The Foot

Delayed Achilles tendon rupture presentation: Non operative management may be the SMART choice

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Cover Letter

Thank you very much for consideration of our paper for publication in your journal. We believe our paper presents an interesting alternative to conventional thinking on chronic or delayed Achilles tendon injuries, even in the younger and more active patients.

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Highlights

- Non-operative management of delayed or chronic Achilles Tendon injuries
- Swansea Morriston Achilles Rupture Treatment Protocol
- Treatment in the young and sportingly active population

Delayed Achilles tendon rupture presentation: Non operative management may be the SMART choice

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Daniel MG Winson: Data collect, write-up, statistical analysis.

Rory MacNair: Study design, data collection.

Anne-Marie Hutchinson: SMART protocol and lead physiotherapist for trail patients.

Nick J Owen: Biomechanical analysis of trial patients, statistical analysis.

Rhodri Evans: Collection of MRI scans and analysis of results.

Paul Williams: Study Design, Manuscript editing.

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Abstract

Introduction:

This biomechanical study aims to assess the function of patients who were treated non-operatively for delayed diagnosis Achilles tendon rupture. Patients were treated using the Swansea Morriston Achilles Rupture Treatment protocol (SMART), which is a physiotherapy led non-operative treatment program.

Methods:

19 patients (16M:3F) were enrolled and prospectively assessed using ARS/ATRS (PROMS), Ankle ROM and isokinetic peak torque for plantarflexion of the ankle. MRI scans of both the injured and uninjured TA were performed to compare both AP diameter and length.

Results:

Both ATRS and ARS improved between short and long-term follow-up. The mean difference in plantar torque between the injured and uninjured leg was 21.9%. There was no significant difference in ankle plantarflexion or dorsiflexion. There was no significant difference in length of the injured and uninjured TA on MRI. 3 patients failed the SMART protocol requiring surgical fixation.

Discussion:

The SMART protocol can be an effective method of treatment even in younger and active patients especially if delay to treatment is less than 12 weeks. It may still be preferable for patients with a large gap size or high functional demand to elect for surgical intervention, but clinicians should consider the SMART protocol

as an alternative to surgery and discuss it with some patients as a viable alternative.

Keywords: Tendoachilles, Conservative, Chronic, Delayed

Abbreviations: TA: Tendoachilles; **SMART:** Swansea Morriston Achilles Rupture Treatment

Introduction

Delayed Achilles tendon ruptures have traditionally been treated by surgical intervention with extensive literature reporting better outcomes for the surgically treated patient [1-5]. Maffulli supports the operative management in the treatment of chronic Achilles tendon rupture [6] and Padinilam goes on to state that although non-operative treatment may be indicated for some patients, most are best managed with surgical reconstruction [7].

Different terminology has been used throughout the literature to describe a delayed tendon rupture including, neglected rupture, chronic rupture, missed rupture, late rupture or old rupture. There is also a variation in the definition of timing relating to when an Achilles tendon rupture is no longer acute, ranging from 2 to 6 weeks post index event [8-10].

A multitude of different surgical techniques are described in the literature to treat delayed Achilles tendon rupture [11-16]. There is however no consensus on the non-operative treatment of delayed tendon ruptures and especially the rehabilitation programs post-immobilization, although it has been previously suggested that its use is only for very low demand patients [7,17]. The main objective of treatment, whatever method employed, is to restore the normal length and tension to the Achilles tendon complex [18,19].

The purpose of the current study was to assess the biomechanical function of patients who were treated non-operatively for delayed diagnosis Achilles tendon rupture. The study also sought to establish whether adequate outcome measures can be achieved through non-operative treatment alone using the Swansea Morriston Achilles Rupture Treatment protocol (SMART) [8].

Materials and methods

Ethical Approval

Ethical approval was not required for this study as it was ratified as a service evaluation by the local ethics committee.

Patient Recruitment

Between 2008 and 2014 a total of 35 patients were retrospectively identified as having a delayed presentation of an Achilles tendon rupture. In this study delayed presentation was defined as more than two weeks after the index injury. 28 were treated non-operatively and 7 surgically. 3 conservatively treated patients failed the SMART protocol and were treated surgically. They were not included in the study.

19 conservatively treated patients (16M:3F) consented to enroll in the study and participated in the initial follow-up. Patients had a mean age of 60 years (range 39-80 years). After the initial data collection 3 were lost to follow-up (2M:1F), leaving 16 patients (14M:2F) at long-term follow-up. All participants completed the SMART protocol during their initial treatment. The mean time between initiation of treatment and entry into the study was 3.2 years (range 0.8 to 6.4 yrs). Mean time between entry into the study and long-term follow-up was 6.6 years (range 4.1 to 9.3yrs). The mean tendon gap size at presentation was 10.6 mm (0-40mm). Documentation on gap size on Ultrasound Scan and location of the tear was poor with 10/19 scan reports failing to accurately report these factors. This inconsistency is due to difficulty of assessing tendon gap in a

chronic rupture and that a reporting proforma was not universally used in the department at the time of the scans. Since conducting this study we have introduced a standardized proforma within the department to document the gap size and location of tear. Eleven patients reported left sided injury. Mechanism of injury and past medical history are demonstrated in Table 1.

SMART Protocol

The patients were managed conservatively via the SMART protocol which is also used in our department for the management of acute Achilles tendon rupture. As part of the protocol all patients presenting with a clinically suspected rupture have an ultrasound carried out by a consultant musculoskeletal radiologist, and are then seen in a dedicated Achilles clinic, run by specialist physiotherapists. The protocol guides the management of the acute injuries. Due to the more complex nature of delayed injuries the decision for surgical or non-operative management was made by a consultant foot and ankle surgeon. Each case was considered individually, taking into account co-morbidities, the delay until presentation, pre-injury functional status together with the findings on ultrasound. Cause of injury and past medical history are displayed in **Table 1a-c**.

Patients were placed into a weight-bearing equinus cast at the time of diagnosis for two weeks, after which a walking orthosis (Vacoped, Oped UK Ltd, Devizes, United Kingdom) that enabled a gradual reduction in equinus was used. Treatment was supervised by specialist physiotherapists in the Achilles clinic for 10 weeks. After removal of the orthosis all patients were referred to physiotherapy at their local hospital with strict guidelines for further rehabilitation. Ongoing reviews were conducted in the Achilles clinic until at least 8 months post immobilization or until the patient had achieved their desired activity levels. [8]

Clinical and Functional Outcomes

All patients had Achilles Tendon Rupture Scores (ATRS), Achilles Repair Scores (ARS) and complications were recorded at two initial assessments and long-term follow-up assessment. As part of the first assessment, which took place at Swansea University, ankle range of movement, muscle dynamometry and comparison MRI scans of the Achilles tendon were also performed.
Ankle dorsiflexion and plantarflexion were measured using a goniometer (Smith and Nephew, Hull, UK) dorsiflexion was measured in weight-bearing and calculated as the angle between the 5th Metatarsal and the fibular. Plantarflexion was non-weightbearing, again between the 5th MT and fibula.

Muscle function was assessed using an isokinetic dynamometer (Humac Norm, Computer Sports Medicine Inc., Massachusetts, USA). This measured isokinetic peak torque (PT) for plantarflexion of the ankle. Using a validated protocol [20], each evaluation consisted of an active warm-up on a static bike, followed by 6 trials on the dynamometer. The maximum torque for each trial was recorded and the mean peak value of the plantar flexion concentric contraction was used. The values for the uninjured side were also measured for comparison.

All patients had an MRI scan of both lower legs, using a 1.5 Tesla scanner (GE Healthcare, Amersham, Buckinghamshire, UK) . This allowed accurate measurement of the Achilles tendon length and diameter. Any significant abnormalities at the rupture site were also be identified.

Statistical Analysis

Differences between the affected and unaffected leg for muscle function, ankle range of motion and MRI results was calculated by using a two-tailed Student T-test with confidence intervals set at 95% and calculated through SPSS (v.14.0, SPSS Inc. Chicago, Illinois).

Results

Complications

No Cases of re-rupture were encountered. No skin complications secondary to the immobilization occurred. One patient developed a non-fatal Pulmonary Embolus and was treated for this without further complication. This patient had been risk assessed and found to be low risk for Deep Vein Thrombosis and therefore was not started on prophylaxis. Two patients failed the SMART protocol and went on to have a Flexor Hallucis Longus transfer. One further patient was not fully compliant with immobilization and self-discharged from the SMART program 4 weeks early. None of these three patients were included in the study.

Scores

All 19 patients completed ATRS and ARS at initial follow-up and 16 patients at long-term follow-up. Three patients were lost to long-term follow-up (declined to participate). Mean ATRS at initial follow-up was 64.7 (17 to 100), increasing to 83 (39 to 100) at long-term follow-up. Mean ARS at initial follow-up was 71.1 (30 to 100) and 77.5 (35 to 100) at long-term follow-up. The ATRS and ARS scores as divided by delay are demonstrated in the tables below (**Table 2 a-c**). All patients reported that they would proceed with conservative treatment again in similar circumstances regardless of their ATRS and ARS scores.

Strength (torque) testing

Eighteen patients underwent dynamometer testing of plantarflexion at initial follow-up. One patient found it too uncomfortable to finish the testing. The mean maximum plantarflexion torque in the injured leg was 19.9 N.m (6.3 to 34.2 N.m) compared to 25.7 N.m (12.2 to 43.3 N.m) in the uninjured. The mean difference in plantarflexion torque was 21.9% (-62.5% to 63.1%), which was significant (p-value 0.001). Two patients had better strength in the injured leg compared to the uninjured side but both had a history of previous Achilles tendon rupture on the other side.

Ankle Range of Movement

All 19 patients had formal assessment of plantarflexion and dorsiflexion range of movement. There was no significant difference in either plantarflexion or dorsiflexion between the uninjured and injured legs. The data was also analysed to look at only patients who sustained their injury whilst participating in sport or who are under the age of 60 and no significant difference was found between the injured and uninjured legs in range of plantarflexion. There was significantly reduced range of dorsiflexion in the active and under 60 years old groups compared to the uninjured leg. There was no significant difference in plantarflexion or dorsiflexion in those patients with a delay of more than 6/52 (**Table 3**).

MRI examination

Of the original 19 patients, 18 had MRI imaging of both the injured and uninjured tendons at initial follow-up. One patient was unable to tolerate an MRI.
There was no significant difference in tendon length between the injured and uninjured tendons. The injured tendon was significantly larger in the AP diameter in the injured tendon compared to the uninjured tendon (**Table 4**). The AP diameter was also significantly higher in the injured tendon of the active group of patients. There was no significant difference in tendon length in the active, under 60 years or delay of over 6 weeks' patient groups.

Failed patients

3 patients originally enrolled in the SMART protocol went on to have surgical intervention. The reasons for failure are presented in **Table 5**. ARS and ATRS were recorded for 2 of the patients at 4 and 8 month follow-up respectively.

Discussion

The participants in this review study reported good outcomes measures indicated by the Achilles Tendon Rupture Scores (ATRS) and Achilles Repair Scores (ARS) ATRS and ARS. This was particularly the case for patients with a 2- 6 week delayed presentation. When compared to conservatively managed acute Achilles tendon ruptures the results are equivalent. Hutchinson et al reported ATRS of 72.4 at 9 months and ARS of 72.3 at 9 months following completion of the SMART Protocol [8]. These scores compare favorably with the literature advocating surgical repair, with Anathallee et al reporting an ATRS of 91.3 at 5 years in patients using the Achillon suture passing device [21] and Lever et al reporting an ATRS of 83 at 6 years following FHL transfer [22]. Our study shows that delays of over 12 weeks have less improvement than those under 12 weeks. We believe that after 12 weeks the remodeling phase of tendon healing is sufficiently advanced that the rupture gap cannot be reduced by the SMART program alone. We cannot prove or refute this from the data we have though, to do so would require further work. However, on the basis of our results, we would be more inclined to consider surgery as an option for patients presenting with a delay of over 12 weeks, depending on patient factors and co-morbidities.

The peak torque deficit in our patients is marginally better than the mean torque deficit reported for both conservatively treated acute tears (23%) and surgically treated delayed tears (24%) [22-24]. Importantly none of these studies reported a decrease in functional scores, indicating the decrease in strength does not correlate to a subjective decrease in function. Our results could be biased by the two patients with greater strength in injured side compared to the uninjured side. However, even if these scores are excluded the mean difference is calculated at 3% which is still comparably satisfactory.

Our study reports that there is no significant reduction or increase in ankle range of motion following treatment via the SMART protocol. Wegrzyn et al reported a similar range of movement (45.5^0 plantarflexion and 12^0 dorsiflexion) following FHL transfer, which was also not a significant difference to the non-operative side [25].

Myerson reported that chronic ruptures will have lengthening of the tendon which leads to loss of mechanical efficiency and subsequent loss of strength [26]. In contrast to this our study found that there was not a significant difference in tendon length between the injured and uninjured legs following treatment with the SMART protocol. The injured tendon was significantly thicker in the AP diameter, however we do not know if this thickness decreased over time as MRI was only performed at the initial follow-up.

The most reproducible way of assessing tendon length is a linear measurement from the myotendinous junction to the most inferior part of the calcaneus insertion. However, with a lax tendon there is more of an element of curve so a simple linear measurement might underestimate or under measure any increase in tendon length. This must be appreciated as a limitation in the study.

There is a variation in the existing literature as to what constitutes a delayed or late diagnosis of Achilles tendon rupture [8,9,10]. We set our criteria for delayed presentation at 14 days because the injury will be into the reparative phase of healing and passed the initial inflammatory stage.

Three patients initially treated on the SMART program requested a change in treatment part way through the program. This was due to the patients' subjective poor response to treatment. Two patients aged 45 and 55 both requested surgery due to perceived poor outcomes subjectively despite ATRS and ARS scores better than some patients within the same group. Retrospective review of the clinic notes shows that while their scores were lower than the average score they were not the lowest scores in their subgroup at initial follow-up. This suggests that they may have gone on to improve both their ARS and ATRS had they persisted with the SMART programme. No post-operative scores are available for comparison. The third patient did not have any scores done following the initiation of SMART treatment. Throughout his treatment there were issues with compliance with treatment plans and he remained dissatisfied with his outcome even following surgery.

A total of 7 patients went straight for surgical intervention and were not offered treatment on the SMART program. These patients had an average delay to

presentation of 207 days (range 20 to 730 days). The decision to proceed straight for surgical treatment was made based on either large gap sizes or significant delay to presentation of greater than 12 weeks. As previously stated, our study suggests that these patients do not perform as well with the SMART program and therefore surgery was likely selected in these patients for this reason.

A limitation of our study was the relatively small group of patients (n=19) in our study group, although this is similar sizes as in much of the existing literature. A larger sample size would allow us to explore the differences in the different delay groups with greater statistical significance. Our surgically treated group did not reach the required statistical power threshold and was therefore not included in the study. This means that we have no direct comparison of conservatively and surgically treated patients in our center. This would be an interesting future study to undertake.

Conclusion:

We believe that contrary to much of the current literature, surgery is not always required following delayed Achilles tendon rupture presentation. The SMART protocol can be an effective method of treatment even in younger and active patients especially if the delay to treatment is less than 12 weeks. It may still be preferable for patients with a large gap size or high functional demand to elect for surgical intervention, but clinicians should consider the SMART protocol as an alternative to surgery and discuss it with some patients as a viable alternative.

Brief Summary:

- Traditionally delayed or chronic Achilles tendon ruptures are treated surgically in all but the most unsuitable surgical candidates.
- The use of a dedicated physiotherapy rehabilitation programme, such as the SMART Protocol, for the treatment of delayed Achilles tendon rupture leads to good clinical outcomes.
- The SMART protocol is a viable treatment option for the treatment of delayed Achilles tendon injuries even in young and physically active patients

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Conflict of Interest

The authors have no conflicts of interest to declare.

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Tables

Table 1a: Delay of 2 to 6 weeks. Patient demographics, delay to treatment, gap size, time to follow-up, mechanism of injury and past medical history of all patients

	Age	Sex	Delay to treatment (days)	Gap Size (mm)	Time to initial FU (Years)	Time to long-term FU (Years)	MOI	PMHx
1	*47*	M	14	5	6.2	9.3	Dancing	Nil
2	*62*	M	15	-	6.3	9.3	Running in sea	Nil
3	*56*	M	26	20	1.4	4.5	Tennis	Nil
4	*67*	M	28	0	1.2	4.3	Mechanical fall	Monoclonal glamopathy, prostate Ca
5	*80*	M	32	-	1.1	4.1	Unsure	IDDM
6	*62*	M	35	0	3.8	6.9	Chasing squirrels	Menieres, vertigo
7	*64*	F	35	45	1.1	4.1	Fall off box	Nil
8	*56*	M	42	0	3.2	6.2	Badminton	Parkinsons, visual impairment

Table 1b: Delay 6 to 12 weeks. Patient demographics, delay to treatment, gap size, time to follow-up, mechanism of injury and past medical history of all patients

	Age	Sex	Delay to treatment (days)	Gap Size (mm)	Time to initial FU (Yrs)	Time to long-term FU (Yrs)	MOI	PMHx
9	*59*	M	44	40	2.4	5.6	Mechanical fall	Peripheral neuropathy, PE while in POP
10	*64*	M	44	-	2.1	5	Unsure	IDDM
11	*67*	M	49	-	1.8	-	Foot caught in dog lead	Nil
12	*45*	M	49	-	6.4	9.4	Squash	Nil
13	*63*	F	55	-	2.1	-	Tennis	Nil
14	*80*	M	56	-	3.2	6.3	Unsure	Bilat TKRs
15	*56*	M	61	9	5.6	8.8	Mechanical fall	Brodie's abscess injury side (open debridement & abx beads)

Table 1c: Delay >12 weeks. Patient demographics, delay to treatment, gap size, time to follow-up, mechanism of injury and past medical history of all patients

		Age	Sex	Delay to treatment (days)	Gap Size (mm)	Time to initial FU (Yrs)	Time to long-term FU (Yrs)	MOI	PMHx
16		*62*	F	87	0	2.8	6.1	Tennis	Nil
17		*51*	M	107	-	0.9	-	Trip	Nil
18		*39*	M	135	-	2.5	5.9	Football	Eczema, steroids, depression
19		*66*	M	249	34	6.6	10.3	Running	Eczema

Table 2a: Delay of 2 to 6 weeks. ATRS and ARS at Initial and long-term follow-up. Including 2 patients who failed SMART (F1+2)

	Initial ATRS	Long-term ATRS	Initial ARS	Long-term ARS
1	93	86	90	100
2	71	97	65	90
3	99	100	95	100
4	72	88	75	90
5	17	41	35	50
6	79	96	95	80
7	71	69	70	75
8	58	91	70	80
Av	**70**	**83.5**	**74.38**	**83.13**
F1	46	-	70	-
F2	61	-	80	-

Table 2b: Delay of 6 to 12 weeks. ATRS and ARS at Initial and long-term follow-up.

	Initial ATRS	Long-term ATRS	Initial ARS	Long-term ARS
9	43	91	65	80
10	46	81	60	45
11	51	-	50	-
12	95	99	95	90
13	100	-	100	-
14	80	100	90	100
15	51	97	85	95
Av	**66.6**	**93.6**	**77.9**	**82.0**

Table 2c: Delay of >12 weeks. ATRS and ARS at Initial and long-term follow-up.

	Initial ATRS	Long-term ATRS	Initial ARS	Long-term ARS
16	57	87	55	60
17	63	-	70	-
18	21	39	30	35
19	63	66	55	70
Av	**51**	**64**	**52.5**	**55**

Table 3: Comparison of Plantarflexion (PF) and Dorsiflexion (DF) between injured and non-injured legs. Results are also displayed for patients who sustained the injury during sporting activity (active group), patients under the age of 60 and patients whose delay to treatment was more than 6 weeks. All figures are representative of the mean and the range.

	PF (^{0})	**PF Active Group (^{0})**	**PF <60yr (^{0})**	**PF >6/52 (^{0})**	**DF (^{0})**	**DF Active Group (^{0})**	**DF <60yr (^{0})**	**DF >6/52 (^{0})**
Injured (range)	48.84 (38 to 66)	49.40 (38 to 66)	49.60 (40 to 60)	47.27 (38 to 61)	18.26 (8 to 28)	19.32 (10 to 28)	19.00 (15 to 26)	70.73 (64 to 77)
Uninjured (range)	52.16 (8 to 28)	52.90 (41 to 68)	51.30 (41 to 60)	50.91 (40 to 61)	20.58 (9 to 35)	21.20 (16 to 30)	22.25 (11 to 30)	68.73 (55 to 79)
p Value	0.22	0.34	0.47	0.23	0.23	**0.001**	**0.002**	0.45

Table 4: Comparison of Achilles tendon length and AP diameter between injured and non-injured legs. Results are also displayed for patients who sustained the injury during sporting activity (active group), patients under the age of 60 and patients whose delay to treatment was more than 6 weeks. All figures are representative of the mean and the range.

	Length (mm)	**Length Active Group (mm)**	**Length <60yr (mm)**	**Length >6/52 (mm)**	**AP (mm)**	**AP Active Group (mm)**	**AP <60yr (mm)**	**AP >6/52 (mm)**
Injured (range)	104.94 (51 to 155)	95.80 (51 to 155)	104.57 (64 to 152)	116.55 (51 to 155)	12.99 (8 to 17)	13.76 (11 to 17)	13.07 (10 to 17)	12.91 (10 to 17)
Uninjured (range)	97.31 (43 to 139)	84.09 (43 to 134)	105.74 (54 to 136)	110.89 (55 to 139)	10.16 (6 to 19)	9.34 (6 to 19)	11.84 (6 to 19)	10.90 (6 to 15)
p Value	0.49	0.45	0.94	0.69	**0.009**	**0.003**	0.53	0.09

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Conflicts of Interest

The authors have no conflicts of interest to declare.