Musculotendinous ruptures of the achilles tendon had greater heel-rise height index compared with mid-substance rupture with non-operative management: A retrospective cohort study

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Introduction: Achilles tendon ruptures (ATRs) may occur at varying locations with ruptures at the mid-substance (MS) of the tendon most common, followed tears at the musculotendinous (MT) junction. There is scant literature about the outcome of MT ATR. This study compared the outcome of patients with a MT ATR with patients following a MS ATR.

Methods: The diagnostic features and clinical outcome of 37 patients with a MT ATR were compared with a cohort of 19 patients with a MS ATR. Patients in both groups were managed non-operatively and received the same rehabilitation protocol with weight-bearing rehabilitation in protective functional brace.

Results: From February 2009 to August 2023, 556 patients presented with an ATR. Of these, 37 (6.7 %) patients were diagnosed with a MT tear. At final follow-up, at 12 months following injury, the MT group reported an Achilles tendon total rupture score (ATRS) of mean (standard deviation (SD)) of 83.6 (3.5) (95 % confidence interval (CI) 81.8, 85.4) and median (inter-quartile range (IQR)) ATRS of 86 points (78–95.5) and the MS group mean (SD) of 80.3 (8.5) (95%CI 76.1, 80.5) and median (IQR) of 87 points (59–95) (p = 0.673). Functional evaluation, however, revealed statistically significant differences in mean (SD) heel-rise height index MT group 79 % (25) (95%CI 65.9, 92.1) and MS group 59 % (13) (95%CI 51.9, 67.1) (p = 0.019). In the MT rupture group, there were considerably less complications than the MS rupture group.

Conclusions: When managed non-operatively, with only a 6 weeks period of brace protection, patients have little limitation although have some residual reduction of single heel-rise at the one-year following MT ATR.

Level of evidence: IV.

What are the new findings?

- The incidence of achilles tendon rupture at the musculotendinous junction was found to be 6.7 %.
- There are different diagnostic characteristics between musculotendinous and mid-substance achilles tendon rupture.
- At 12 months following injury, patients were found to have an achilles tendon total rupture score of 86 points and a heel-rise height index of 79 %.

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Introduction

Achilles tendon rupture (ATR) is a debilitating injury, which poses a considerable burden over a prolonged period of recovery. After 2 months of brace protection and rehabilitation, patients may not return to their pre-existing level of functional activity [1]. Research has focused on determining the optimal treatment of rupture between non-operative and operative repair [2–5].

ATR may occur at varying locations with ruptures at the mid-substance (MS) of the tendon most common, followed tears at the musculotendinous (MT) junction and finally tears at the Achilles insertion into the calcaneum being least common [6]. After MT ATR, the usual diagnostic triad of loss of the normal resting ankle position, termed the Achilles tendon resting angle (ATRA) [7], the presence of a palpable gap within the tendon and the calf squeeze test are challenging to perform and may be less reliable. Simmonds [8] noted that tears at the MT junction may have increased calf swelling due to bleeding and haematoma from the muscular portion of the tear. Overall, for ATR, diagnostic imaging has been found to be less reliable than clinical examination by an experienced practitioner [9–11] but may be required for MT tears.

Given the increased adoption of non-operative treatment for ATR, tears at the MT junction may have been grouped with MS tears without appreciating the difference in location and a potential difference in tears at the MT junction may have been grouped with MS tears without experiencing practitioner [9–11] but may be required for MT tears.

Patient evaluation

Patients were evaluated at the 3, 6, 9, and 12-month time points to determine their ATRA and calf circumference (CC) by the same examiner. ATRA is a quantified measure of the resting angle of the ankle [7]. This has been shown to be valid, reliable, responsive, and reproducible measure in individuals with ATR [17–19]. 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, measured using a standard 30 cm goniometer, with the patient lying prone and both knees flexed to 90°. The absolute ATRA was the resting angle of the injured Achilles tendon. The relative ATRA was the difference between the ATRA on the injured side and the non-injured side. The CC was measured at 15 cm below the medial joint line of the knee. Also, at the 12-month point, the patient's reported outcome was determined using the Achilles tendon total rupture score (ATRS) [20].

Methods

Since 2009, patients presenting to Princess Royal District General Hospital diagnosed with an ATR were entered into a database and followed up for 12 months following injury. The location of the tear was determined by history, clinical examination and where necessary imaging. This is a retrospective study, using prospectively acquired data as part of routine evaluation, comparing the diagnostic features and outcome of acute tears at the MT junction with tears at the MS of the Achilles tendon. All patients had acute injuries presenting within 3 days following injury. Patients presenting beyond this time period were considered to be not suitable for non-operative management and so were excluded.

Patients were diagnosed with a MT tear clinically and then using imaging. The history was of a sudden pop or pain experienced to the Achilles tendon. The clinical features were altered posture to the ankle, termed the ATRA, a calf squeeze test indicating altered tendon continuity compared with the uninjured side, focal tender defect at the MT junction, and absence of a distinct gap at the MS of the tendon. All patients who were suspected clinically of having a MT tear had the diagnosis confirmed using ultrasonography. Both complete and partial tears at the MT junction were included, tears in the medial gastrocnemius and the MS of the Achilles tendon were excluded from this group.

Patients in the MS ATR group were diagnosed clinically. The clinical features of MS ATR were an increased ATRA [1], a calf squeeze test indicating the absence tendon continuity compared with the uninjured side and a distinct palpable gap at the MS of the Achilles tendon. Given that there was a distinct gap at the MS of the Achilles tendon confirming the site of rupture, further imaging was not performed.

Following presentation and diagnosis, all patients were placed into an equinus functional brace made from synthetic casting material in plantar flexion [15]. Patients were permitted to mobilise touch weight-bearing on the metatarsal heads as tolerated using elbow crutches [16]. After two weeks, the posterior half of the cast was removed leaving the anterior shell in situ. This restricted dorsiflexion but permitted some active plantar flexion. At this two-week time point, active plantar flexion, inversion, and eversion exercises were commenced, but active dorsiflexion was avoided. After the six-week time point, the functional brace was discontinued and patients were given a 1.5 cm in-shoe heel wedge for the next 6 weeks and referral for physiotherapy for gait retraining and a progressive strengthening exercise programme.

Statistical analysis

All data were analysed using Statistical Package for Social Sciences version 28 (IBM Corp, Armonk, NY). Patients with MT ATR were compared with the cohort of patients with MS ATR using a similar post-injury protocol. Descriptive statistics were reported using mean and standard deviation (SD 95% confidence interval (CI)) and median (interquartile range (IQR) 25th–75th percentile) values. The normality of data was checked by visual inspection of histogram and assumptions for the parametric test were found to be satisfactory. Categorical analysis was performed using Cross Tabs and Fischer's Exact test. Repeated measures of the ATRA over time were compared using two-way analysis of variance. Statistical significance was taken to be 0.05. All patients who met the inclusion criteria were included in the study. Therefore, no sample size calculation was performed as all patients that were diagnosed and received 6 weeks of brace protection were included. The null hypothesis
was that there was no difference in patient reported or functional outcome between MT and MS ATR.

**Results**

From February 2009 to August 2023, 556 patients presented with an ATR. Of these, 37 (6.7%) patients were diagnosed with a MT tear (Fig. 1).

There were 37 patients who sustained a MT ATR with mean (SD) age 51 (12.5) years, and of these, 4 were female and 19 affected the left Achilles tendon. In the MS group, there were 24 patients with mean (SD) age 56 (13.5) years, 7 were female and 7 affected the left ankle (Table 1).

The number of patients that were evaluated at the 3, 6, 9, and 12 month points are as follows: MT 15, 15, 10, and 14, MS 17, 14, 9, and 14. The assumptions on the normality of data for the parametric test were found to be satisfactory.

The activity during which MT tears were sustained was football 20%, running 20%, pushing vehicles 20%, and badminton 10%. This was similar to the activities during which ruptures were sustained in the MS group: football 29%, walking 29%, and racket sports 10%.

There was no significant difference between the mean (SD) relative CC at presentation MT -0.43 (2.7) cm and MS 0.15 (1.6) cm.

The progress of the ATRA from diagnosis to final follow-up shows a pattern of reduced plantar flexion following cast treatment and then increased plantar flexion with weight bearing and rehabilitation (Fig. 2). Six patients in the MT group had an ATRA at diagnosis that was either equal to or in greater plantar flexion than the non-injured side. Ten patients in the MT group had a CC at presentation that was greater than the non-injured side than eight in the MS group. The ATRA increased following the cessation of brace immobilisation in both groups. The increase occurred earlier by the 3 month point in the MS group compared with the 3–6 months point in the MT group. There were statistically significant differences between two groups at the mean (SD) (95%CI) relative ATRA at 9 months (−6.9 (4.6) (95%CI -8.1, -2.7) (MT) compared with −10.8 (3) (95%CI -8.9, -12.5) (MS), p = 0.006) and 12 months (−5.5 (5) (95%CI -7.7, -3.5) (MT) compared with −10.7 (4.2) (95%CI -13.9, -9.9, -13.9) (MS), p = 0.019).

At final follow-up, at 12 months, the MT group reported an ATRS of 83.6 (3.5) (95%CI 81.8, 85.4) and median (IQR) ATRS of 86 points (78–95.5) and the MS group mean (SD) of 80.3 (8.5) (95%CI 76.1, 80.5) and median (IQR) of 87 points (59–95) (p = 0.673). Functional evaluation at final follow-up, however, revealed statistically significant differences in mean (SD) HRHI MT group 79% (25) (95%CI 65.9, 92.1) and MS group 59% (13) (95%CI 51.9, 67.1) (p = 0.019). All patients in the MT group evaluated were able to perform a single heel rise on the affected side. Two patients in the MS group were unable to perform a single heel rise on the affected side but it needs to be appreciated that they were unable to perform this on the non-affected side either.

In the MT rupture group, there were considerably less complications than the MS rupture group (Table 2). The most common complication was tendon elongation followed by nerve dysaesthesia in MS group. In the MT group, no patients were considered to have suffered significant

**Fig. 1.** Flow diagram of patients included in this study. ATR = Achilles tendon rupture, ATRS = Achilles tendon total rupture score, ATRA = Achilles tendon resting angle, HRHI = heel-rise height index, n = number.

**Fig. 2.** The progression of Achilles tendon resting angle from diagnosis, through brace protection and 12 months of rehabilitation following Achilles tendon rupture. ATRA = Achilles tendon resting angle, MT = musculotendinous rupture, MS = mid-substance rupture, w = weeks, m = months.

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**Table 1**

<table>
<thead>
<tr>
<th>Patient demographics.</th>
<th>Musculotendinous</th>
<th>Mid-substance</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>37</td>
<td>24</td>
<td>N.A.</td>
</tr>
<tr>
<td>Age/Years</td>
<td>51 (12.5)</td>
<td>56 (13.5)</td>
<td>0.111</td>
</tr>
<tr>
<td>Gender F/M</td>
<td>4/33</td>
<td>7/17</td>
<td>0.08</td>
</tr>
<tr>
<td>Side L/R</td>
<td>19/18</td>
<td>7/17</td>
<td>0.099</td>
</tr>
</tbody>
</table>

F = Female, M = Male, L = left, R = right. N.A. = Not applicable.
tendon elongation evaluated with ATRA. In the MS group, four (21%) patients suffered tendon elongation.

Discussion

The most important finding of this study was that patients with a MT ATR with only a 6 weeks period of brace protection, have little limitation, although have some residual reduction of single heel-rise at the one-year following injury. Patients with MT tears in this study reported a median ATRS of 85 points at 11 months follow-up, termed good (>80 points) according to Svedman et al. [28]. This is a high score for patients managed non-operatively for MS ATR with reported scores around 80 points being reported [12,29,30]. This suggests that patients have less limitation following MT ruptures compared with MS ruptures. It should be noted that the comparison MS group had a median ATRS of 87 points in this series; however, scores were completed using the same principles which were subsequently published by Swennergen Hansen et al. [31].

Functional evaluation, however, revealed statistically significant differences in HRHI. Patients following MT rupture recovered greater HRHI than those in the MS group. The scores in the MT group were similar to that following minimally invasive repair of MS ATR (82%) [1]. This study showed that patients with MT ATR demonstrated similar ATRS but greater plantar flexion function than that attained following MS tear.

Giordano et al. [6] reported that patients with MT ruptures were found to be younger, 35.1 years, compared with patients with MS tears. In Ahmad et al. [14] series, the mean age of patients was 40.8 years. However, in the present study, the mean age for the MT group was 51 years, and there was no statistically significant difference between the groups. Most series of patients with ATR report mean ages in the 5th and 6th decade; however, ages are considered by many to be increasing [22–26]. The activities during which MT ruptures were sustained was typical for ATR in this region with predominantly football in male patients [16,27].

In Giordano et al. series [6] all 14 patients were treated with operative treatment, either end-to-end or augmented repair. This contrasts with the traditional paradigm of non-operative treatment for MT ATR. Ahmad et al. [14] described patients with myotendinous ruptures reporting scores of 95.2 points out of 100 (66.7–100) using the FAAM after 40.8 months of follow-up. Patients received the same duration of brace protection 6 weeks being managed non-operatively.

Very few complications occurred in the MT group with no cases of re-rupture or skin complications requiring treatment; however, one case of deep venous thrombosis and one patient reported symptoms consistent with adhesion [32] did occur. In the MS group, there was two cases of re-rupture and one case of non-union resulting in tendon elongation consistent with previous studies following non-operative treatment after ATR [12,29]. No patients in the MT group were considered to have suffered tendon elongation; however, this occurred in a fifth of patients following MS tear despite receiving brace protection for 6 weeks. It is, therefore, possible that MT ruptures are less prone to re-rupture and elongation than MS tears; however, this conclusion could not really be made with the numbers of patients in these groups.

Although not the primary aim of this study, the diagnosis of MT ATR was considered to be more challenging than MS tears. Patients did not all have an increased ATRA, the calf squeeze test was painful, affecting assessment, and frequently no distinct palpable gap was discernible at the muscle tendon junction. In all cases, there was clinical suspicion of rupture so that imaging was required for diagnosis. The lower ATRA may indicate partial rupture occurring with the larger MT zone of injury compared with the MS site of rupture. In his paper, Simmonds [8] stated that patients may have an increased CC due to increased bleeding from the vascular muscle portion of the calf. This haematoma could account for increased pain leading to reduced sensitivity of the calf squeeze test. Previous studies on tears at the MS of the Achilles tendon have indicated higher clinical accuracy than magnetic resonance imaging (MRI) imaging [9–11], however for MT tears the present study would suggest that imaging is required for diagnosis at this stage in the understanding of this injury. MRI was used to diagnose myotendinous ruptures in Ahmad et al. series [14]. It is recommended that imaging is performed if there is doubt about the location of tear in ATR.

Strengths of this study include that validated outcome measures specific to ATR have been used. One of the main limitations of this study includes the loss to follow-up resulting in reduced numbers. This could suggest that many patients were satisfied with their outcome following this injury and did not attend. Alternatively, patients may have attended elsewhere although given current management trends operative treatment would be unlikely [22–26]. The relative infrequency of MT ATR makes the determination of outcome measures for this group of patients challenging. Additionally, patients were included over a considerable period of time and outcome evaluation expanded with time. This meant that many values were not available for all patients. Also, a number of patients did not attend clinic during the period of the COVID pandemic. Loss to follow-up in is an appreciated problem in database series. In Hutchison et al. 2015 series [30] only 43 out of 273 (15.8%) patients were evaluated after 9 months following rupture.

Another limitation of this study is the use of ultrasonography in the MT group alone rather than both groups to confirm the location of the rupture. Patients were only included in the MS group if there was a discrete palpable gap or defect in the MS of the achilles tendon. Patients in the MT group had the absence of a discrete palpable gap to the tendon and so required ultrasonography to aid diagnosis of rupture and the location of the rupture at the MT junction.

Additionally, the operator-dependent nature of ultrasonography is a factor. The size, multplanar nature, and complexity of MT tears make them challenging to describe and compare. Some MT tears may propagate into the tendon substance and yet, however, were partial in that there was no complete discontinuity between the tendon ends. All of these variables may influence outcome in addition to the variation of description between ultrasonographers.

It is important that the characteristics of MT ATR are appreciated and cases are diagnosed using imaging to differentiate from MS rupture. On an individual patient basis, this would avoid MT patients from having surgical repair or unnecessary inconvenient prolonged periods of brace protection as the duration of brace protection following ATR is generally considered to be 8 weeks. From a research perspective, it is important to identify patients with MT ruptures so that they are not erroneously included into studies on MS ruptures. The improved outcome of these patients in this series could result in incorrect findings if patients with MT ruptures were erroneously included.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

The Authors declare that they have no competing interests.

Mr Carmont has received bursaries from the British Orthopaedic Foot Ankle Society and the British Association of Sport and Exercise Medicine.

Table 2
Complication rates and numbers in both injury groups.

<table>
<thead>
<tr>
<th>Complication:</th>
<th>Musculotendinous/ % (n)</th>
<th>Mid-substance/ % (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Re-rupture</td>
<td>0</td>
<td>8.3 (2)</td>
</tr>
<tr>
<td>Tendon elongation</td>
<td>0</td>
<td>21 (4)</td>
</tr>
<tr>
<td>Non-union</td>
<td>0</td>
<td>4.2 (1)</td>
</tr>
<tr>
<td>Adhesion</td>
<td>2.7 (1)</td>
<td>0</td>
</tr>
<tr>
<td>Deep venous thrombosis</td>
<td>2.7 (1)</td>
<td>4.2 (1)</td>
</tr>
<tr>
<td>Nerve dysesthesia sural</td>
<td>0</td>
<td>12.5 (3)</td>
</tr>
<tr>
<td>and deep peroneal</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

151
Acknowledgements

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References