MORPHOMETRIC ANALYSIS OF TENDOACHILLES TENDON WITH ITS CLINICAL IMPLICATIONS

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ABSTRACT

Background: Tendoachilles tendon, the strongest and thickest tendon of the body, is formed by tendons of soleus and gastrocnemius begins near the middle of the back of leg and is inserted to the midpoint of the posterior surface of the calcaneum. Normal morphometric measurements of Achilles tendon serve as an important landmark in its anthropometric evaluation and biomechanical attribute. The morphological changes in the tendon size provide important health information for the management of various clinical conditions related to Achilles tendons like simple tendinopathy or acute ruptures of it etc.

Aim: The current study aimed at finding out the detailed morphometric measurements of the Achilles tendon which can be of substantial use to clinicians for determining any pathological conditions associated with tendoachilles.

Materials and Methods: Total 108 lower limbs from 54 donated embalmed cadavers (31 males & 23 females) of age between 55 to 85 years were procured for dissection. The study was carried out in the department of Anatomy SMIMER Surat.

Results: Present cadaveric study found that the length of tendoachilles was significantly high in male than in female and no statistically significant difference in length of tendoachilles between right and left side were noted. The width of the tendoachilles at origin between the right and left side tendons was statistically significant.

Discussion: We found that the length of Tendoachilles was significantly high in male than in female and also width of the tendoachilles at origin was more on right side. Being a frequent site for rupture, degenerative change and inflammation, knowledge pertaining to normal morphometric measurements of Achilles tendon is imperative before determining any pathological variations associated with the tendon and opens the management options to orthopedic surgeons, podiatrist, sports physicians and physiotherapists.

KEY WORDS: Tendoachilles tendon, Tendocalcaneus, Morphometric analysis, Tendinopathy.

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INTRODUCTION

The Achilles tendon, named after the seemingly indestructible mythological Greek warrior. The Achilles tendon is the strongest and thickest and...
more resistant tendon of the human body. It is also one of the most common sites of overuse injuries among athletes [1]. This tendon in the body begins near the middle of the back of the leg and made up of the tendons of the soleus and two heads of the gastrocnemius muscles and is attached to the midpoint of the posterior surface of the calcaneum [2].

The Achilles is directly related to the upright stance and bipedal locomotion of the human providing unique characteristic features to the human[3]. The Achilles with its muscles soleus and two heads of the gastrocnemius and other antigravity muscles of lower limb are much better developed in bipeds in comparison to quadrupeds helping them to lift the whole body up during attaining the erect posture and also in walking up a staircase [4]. The Achilles tendon has been a key player in natural selection process. It was absent from Australopithecus and originated in hominids since more than three million years ago [5].

During development of limbs, rotation of the limb bud occurs i.e. Achilles tendon is twisted and therefore the fibers from the gastrocnemius get arranged on lateral side and those from the soleus get arranged on medial side and are inserted accordingly on calcaneum [6, 7]. Part of the Tendo-achilles which is derived from gastrocnemius can be twisted variably relative to soleus because gastrocnemius crosses the knee joint. Because of this twisting, when the Achilles tendon is under load, it is subject to wringing action [8].

The human has largest angle between the long axis of tibia and calcaneum as compared to any mammal. Due to upright posture of the human, the foot is at right angle to the leg and the Achilles tendon approaches the back of the foot tangentially which generates heavy torque [9].

The Achilles tendon is one of the strong planter flexor of ankle joint. It transmits approximately seven times force of the body weight during running while in standing it transmits only half of the body weight [8].

The Achilles tendon is more vulnerable to injury because of its limited blood supply and combination of forces to which it is subjected [2, 10]. The Achilles tendon consists of collagen type 1 fiber [11]. However, resynthesized collagen becomes type III after the injury [12]. The human Achilles tendon reflects age related changes in its cellular and fibrous components. These changes are often manifested with flattening of the cells along with their decreased quantity [13]. The Achilles tendon is a frequent site to degenerative changes, inflammation and rupture. Pathology of the tendon results in imbalance between mobility and stability. The morphological and morphometric analysis of the Achilles tendon is related to functional necessity and its knowledge provide important health information about tendon such as its undue thickening which could be a precursor for tendon rupture [14]. Therefore, normal morphometric measurements of Achilles tendon serve as an important landmark in its anthropometric evaluation and biomechanical attribute. The normal morphometric measurements of the Achilles tendon Knowledge is imperative before determining any pathological variations associated with it.

MATERIALS AND METHODS

The current study aimed at finding out the detailed morphometric measurements of the Achilles tendons. For this study 108 lower limbs, 54 right and 54 left lower limbs of 54 donated embalmed cadavers (31 males & 23 females) of age group ranging from 55 to 85 years were procured for dissection. The study was conducted in the department of Anatomy SMIMER, Surat. All the lower limbs of cadavers were thoroughly and meticulously dissected. The soleus and gastrocnemius muscles were dissected from their origins. The measurements of Tendo-achilles tendons were taken with the help of measuring scale (figure- 1).

Following parameters were considered for study:

1. Length of tendoachilles tendon (from its formation/origin to insertion)
2. Proximal width of the tendon (near its origin),
3. Middle width of the tendon (midway between origin and insertion)
4. Distal width of the tendon (near its insertion).

The distal width of the tendon was measured at the closest point of insertion to the calcaneal tuberosity.
Fig. 1: shows the measurements of Tendoachilles:

DW- Distal width, L- Length, PW- Proximal Width, MW- Middle width.

OBSERVATIONS

The following findings were observed in our study.

<table>
<thead>
<tr>
<th>Side of Tendoachilles</th>
<th>Length of Tendoachilles tendon in centimeters</th>
<th>Width of Tendoachilles tendon in centimeters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>At origin/Proximal width</td>
</tr>
<tr>
<td>Right Tendoachilles (54)</td>
<td>7.24 ± 2.57</td>
<td>1.45 ± 0.18</td>
</tr>
<tr>
<td>Left Tendoachilles (54)</td>
<td>7.06 ± 2.16</td>
<td>1.35 ± 0.25</td>
</tr>
<tr>
<td>P value</td>
<td>0.07</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Note: P value <0.05 is significant

Table 2: Showing morphometric measurements of tendoachilles tendons in male and female.

<table>
<thead>
<tr>
<th>Gender</th>
<th>Length of Tendoachilles tendon in centimeters</th>
<th>Width of Tendoachilles tendon in centimeters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>At origin/Proximal width</td>
</tr>
<tr>
<td>Male</td>
<td>7.93 ± 2.66</td>
<td>1.23 ± 0.33</td>
</tr>
<tr>
<td>Female</td>
<td>6.34 ± 1.61</td>
<td>1.40 ± 0.22</td>
</tr>
<tr>
<td>P value</td>
<td>0.003</td>
<td>0.41</td>
</tr>
</tbody>
</table>

The length of tendoachilles tendon varies from individual to individual. In our study, average length of all 108 cadaveric lower limbs was 7.15±2.37 cm and mean length of right tendoachilles tendon was 7.24 ± 2.57 cm and that of left was 7.06 ± 2.16 cm. Tendoachilles length showed no statistically significant differences between the right and left side. The mean width of right tendoachilles tendon at its origin was 1.45 ± 0.18 cm, at middle it was 1.23 ± 0.30 cm and at insertion it was 2.33 ± 0.52 cm. The mean width of left tendoachilles tendon at origin was 1.35 ± 0.25 cm, at middle it was 1.25 ± 0.28 cm and at insertion it was 2.25 ± 0.46 cm. The right and left tendoachilles showed statistically significant difference in width at its origin. (p value is 0.02) (Table –1).

The mean length of tendoachilles tendon in male was 7.93 ± 2.66 cm and in female it was 6.34 ± 1.61cm. Tendoachilles length between the male and female tendons was statistically significant. (p value is 0.003). The mean width of tendoachilles tendon in male at origin was 1.23 ± 0.33 cm, at middle it was 1.25 ± 0.45 cm and at insertion it was 2.13 ± 0.63 cm. The mean width of tendoachilles tendon in female at origin was 1.40 ± 0.22 cm, at middle it was 1.23 ± 0.45 cm and at insertion it was 2.18 ± 0.62 cm. (Table–2). But the width of Tendoachilles did not show statistically significant difference.

DISCUSSION

Tendocalcaneus or human Achilles tendon is the most easily accessible, superficial tendon of
human body that transfers the force of muscles to the bones [15,16]. The Tendoachilles is a conjoined tendon made up of Gastrocnemius and Soleus muscles. The soleus plantar flexes the ankle joint and it act as postural muscle because it contains a high proportion of slow-twitch fibers preventing the body from falling forward when standing. However the gastrocnemius also flexes the knee joint and promotes the vigorous propulsive movements because contains a greater number of fast twitch fibers.

Different opinions regarding morphometric changes of tendoachilles have been laid down among various races and social groups. Some studies reported that tendoachilles morphometry vary considerably in different races and social groups while few studies documented that no such differences exist between various races. In our study, we found that average length of tendoachilles in all 108 cadaveric lower limbs was 7.15 ± 2.37 cm. This finding similar with the study of Naveen Ku et al which showed average length of Tendoachilles 7 cm.[17] A study of Apaydin N et al stated that the average length of the tendoachilles is 15 cm, ranging from 11 to 26 cm. This variation can be due to different racial population used in their study as weight and body mass index has also a good correlation with tendon size [18,19].

The mean length of right tendoachilles tendon was 7.24 ± 2.57 cm and that of left tendoachilles tendon was 7.06 ± 2.16 cm. Tendoachilles length showed no statistically significant differences between the right and left side tendons. This is similar to study of Naveen Ku et al. and study by Canbolat M, et al which also showed no significant difference in length of right and left tendoachilles. Canbolat M. et al also found that Achilles tendon width, thickness and area showed no significant differences between the right and left side tendons. This study also confirmed the changes in various morphometric measurements among the individuals who are active in sports and sedentary life style [19]. Bailus et al confirmed the differences in the length of the tendon between dominant and non-dominant side in cadaveric study [20]. Egwu OA et al in Nigerian population documented that significant change in the thickness of tendoachilles between dominant and non-dominant feet and also in right and left side Tendoachilles [21].

In present study, width of Tendoachilles range was from 1.20 to 1.70 cm at origin, 1.00 to 1.90 cm at middle and 1.50 to 3.00 cm at insertion showing the width of tendon was gradually decreasing from its origin to midsection then broadens at its insertion site. These findings are similar to Apaydin N et al study which showed that the mean width of tendoachilles gradually decreases at the midsection from at its origin. He also documented that tendoachilles becomes more rounded at an average of 4 cm above the calcaneus, of about width of 3.4 cm (2.0–4.8 cm) at its insertion site over the posterior surface of the calcaneus [18]. Knobloch et al. found that the width of the tendon ranged from 2 to 6 cm [22]. De Mallo et al. stated that the tendoachilles width would be higher in the overweight body mass index individuals as compared to normal individuals [23].

During comparison of various parameters between right and left limbs, we found that mean width of right tendoachilles tendon at origin was 1.45 ± 0.18 cm, 1.23 ± 0.30 cm at middle and 2.33 ± 0.52 cm at insertion. The mean width of left tendoachilles tendon at origin was 1.35 ± 0.25, at middle it was 1.25 ± 0.28, at insertion it was 2.25 ± 0.46. We found that width of the tendoachilles between the right and left side tendons at origin was statistically significant (p value is 0.02).

In this study, Tendoachilles length between the male and female tendons was statistically significant. (p value is 0.003) which is similar to study of Canbolat M et al who suggested that males have higher length and width than female and concluded that this can be due to differences in muscle strength and mechanical property.[19,24].

In our study, mean width of tendoachilles tendon in male at origin was 1.23 ± 0.33 cm, at middle it was 1.25 ± 0.45 cm and at insertion it was 2.13 ± 0.63 cm. The mean width of tendoachilles tendon in female at origin was 1.40 ± 0.22 cm, at middle it was 1.23 ± 0.45 c and at insertion it was 2.18 ± 0.62 cm. (Table-2).

Munteanu SE at al said that the thinner tendons
are more prone to the risk of tendinopathy and tendency to rupture in comparison to thicker tendon [25]. Koivunen-Niemela & Parkkola opined that the flat arched foot type is often associated with a thinner tendoachilles tendon. They also believe that the variation in the shape of the tendon caused up to 25% variation in its width and that differences in population height could also be related to the tendon thickness [26].

During our literature review we came across that various studies of morphometric evaluation of tendoachilles were done ultrasonographically while cadaveric studies related to Tendoachilles were very less. Studies have shown that ultrasound image measurements of the tendo-calcanecus had exact correlation with the measurements on cadavers. This indicates that morphometric evaluation of tendoachilles in cadavers is a valid and reliable factor which is considered as a gold standard for measurement [27].

As morphological and morphometric variation of Tendoachilles are related to functional requirements, they can be an important landmark for anthropometric evaluation and biomechanical characteristics. The achilles tendon provides a learned practical well-referenced approach to the various manifestations of achilles tendinopathies, acute rupture of the achilles tendon, chronic heel ulcer. The knowledge regarding the normal morphometric measurements of Achilles tendon is imperative before determining any pathological variations associated with the tendon and allows exploring newer options for specific management.

Achilles tendinopathy numbers has been increased in recent years amongst athletes due to overuse of Achilles tendon. Our study presenting normal values of tendoachilles would be very helpful to sport medicine physicians for diagnosis and treatment of Achilles tendon overuse injuries and explain the pathology associated to tendinopathy.

CONCLUSION

Present cadaveric study found that the length of Tendoachilles was significantly high in male than in female and also found that width of the tendoachilles at origin was more on right side. The knowledge regarding the normal morphometric measurements of Achilles tendon may provide new insights in the management of Achilles tendinopathy to orthopedic surgeons, podiatrist, sports physicians and physiotherapists and it can be useful as a tool for diagnosis of achilles tendon medicine.

Conflicts of Interests: None

REFERENCES


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