.¹ The name Achilles was described in the Iliad by poet Homer between 750 and 650 BC. Achilles was a magnificent warrior and according to myth he was made invulnerable in infancy by his mother who plunged him into the river by holding on one of his heel. This heel was the site where he was mortally wounded by a poisoned arrow during the Trojan war.²

The AT is a conjoined tendon of gastrocnemius and soleus muscles and occasionally may have a small contribution from plantaris muscle. They are the main plantar flexors of ankle joint. The tendon is subjected to the highest loads in the body with tensile loads up to ten times body weight during running, jumping and skipping.³ Anatomically the myotendinous unit is inserted on the posterosuperior part of calcaneus.⁴ The tendon is also a hallmark of bipedal man as it was absent in great apes, our immediate ancestors. It has even been suggested that the tendon has helped to shape the human evolution which probably originated in homo more than three million years ago.⁵ The AT is composed of Type I collagen fibres which account for its considerable tensile strength and is one of the most commonly torn tendons

in human body.^{6,7} The pathology of AT ranges from tendinosis to frank tears and can affect athletes as well as non-athletes.⁸ Male sex, obesity, with increasing age and smoking habit the AT is found to have positive correlation with its injury.⁹ Use of drugs like corticosteroids and fluoroquinolones have also been found to weaken the tendon with associated tendinitis and increase risk of rupture.¹⁰ AT rupture has been found in a patient with Addison's disease¹¹ and spontaneous bilateral AT ruptures have been also reported in patients with chronic obstructive pulmonary disease.¹² The congenital disorders of AT may result in toe walking or equines deformity in children.¹³

Most of the previous studies on AT were found to be analyzed using ultrasonography and magnetic resonance imaging and very few studies were found to be conducted in cadavers. Hence due to the limited availability of data in this regard, this morphometric measurements of AT in cadavers were carried out which will also serve as an important landmark in anthropometric evaluation and biomechanical characteristics.

MATERIALS AND METHODS

The study was carried out after getting an ethical approval from the Institutional Review



Fig. 1: Showing the procedure to measure the total length of AT

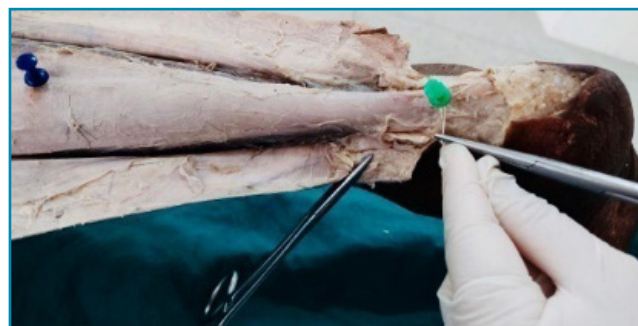


Fig. 3: Showing the procedure to measure the distal width of AT



Fig. 2: Showing the procedure to measure the proximal width of AT



Fig. 4: Showing the procedure to measure the proximal circumference of AT

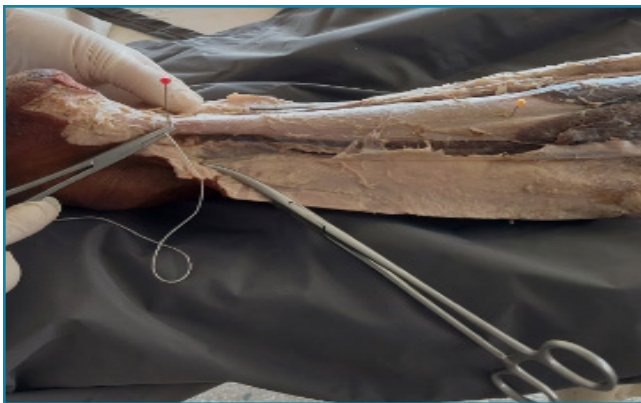


Fig. 5: Showing the procedure to measure the distal circumference of AT

Committee of Nepal Medical College Teaching Hospital, Gokarneshwor – 8, Kathmandu, Nepal (Ref. No: 020 – 078/ 079). An observational, descriptive study was conducted over a period of seven months from August 2021 to February 2022 in the Department of Human Anatomy of Nepal Medical College Teaching Hospital, Gokarneshwor-8, Kathmandu, Nepal. The study included forty lower limbs of twenty male cadavers which were allotted for teaching learning activities of undergraduate medical students. The lower limbs of cadavers having any obvious cuts or deformities and the female cadavers were excluded from the study due to its adequate unavailability. Before starting the dissection, the body was kept in prone position and the lower limbs were placed in full extension. A longitudinal incision in the posterior surface of each lower limb was made extending from mid-point of upper limit of popliteal fossa to inferior aspect of calcaneus bone. A transverse incision was made at the upper limit of popliteal fossa and another incision was made on the medial and lateral sides of posterior part of plantar surface of foot perpendicular to the longitudinal incision.²⁶ The skin, superficial fascia and deep fascia were removed to expose the calf muscles and

tendoachilles and the various parameters were measured as follows.

The lowest point on the musculotendinous junction of gastrocnemius muscle and AT close to its insertion was marked by a pin. The total length of AT was measured from upper to the lower pin marked point with the help of a steel ruler (Fig. 1). The proximal width of AT was measured at the lowest point of musculotendinous junction (Fig. 2) and its distal width was measured at the closest point of its insertion to calcaneal tuberosity (Fig. 3). Both the proximal and the distal circumferences were measured around the proximal width and the distal width of AT tendon respectively (Fig. 4 and 5). The measurements were taken using a thread and the length of thread was later straightened and measured by a steel ruler. The measured parameters were recorded and the descriptive statistical analysis including mean and standard deviation were computed and analyzed by using a statistical tool as SPSS-16 and the findings were illustrated in a tabular form.

RESULTS

Twenty right and twenty left legs of male cadavers were included in the study. The mean length of right Achilles tendon measured was 16.65 ± 1.72 cm as illustrated in Table 1. The maximum length of right Achilles tendon recorded was 23 cm and minimum length was found to be 15 cm. The mean proximal width of right Achilles tendon was 5.50 ± 1.07 cm (Table 2) and the mean proximal circumference of right Achilles tendon was measured as 10.67 ± 2.20 cm (Table 3). Similarly the other measurements taken on right Achilles tendon were its distal width and distal circumference which were measured as 2.22 ± 0.54 cm and 4.27 ± 0.67 cm respectively (Table 4 and Table 5). The mean length of Achilles tendon on its left side was

Table 1: Mean and standard deviation of total length of Achilles tendon in both sides

Total no. of lower limbs (n)	Mean length of right Achilles tendon in cm (Mean ± SD)	Mean length of left Achilles tendon in cm (Mean ± SD)	P-value
40	16.65 ± 1.72 cm	16.35 ± 1.49 cm	0.01

Table 2: Mean and standard deviation of proximal width of Achilles tendon

Total no. of lower limbs (n)	Mean of proximal width of right Achilles tendon in cm (Mean ± SD)	Mean of proximal width of left Achilles tendon in cm (Mean ± SD)	P-value
40	5.50 ± 1.07	5.25 ± 0.88	0.08

Table 3: Mean and standard deviation of proximal circumference of Achilles tendon

Total no. of lower limbs (n)	Mean of proximal circumference of right Achilles tendon in cm (Mean ± SD)	Mean of proximal circumference of left Achilles tendon in cm (Mean ± SD)	P-value
40	10.67 ± 2.2	10.57 ± 1.78	0.15

Table 4: Mean and standard deviation of distal width of Achilles tendon

Total no. of lower limbs (n)	Mean of distal width of right Achilles tendon in cm (Mean ± SD)	Mean of distal width of left Achilles tendon in cm (Mean ± SD)	P-value
40	2.22 ± 0.54	2.05 ± 0.27	0.00

16.35 ± 1.49 cm (Table 1). The maximum length of Achilles tendon measured on left side was 21 cm and minimum length was found to be 15 cm. The mean proximal width of left Achilles tendon was 5.25 ± 0.88 cm (Table 2) and the mean proximal circumference of left Achilles tendon was measured as 10.57 ± 1.78 cm (Table 3). Similarly the other measurements recorded on left Achilles tendon were its distal width and

rupture.¹⁴ Excessive stretching and tightness of AT are thought to be the risk factors of plantar fasciitis and various studies have revealed that there is a continuation of fibres of AT with plantar fascia.^{15,17,25} The study on morphometric measurements of AT have been carried out by various researchers using different methods. In comparison to other methods of study the cadaveric approach seems to be more idealistic

Table 5: Mean and standard deviation of distal circumference of Achilles tendon

Total no. of lower limbs (n)	Mean of distal circumference of right Achilles tendon in cm (Mean ± SD)	Mean of distal circumference of left Achilles tendon in cm (Mean ± SD)	P-value
40	4.27 ± 0.67	4.0 ± 0.42	0.00

distal circumference which were recorded to be 2.05 ± 0.27 cm and 4.0 ± 0.42 cm respectively (Table 4 and Table 5).

On correlating the various parameters measured between right and left lower limbs, the length of right Achilles tendon was found to be more than the left side having p – value of 0.01 (Table 1). Similarly, the distal width and distal circumference of Achilles tendon on right side was found to be more than the left with p - value of 0.00 (Table 4 and Table 5). However, the morphometry of proximal width and proximal circumference of Achilles tendon on both right and left sides were not statistically significant as they show the p-value of 0.08 and 0.15 respectively (Table 2 and Table 3).

DISCUSSION

Over the past few decades the study on Achilles tendon has been an area of attraction to many researchers and probably this could be due to the fact that despite being the strongest tendon in the body it is a frequent site of degenerative changes, inflammation and

as it provides a 3D – view of the structure from which different parameters can be measured by direct observation.²⁶

Different opinions regarding morphometric variations of AT have been postulated. Some studies have reported that AT morphometry vary considerably among various races while some reported that there were no significant correlation between the AT morphometry and the age group, races and ABO blood groups. Nevertheless the tendon width was found to be more in overweight body mass index group.¹⁶

The value of mean length of AT obtained in the present study (Table 1) highly coincided with the value mentioned in standard textbook of Anatomy.¹ The various morphometric parameters of the present study (Table 1 to Table 5) was found to be similar with the study conducted by Apaydin *et al* who had also revealed that the Achilles tendon becomes more rounded at its insertion.²⁸ While some researchers had concluded that there was a statistically significant proximal migration of the insertional location of AT with each advancing year.¹⁸ Some study had demonstrated

that superficial part of insertion of AT is represented by fascicles from medial head of gastrocnemius and deep part of its insertion represented by fascicles from soleus tendon.²⁰ Various studies had also confirmed that the fascicles originating from gastrocnemius and soleus muscles were twisted structure.^{21,23}

The findings of the present study also demonstrated that the mean length, distal width and distal circumference on right side was found to be more than that of the left side (Table 1, Table 4 and 5) indicating the relevance of side dominance which had also been explained by Bohm *et al.*²⁹ Some studies found to be claimed that difference in foot types had a direct relationship with AT morphometry where a thin AT was often associated with a flat arched foot type and moreover thin AT was considered as more vulnerable to develop tendinopathy than a thick AT.³⁰ Some study also revealed that calcaneoplasty and reattachment of AT with suture anchors via a lateral approach for insertional tendinopathy achieves good outcome.¹⁹

The present morphometric study also found that the proximal width and proximal circumference showed no statistically significant difference between right and left side (Table 2 and Table 3) which is also similar with the findings of other researchers.^{22,26} However, we found a significant correlation between total length, distal width and distal circumference of Achilles tendon (Table 1, Table 4 and 5) as similar to another cadaveric study.²⁴ Interestingly, morphometric evaluation of AT was also found to be conducted in human aborted fetuses in Poland where they found that there were no significant correlation between sex or side and size of AT in human fetuses.²⁷ In the present

study the width at its origin was found to be more than the width at its insertion (Table 2 and Table 4) which was found to be decreasing from its origin to insertion site unlikely to that of the findings explained by other researcher¹⁴ and this variation is explainable as the studies covered different population group.

The morphometric profiles of Achilles tendon using a cadaveric approach are considered accurate suggesting that the measurements obtained may closely match in the living of similar age although cadaveric approach is faced with numerous limitations like age group, body mass index, sidedness and availability of equal number of cadavers pertaining to both sexes. We also came across some cadaveric studies where the parameters were measured and compared between the both sexes but in present study only male cadavers were included being the limitation of this study. Hence the comparison of parameters between male and female subjects could not be made.

In conclusion, the tendency of Achilles tendon to get damage and the subsequent surgical repair or management makes it vital to understand its morphometry in various populations. The present morphometric evaluation of Achilles tendon in human cadavers can be of substantial help to clinicians before determining any pathological conditions of AT and can also be of help to surgeons during the surgical repair and reconstruction of damaged tendon. The knowledge pertaining to these morphometric parameters can also be useful to sports physicians and podiatrists as well.

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