



Original article

The Achilles tendon resting angle as an indirect measure of Achilles tendon length following rupture, repair, and rehabilitation

Michael R. Carmont^{a,e,*}, Karin Grävare Silbernagel^b, Annelie Brorsson^c, Nicklas Olsson^e, Nicola Maffulli^{c,d}, Jon Karlsson^e

^a Department of Orthopaedic Surgery, Princess Royal Hospital, Shropshire, United Kingdom

^b Department of Physical Therapy, University of Delaware, DE, USA

^c Department of Musculoskeletal Disorders, University of Salerno School of Medicine and Surgery, Salerno, Italy

^d Centre for Sport and Exercise Medicine, Queen Mary University of London, Barts and the London School of Medicine and Surgery, London, England, United Kingdom

^e Institute of Clinical Sciences, Sahlgrenska Academy, University of Gothenburg, Sweden

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Abstract

Background: Rupture of the Achilles tendon may result in reduced functional activity and reduced plantar flexion strength. These changes may arise from elongation of the Achilles tendon. An observational study was performed to quantify the Achilles tendon resting angle (ATRA) in patients following Achilles tendon rupture, surgical repair, and rehabilitation, respectively.

Methods: Between May 2012 and January 2013, 26 consecutive patients (17 men), with a mean (standard deviation, SD) age of 42 (8) years were included and evaluated following injury, repair, and at 6 weeks, 3 months, 6 months, 9 months, and 12 months, respectively (rehabilitation period). The outcome was measured using the ATRA, Achilles tendon total rupture score (ATRS), and heel-rise test.

Results: Following rupture, the mean (SD) absolute ATRA was 55 (8)° for the injured side compared with 43 (7)° ($p < 0.001$) for the noninjured side. Immediately after repair, the angle reduced to 37 (9)° ($p < 0.001$). The difference between the injured and noninjured sides, the relative ATRA, was -12.5 (4.3)° following injury; this was reduced to 7 (7.9)° following surgery ($p < 0.001$). During initial rehabilitation, at the 6-week time point, the relative ATRA was 2.6 (6.2)° ($p = 0.04$) and at 3 months it was -6.5 (6.5)° ($p < 0.001$). After the 3-month time point, there were no significant changes in the resting angle. The ATRS improved significantly ($p < 0.001$) during each period up to 9 months following surgery, where a score of 85 (10)° was reported. The heel-rise limb symmetry index was 66 (22)% at 9 months and 82 (14)% at 12 months. At 3 months and 6 months, the absolute ATRA correlated with the ATRS ($r = 0.63$, $p = 0.001$, $N = 26$ and $r = 0.46$, $p = 0.027$, $N = 23$, respectively). At 12 months, the absolute ATRA correlated with the heel-rise height ($r = -0.63$, $p = 0.002$, $N = 22$).

Conclusion: The ATRA increases following injury, is reduced by surgery, and then increases again during initial rehabilitation. The angle also correlates with patient-reported symptoms early in the rehabilitation phase and with heel-rise height after 1 year. The ATRA might be considered a simple and effective means to evaluate Achilles tendon function 1 year after the rupture.

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Keywords: Achilles rupture; elongation; repair

Introduction

Rupture of the Achilles tendon leads to functional limitation,¹ loss of functional strength,² and endurance.³ Many patients fail to resume sporting activities in the short term, and the injury causes problems for as long as 10 years after rupture.⁴

* Corresponding author. Princess Royal Hospital, Telford, Shropshire TF1 6TF, United Kingdom.

E-mail address: mcarmont@hotmail.com (M.R. Carmont).

The general aim of modern management is to optimize function, as promptly as possible, while minimizing complications. Research has previously focussed on determining optimal methods of treatment, either surgical or nonsurgical, with randomized controlled studies.^{5–12} Rupture is the primary outcome variable in almost all studies with secondary variables being functional outcome, range of motion, calf circumference, and plantar flexion strength.

Some previous studies have reported reduced plantar flexion strength of 10–20% following Achilles tendon rupture,^{2,4,10,13} particularly at the end range of plantar flexion.¹⁴ Compared with the noninjured side, calf muscle activity following rupture is greater during gait and this moderately correlates with the changes in Achilles tendon length ($0.38 < r < 0.52$).¹⁵ Accordingly, it is reasonable to assume that reduced strength during plantar flexion is related to lengthening of the tendon during healing.^{12,13}

The Achilles tendon elongates during the healing and rehabilitation stages.^{16–19} The length of the tendon has been measured either directly using radio-opaque markers being placed within its substance^{16–19} or using imaging modalities such as ultrasound^{13,15} or computed tomography.²⁰ Thus, there is a need to develop a clinically applicable, noninvasive, accurate, and easy-to-perform method to evaluate the length and elongation of the Achilles tendon.²¹

Alteration of the arc of movement of the ankle is an indirect measurement of the Achilles tendon length. Ten millimetres of tendon elongation was shown to result in a 10° increase in dorsiflexion.²² Matles test is a diagnostic sign indicating loss of the tenodesis effect during knee movement from extension to flexion, resulting in increased ankle dorsiflexion after acute Achilles tendon rupture.²³ The resting position of the ankle, due to the tenodesis effect of the Achilles tendon, has been termed the *Achilles tendon resting angle* (ATRA).²⁴ This angle, compared with the noninjured side, may change following rupture, repair, and subsequent rehabilitation.

An observational study was performed to quantify the ATRA following rupture, surgical repair, and rehabilitation. The hypothesis was that the ATRA, an indirect measurement of elongation, would relate to the functional outcome of Achilles tendon rupture.

Materials and methods

Between May 2012 and January 2013, 26 consecutive patients with a midportion rupture of the Achilles tendon were evaluated and included in this study. All patients demonstrated the triad of a palpable gap, the absence of plantar flexion on a calf squeeze, and an abnormal Matles test²³ confirming the diagnosis of rupture of the Achilles tendon.²⁵ Exclusion criterion included the occurrence of a previous contralateral Achilles tendon rupture, although none of the patients had prior rupture in this series. There were 17 male and nine female patients with a mean [standard deviation (SD)] age of 42 (8) years. In 16 patients, the right side was injured.

Patients underwent a minimally invasive repair of the Achilles tendon rupture using an established technique.^{26,27}

Although the majority of patients had their surgery performed under local anaesthesia, 38 (10)% chose general anaesthesia. Repairs were performed using a number 1 absorbable Maxon suture (Covidien, Dublin, Ireland)—eight strands of polyglycolic acid in the configuration of a Bunnell suture proximally and a Kessler suture distally. A 2-cm longitudinal incision was used rather than a transverse stab incision to aid visualization of apposition of the ruptured tendon ends during the repair. A second 2-cm incision was made at the midlateral incision, 8–10 cm proximal to the Achilles insertion. This allowed the sural nerve to be identified and protected during the surgical repair. Patients received prophylactic antibiotic, flucloxacillin (1 g), and 2 weeks of low-molecular-weight heparin [tinzaparin 4500 IU once a day (LEO Pharma, Berkshire, UK)]. Patients were encouraged to bear weight on their metatarsal heads soon after the surgery depending on their tolerance level, using crutches and a protective equinus splint cast for 2 weeks and a dorsal shell for 6 weeks. Thereafter, a 15-mm heel raise was provided. Active movement exercises, plantar flexion, inversion, and eversion contractions (each for 10 seconds) were performed with 10 repetitions, three times/d, and these were commenced at 2 weeks after the surgery.

The ATRA is the angle between the long axis of the fibula and the line from the tip of the fibula to the head of the fifth metatarsal.²⁴ The absolute ATRA is the resting angle of the injured Achilles tendon. The relative ATRA is the difference between the ATRA on the injured side and the noninjured side (Fig. 1A–C). A negative relative ATRA indicates that the injured side is in dorsiflexion; a positive relative ATRA indicates plantar flexion compared with the noninjured side. The ATRA and calf circumferences at 15 cm below the medial joint line of the knee were evaluated at presentation, following surgery, and at 6 weeks and 3 months, 6 months, 9 months, and 12 months after the surgery (Fig. 2A–G). The ATRA was measured using a standard 15-cm arm goniometer with 2° increments. The calf circumference was measured using a standard tape measure with 0.1-cm increments. The ATRA was also measured under general anaesthesia in the 10 patients who chose this option. Patients symptoms and physical activity were evaluated with the Achilles tendon total rupture score (ATRS)^{1,28} and Tegner activity score.²⁹ A test of heel-rise height was used to evaluate recovery of calf muscle function.³⁰ For this test, the maximal single-leg heel-rise height in centimetre was documented and the injured and noninjured sides were compared to determine the limb symmetry index (LSI).

All patients gave consent for participation in this study and as their names were removed, the Ethics Committee confirmed that a formal ethical review was not required.

Statistical analysis

All data were analysed using IBM SPSS statistics version 22 (IBM Corp., Armonk, NY, USA). Descriptive statistics for the ATRS were reported using median (range) and mean \pm SD. The LSI was calculated to compare the results from heel-rise

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