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Short- and Intermediate-Term Results of Extracorporeal Shockwave Therapy for Noninsertional Achilles Tendinopathy

Nasr Awad Abdelkader, PhD[1], Mohamed Nasser Kise Helmy, BSc PT[2], Nadia Abdelazem Fayaz, PhD[1], and Emad S. B. Saweeres, FRCS (Tr & Orth), MD[3]

Abstract

Background: Earlier randomized controlled trials (RCTs) reported only midterm (3-4 months) results of extracorporeal shockwave therapy (ESWT) as a treatment for noninsertional Achilles tendinopathy (NAT). This study compared the effectiveness of an eccentric loading program followed by stretching exercises combined with ESWT (study group) or sham ESWT (control group) for treating chronic NAT in both the short and long term.

Methods: This double-blind RCT was conducted between 2018 and 2020. Adult patients with unilateral NAT who failed standard conservative treatment were randomly allocated to either group. Function and pain were assessed at baseline, 1 month, and 16 months using the Victorian Institute of Sport Assessment–Achilles questionnaire (VISA-A) and visual analog scale (VAS), respectively. Mixed-design analysis of variance and nonparametric statistics were performed. Twenty-two men and 28 women aged 18 to 40 years were allocated into 2 equally matched groups.

Results: Function and pain scores in the study group were not significantly different from control group scores at baseline (VISA-A: 22.2 ± 6.5 vs 21.0 ± 5.2 and VAS: 8 ± 1 vs 8 ± 1, respectively). Both groups significantly improved posttreatment (VISA-A: 85 ± 6.2 vs 53.4 ± 7.7 and VAS: 1 ± 2 vs 7 ± 2, respectively). At the 16-month follow-up, outcome scores declined slightly but significantly in the study group (VISA-A: 80 ± 5.3; VAS: 3 ± 2) and improved in the control group (VISA-A: 67 ± 5.6; VAS: 5 ± 1). However, both groups were significantly better than baseline. At both time points, the study group had significantly superior scores (statistically and clinically) than the control group ($P = .0001$).

Conclusions: Combining calf eccentric loading with stretching exercises resulted in significant improvements in the pain and functional scores in patients with NAT. Adding ESWT to this combined protocol resulted in significantly greater improvements in both the short and long term.

Level of Evidence: Level I, randomized controlled trial.

Keywords: noninsertional Achilles tendinopathy, extracorporeal shockwave, eccentric loading, stretching exercise, long-term follow-up

Chronic Achilles tendinopathy (AT) is a common, disabling overuse condition of the foot and ankle, especially during walking and running. AT has 2 types: the insertional type affecting the point of insertion of the Achilles tendon at the calcaneus and the noninsertional type affecting the area 2 to 6 cm proximal to Achilles insertion.[7,10] Several good reviews exist summarizing the pathophysiology, clinical and imaging features, and treatment options of AT.[7,10,26,27,32] Nonoperative treatments should be attempted for at least 6 months before surgery is offered. A multimodal regimen includes painful activity avoidance, nonsteroidal anti-inflammatory drugs (NSAIDs), shoe modifications, orthoses, cryotherapy, nitric oxide, and injections.[7,10,26,27,32,43]

Conventional physical therapy treatment for AT consists of stretching of the gastrocnemius, soleus, and hamstring muscles.[10,23] Presently, heavy-load eccentric calf muscle strengthening exercises, popularized by Alfredson et al,[3] are more widely accepted as the initial intervention for patients with noninsertional AT,[7,10,26,27,32] based on randomized controlled trials (RCTs),[23,28,39] systematic reviews, and meta-analyses.[8,43] However,

[1]Faculty of Physical Therapy, Cairo University, Giza, Egypt
[2]October 6th Hospital, Ministry of Health, Giza, Egypt
[3]Orthopaedic Surgery Department, El-Sahel Teaching Hospital, Cairo, Egypt

Corresponding Author:
Emad S. B. Saweeres, FRCS (Tr & Orth), MD, Orthopaedic Surgery Department, El-Sahel Teaching Hospital, Cairo 11697, Egypt.
Email: prof.saweeres.ortho@gothi.gov.eg

evidence for the superior effectiveness of any particular exercise program is limited.[8,41,47]

Low-energy extracorporeal shockwave therapy (ESWT) is a safe and well-tolerated modality, which could be used as an alternative to or in combination with exercises. Moreover, satisfactory evidence (RCTs,[9,35,38,39,45] systematic reviews, and meta-analyses[1,13,17,42,43]) exists to support its effectiveness for treating chronic noninsertional AT. Costa et al[9] have reported no alleviation of pain during rest or walking (only pain during sports was alleviated) when ESWT was compared to placebo. Although Rompe et al[39] have demonstrated that both ESWT and eccentric exercises were significantly better than the wait-and-see policy, they found that the outcomes of shockwave therapy and exercises were comparable. In their more recent RCT, Rompe et al[38] compared eccentric loading alone with a combination of eccentric exercises and ESWT and found this combination to be more effective than the exercise program alone in alleviating pain and improving function. While the rate of complete recovery using either eccentric loading or ESWT alone was 60% and 52%, respectively,[39] the combination of the 2 modalities increased the complete recovery rate to 82%.[38]

Two other RCTs have incorporated stretching exercises along with eccentric loading in their conservative (control) program.[35,45] Both studies randomized their patients to receive either active or sham ESWT combined with the aforementioned exercise program. While both trials showed a better improvement in the active ESWT group, only improvement in function was statistically significant in the first study.[35] The pain reduction in the first study and the reduction of pain and improvement in function in the other study[45] failed to reach statistical significance. In addition, both studies reported only midterm follow-up outcomes (3-4 months).

The aim of the present double-blind prospective RCT was to compare the effectiveness of a program composed of eccentric training followed by stretching exercises (control group) and the same program combined with ESWT (study group) for treating chronic noninsertional AT in both the short and long term (16-month follow-up).

Methods

Study Design

This double-blind RCT was conducted at the faculty of physical therapy in Cairo, Egypt, from October 2018 to May 2020. The study sample included 50 patients clinically diagnosed with noninsertional AT who were referred by the orthopedic department. Patients who agreed to participate signed an informed consent form. The study was approved by the institutional ethical committee (number: P.T.REC/012/002042) of our faculty and registered at ClinicalTrials.gov (ID: NCT04376294).

All patients were diagnosed and referred by a physician according to the following criteria: (1) unilateral noninsertional AT, (2) pain at the Achilles tendon for at least 6 months (chronic AT), and (3) failure of conservative treatment (eg, NSAIDs, ice, shoe modification, and avoidance of overuse activities) for at least 3 months.

Patients who (1) underwent physical therapy 4 weeks before enrollment in the study; (2) had taken NSAIDs during the previous week; (3) had peritendinous injection of corticosteroids or anesthetics within the last 4 weeks preceding the study; (4) had bilateral AT; (5) had ankle osteoarthritis, radiculopathy, or systemic neurological diseases that may cause posterior ankle pain; or (6) had previous injury or surgical treatments of the ankle were excluded from the study.

Patients enrolled in the study were randomized into 2 groups (the study and control groups) using computer-generated numbers in sealed opaque envelopes. Patients in the study group received ESWT in addition to conservative physical therapy treatments consisting of eccentric training of the calf muscles followed by stretching of the gastrocnemius, soleus, and hamstring muscles. Patients in the control group received the same conservative physical therapy treatment as well as sham ESWT. The total duration of treatment was 4 weeks. All patients were instructed to avoid taking NSAIDs or any analgesics during the treatment period, and they were blinded to the type of treatment they received.

Baseline

Seventy-four patients were assessed for eligibility. Twenty-two patients did not meet the inclusion criteria (5 patients had bilateral AT, 7 had a history of peritendinous corticosteroid injections, and 10 had an associated ankle pain) and 2 refused to participate; all were, therefore, excluded (Figure 1). The study population consisted of 22 men and 28 women aged 18 to 40 years with chronic noninsertional AT who were randomly assigned to 2 equal groups using computer-generated numbers in sealed envelopes. The 2 groups were comparable (Table 1) with no significant differences in any of the demographic characteristics.

Treatment

Extracorporeal shockwave therapy. All patients in the study group received 4 sessions of shockwave at weekly intervals using an ESWT machine (DOULITH SD1; Storz Medical). Each session of ESWT consisted of 2000 pulses with 3 bar pressure (equals an energy flux density of 0.1 mJ/mm^2) and frequency of 8 pulses/s. The treatment was performed on the patients while they were in the prone position with a small pillow under the ankle (neutral position). Shockwaves were applied in a circumferential pattern, targeting the point

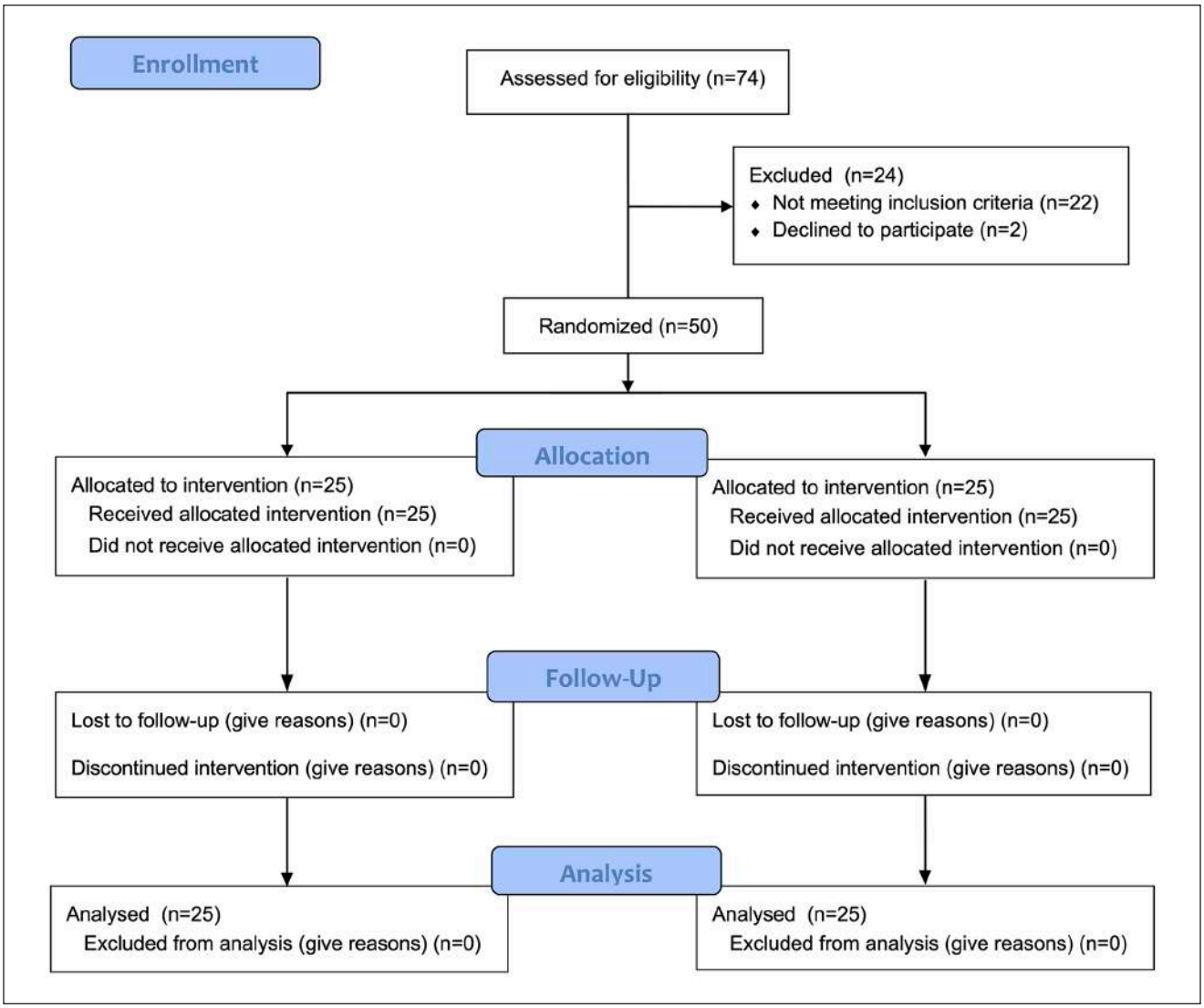

Figure 1. Flowchart of the trial from the baseline. All patients were assessed posttreatment (at 4 weeks) and at long-term follow-up (at a minimum period of 13 months).

Table 1. Demographic Characteristics of the Study Cohort.

Items	Study group, mean (SD)	Control group, mean (SD)
Age, y	29.9 (7.0)	28.3 (6.8)
Body mass, kg	78.2 (10.6)	77.8 (9.2)
Height, cm	172.6 (10.6)	174.4 (8.5)
Body mass index, kg/m^2	25.7 (1.6)	25.3 (1.6)

of maximum tenderness.[35,38,39] Patients in the control group were placed in the same position and received sham ESWT. Ultrasound gel was applied to the patient's skin, and the handpiece of the machine was moved in a similar fashion. The machine settings were adjusted to generate zero energy while producing the same sound effect. Throughout the study, patients in both groups were blinded to the type treatment they received.

Eccentric training of the calf muscles. Patients were asked to stand on the edge of a wooden step with all their body weight on the forefoot of the affected leg and the ankle in

plantarflexion. The patients were then asked to slowly dorsiflex the ankle to a count of 5, loading the calf muscle eccentrically and lowering the affected limb until the planter surface of the heel became lower than the level of the wooden step. This maneuver was performed with the knee of the affected lower limb extended to load the gastrocnemius and with the knee flexed to load the soleus muscle. The calf muscles were loaded only eccentrically, as the patients were instructed to return to the starting position using the sound limb or his upper limbs. The patients in both groups were instructed to perform 3 sets of 15 repetitions (with a 1-minute rest between sets), twice a day (morning and evening), 7 d/wk, for 4 weeks.[2,3,12,31,40]

Gastrocnemius, soleus, and hamstring stretch. For gastrocnemius stretch, the patients were instructed to stand in front of the wall. With the involved leg positioned backward and the knee extended, the patient was instructed to lean forward (flexing the knee of the front sound leg) while maintaining the heel of the involved foot (back foot) in contact with the ground. The patients were instructed to lean forward as much as they could for 30 seconds. The soleus stretch was conducted using the same maneuver but with the involved knee slightly bent. For hamstring and gastrocnemius stretch, the patients were asked to lay supine on a treatment table with their hips of the involved limb in 90 degrees of flexion. Then, the patients were instructed to place their hands around their involved knees (posterior aspect) and extend them slowly until they felt a stretch at the back of the thigh and maintain this position for 30 seconds while pulling the foot toward their faces. Alternatively, the hamstring and gastrocnemius were stretched from a long sitting position. On a treatment table with the involved knee extended, the patients were instructed to pull their foot toward their face with a towel (around the ball of the foot) by both hands and sustain this position for 30 seconds. All patients in both groups were instructed to perform stretching of the gastrocnemius, soleus, and hamstring muscles twice a day for 3 repetitions (with 30-second stretch and 30-second rest) 7 days a week for 4 weeks. All these stretches were performed directly after the eccentric exercises.[23,34]

Assessments. The primary outcome measure was functional activity of the patients as measured by the Victorian Institute of Sport Assessment–Achilles questionnaire (VISA-A),[36] which is a valid and reliable tool[19] and is the gold standard for evaluating pain and function in AT.[30] The VISA-A consists of 8 questions covering Achilles tendon pain during different situations. Questions 1 to 7 are scored out of 10, while question 8 is scored out of 30. The total score of the VISA-A is 100. The secondary outcome measure was pain that was measured by the visual analog scale (VAS), which is a well-known, valid, and reliable measuring tool for pain.[18]

Each patient was assessed 1 day before starting the first session (*baseline assessment*), 1 day after the last session (after 4 weeks from baseline; *posttreatment*), and after a minimum of 13 months from baseline (mean ± SD = 16 ± 2.3 months; range, 13-18 months; *follow-up*) by an independent assessor (a physiotherapist) who did not administer the ESWT (real or sham) and was only gathering the outcome data. This assessor was not involved in the study and was blinded to the patients' allocations to either group.

Statistical analysis. Sample size was calculated a priori using G*Power (version 3.1.9.6)[14] based on the effect size in the VISA-A estimated from mean difference reported in earlier RCTs.[38] Considering α error = 0.05 and a study power of 0.95%, the sample size needed was calculated to be 24 patients for each group.

As a prerequisite for parametric analysis, data were screened for normality assumption using the Shapiro-Wilk test, homogeneity of variance using Levine's test, homogeneity of covariance using Box's test, and the presence of extreme scores using outliers.

The data for functional activity (VISA-A) were normally distributed ($P = .05$), and homogeneity between covariances was observed ($P > .05$). Accordingly, a 2 × 3 mixed-design (generalized linear mixed model [LMM]) analysis of variance (ANOVA) was used to compare the tested variables of interest at different tested groups and measuring periods.[6] However, the normality and homogeneity of variance assumptions were violated for pain as measured by the VAS (raw data and after logarithmic transformation, $P = .0001$). Therefore, nonparametric statistics (the Friedman test) was used to measure the differences among the 3 measuring periods within each group, and Wilcoxon signed-rank tests were used as post hoc tests wherever the Friedman test was significant. The Mann-Whitney *U* test was used to compare both groups. The α level was set at 0.05 for all statistics. All statistical analyses were performed using Statistical Package for the Social Sciences (SPSS version 23; SPSS, Inc).

Results

Posttreatment Changes

The mean values of functional activity (VISA-A score) in both groups before treatment (Table 2) were comparable (mixed-design ANOVA, $P = .063$). Mixed-design ANOVA revealed significant within-group effects ($F = 898.427$; $P = .0001$) and between-group effects ($F = 181.341$; $P = .0001$). A significant interaction effect for intervention and follow-up time was observed ($F = 69.093$; $P = .0001$). The functional scores improved significantly in both groups after treatment (multiple pairwise post hoc comparisons, $P = .0001$). The improvements in the study group

Table 2. VISA-A Scores and Mean Difference (as a Measure of Functional Activity) at Baseline, Posttreatment, and Follow-up for Both Groups.[a]

Functional activity	Baseline, mean (SD)	Posttreatment (1 month), mean (SD)	Follow-up (16 months), mean (SD)	Mean difference (95% CI)		
				(Post – baseline)	(Follow-up – baseline)	(Follow-up – post)
Study group	24.2 (6.5)	85 (6.2)[b]	80 (5.3)[b,c]	60.8 (56.0 to 65.5)	55.8 (51.4 to 60.2)	−5 (8.6 to 1.4)
Control group	21.0 (5.2)	53.4 (7.7)[b]	67 (5.6)[b,c]	32.4 (28.0 to 36.9)	46.0 (41.9 to 50.1)	13.6 (10.3 to 16.9)
P value (between-group comparison)[d]	.063	.0001	.0001			
Mean difference (study vs control)	3.3 (−0.2 to 6.7)	31.6 (27.5 to 35.8)	13 (9.8 to 16.2)			

Abbreviation: VISA-A, Victorian Institute of Sport Assessment–Achilles questionnaire.
[a]*P* values were calculated using linear mixed-model analysis of variance.
[b]Significantly different from baseline (multiple pairwise within-group post hoc comparison tests).
[c]Significantly different from posttreatment (multiple pairwise within-group post hoc comparison tests).
[d]Between-group multiple pairwise post hoc comparison tests.

were better than those in the control group. The difference between groups after treatment was statistically significant (multiple pairwise post hoc comparisons, $P = .0001$).

A significant reduction in pain (Friedman test, $P = .0001$) following treatment in both groups was observed (Table 3, expressed as median and SD). Post hoc analysis (Wilcoxon signed-rank tests) confirmed a significant difference in VAS ($P < .05$) after treatment compared to that at baseline in both groups. Although both groups did not differ regarding pain intensity at baseline (Mann-Whitney *U* test, $P = .867$), pain reduction was significantly better in the study group than in the control group (Mann-Whitney *U* test, $P = .0001$).

Long-Term Follow-up

At the intermediate-term follow-up (mean, 16 months), functional scores showed a slight but still significant ($P = .003$) decrease in the study group. Alternatively, the VISA-A scores in the control group continued to increase at follow-up (multiple pairwise post hoc comparison, $P = .0001$), although they never reached the scores achieved in the study group (Table 2). Pain scores showed a similar trend to that in functional scores, with elevation in the study group and reduction in the control group at follow-up. Although this change was statistically significant compared to posttreatment (Wilcoxon signed-rank tests, $P = .0001$), values at the final follow-up were still better than those at baseline (Table 3).

At the latest (16 months) follow-up, the functional and pain scores were significantly better than those at the baseline (mixed-design ANOVA and Wilcoxon signed-rank tests, respectively, $P = .0001$ for both). At all time points, both scores in the study group were significantly better than those in the control group (mixed-design ANOVA and Mann-Whitney *U* test, respectively, $P = .0001$ for both).

Discussion

This study is the first RCT to report the functional outcome and pain scores for patients with noninsertional AT at an average follow-up period of 16 months. Patients in both groups significantly improved posttreatment (at 4 weeks) and follow-up compared to their baseline condition. Patients who received low-energy ESWT in addition to conventional exercises had a significantly better outcome than those who received conservative physical therapy treatment only (eccentric training followed by stretching exercises). These results conform to the results of studies, reviews, and meta-analyses that suggested that the combination of ESWT and exercises is an effective treatment for AT.[1,13,35,38,39]

One cannot miss the line of thought portrayed by RCTs reporting the effects of ESWT in AT (Table 4). Initially, RCTs compared shockwave therapy only to placebo,[9] the

Table 3. Descriptive Statistics and Nonparametric Tests for Visual Analog Scale (VAS) at Different Measuring Periods for Both Groups, median (SD).[a]

VAS	Baseline, median (SD)	Posttreatment (1 month), median (SD)	Follow-up (16 months), median (SD)
Study group	8 (1)	1 (2)[a]	3 (2)[b,c]
Control group	8 (1)	7 (2)[a]	5 (1)[b,c]
P value (study vs control)	0.867	0.0001	0.0001

[a]*P* values for comparison between groups using the Mann-Whitney *U* test.
[b]Significantly different from baseline (using Wilcoxon signed-rank tests, post hoc).
[c]Significantly different from posttreatment (using Wilcoxon signed-rank tests, post hoc).

wait-and-see policy, and eccentric exercises.[39] It soon became clear that combination therapies might result in better outcomes than a single modality. Rompe et al[38] subsequently compared eccentric loading alone to a combination of eccentric loading and ESWT. This combination resulted in a higher success rate (82%) than either eccentric loading or ESWT alone (60% and 52%, respectively). However, strengthening and stretching are both essential elements in the rehabilitation program for patients with AT.[4] Muscle stretching after strengthening exercises has been practiced by sports players for ages. Low-intensity stretching was shown to have moderate beneficial effects on perceived recovery of muscle function and postexercise muscle soreness.[5] In addition, it alleviates muscle stiffness and reductions in range of motion induced by exercise.[44] Other RCTs have therefore started to integrate stretching exercises with eccentric loading into their conservative (control) protocols[35,45] and compared this incorporation to the same program along with ESWT. Those RCTs only reported midterm follow-up data (3-4 months). Using our combined protocol, we obtained similar VISA-A scores in the study group (85 $\pm$ 6.17 posttreatment and 80 $\pm$ 5.34 at final follow-up) to that reported by Rompe et al[38] (86.5 $\pm$ 16). Although the functional scores posttreatment in our combined exercise protocol group were slightly less favorable than those in the aforementioned RCT, the score at the final follow-up (67 $\pm$ 5.59) was comparable to their eccentric loading group (73 $\pm$ 19). Our patients, however, had lower scores than their patients at baseline (24.22 $\pm$ 6.52 and 20.96 $\pm$ 5.21 vs 50.2 $\pm$ 11.1 and 50.6 $\pm$ 10.3 for the study and control groups, respectively). Moreover, the mean posttreatment difference between groups in the present study was higher than that in the latter study (31.6 vs 13.5) with a much narrower confidence interval, which does not cross zero, unlike the former study.

The significant decrease in the functional scores and increasing pain scores in the study group of the present study at an average 16-month follow-up highlight the importance of a longer-term follow-up for studies reporting outcomes of treatments for AT. The only RCTs in literature that included a "long-term" follow-up reported either combined data for both the study and control groups[9] or a global "general assessment" of patients (on a 6-point Likert scale),[38,39] indicating that the treatment was either successful or failed with no exact outcome scores or statistical comparison. Fan et al[13] conducted a systematic review with meta-analysis to investigate the efficacy of ESWT compared to other nonsurgical treatments (including sham ESWT). They reported that VAS pain scores were not significantly different for follow-ups shorter or longer than 6 months. However, this analysis was based on 3 studies only, none of which was an RCT. In a study by Rompe et al,[38] 19 patients in group 1 (eccentric loading) and 28 patients in group 2 (eccentric loading and shockwave) had a successful outcome based on 4-month data. Those numbers were reduced to 16 and 24, respectively, at the 1-year follow-up. Despite the change in outcome scores in our study at the final follow-up, all patients in this study had significantly better scores than baseline. The latter study, as well as our own results, emphasizes the importance of reporting longer-term data for studies involving treatment of AT.

The results of this study support incorporating ESWT, in addition to conventional physical therapy, in any treatment protocol for AT. Evidence in the literature so far has been conflicting, with many RCTs and reviews supporting shockwave therapy,[1,13,38,39] while others have shown no benefit of adding this modality to other therapeutic regimens.[9,35,45] The latter studies, which failed to demonstrate a significant benefit of ESWT, have used high-energy shockwaves,[16] casting some doubt about the appropriate energy level that may be applied to such lesions. Moreover, 2 RCTs[35,45] used the American Orthopaedic Foot & Ankle Society (AOFAS) clinical rating system, an outcome score not specific for the condition being studied. While the VISA-A was developed as a valid, reliable, and responsive index for the severity of AT,[36] the AOFAS score might not be the best scoring system for patients with AT. It includes items such as ankle stability and subtalar range of motion as well as alignment[24]; all are unrelated to AT and would not change over time with treatment, a limitation acknowledged by the authors of one of the aforementioned studies.[35]

Previous RCTs have compared either the follow-up (posttreatment) scores of the study groups[9,35,45] or the changes in score between the baseline and follow-up.[38,39] These 2 simple approaches usually yield the same estimated treatment effect, except in cases when there is imbalance in

Table 4. Summary of Randomized Controlled Trials Studying the Effects of ESWT on Patients With Achilles Tendinopathy.[a]

Study	Groups	Sessions	Patients	Outcome	Follow-up, mo	Conclusion
Costa et al (2005)[9]	• ESWT (high energy, 0.2 mJ/mm^2) • Placebo (bubble wrap)	3 over 2 months	49 (2 groups)	VAS (rest, walking sports) FIL EQol-5D and health score Clinical assessment	3 and 12[b]	No support for using shockwave (mainly mid-substance). Only pain with sport improved, not with rest or walking Detailed outcomes only reported at 3 months
Rompe et al (2007)[39]	• Eccentric loading • ESWT (repetitive low energy, 0.1 mJ/mm^2) • Wait-and-see	3 over 3 weeks	75 (3 groups)	VISA-A General assessment (Likert scale) Pain (NRS, pain threshold, and tenderness)	4	Eccentric loading and ESWT comparable Both better than the wait-and-see policy
Rasmussen et al (2008)[35]	• Stretching and eccentric exercise + rESWT (0.12-0.51 mJ/mm^2) • Stretching and eccentric exercise + sham	4 over 4 weeks	48 (2 groups)	AOFAS VAS (walking, stairs, working, and running)	1, 2, and 3	ESWT group better function (more so at 8 and 12/52) No significant difference in pain ESWT supplements treatment
Rompe et al (2009)[38]	• Eccentric loading • Eccentric loading + ESWT (low energy, 0.1 mJ/mm^2)	3 over 3 weeks	68 (2 groups)	VISA-A, general assessment and pain assessment (see Rompe et al[39])	4 and 12[c]	Combination (eccentric loading + ESWT) more effective
Vahdatpour et al (2018)[45]	• Conservative plan (stretching exercises, massage, eccentric training and diclofenac) + ESWT • Conservative plan + sham ESWT	4 over 4 weeks radial and focused shockwave[d]	43 (2 groups)	AOFAS VAS	1 and 4	ESWT group improved but not statistically significant AOFAS score only significantly different at 4 months Type of AT not specified
Rompe et al (2008)[37]	• **Eccentric loading** • ESWT (low energy, 0.12 mJ/mm^2)	**3 over 3 weeks**	**50 (2 groups)**	**VISA-A, general assessment, and pain assessment (see Rompe et al[39])**	**4 and 15[c]**	**ESWT better in (insertional) Achilles tendinopathy**
Pinitkwamdee et al (2020)[33]	• **Stretching exercise + rESWT (low energy, 0.12-0.16 mJ/mm^2)** • Stretching exercise + sham	**4 over 4 weeks**	**31 (2 groups)**	**VAS** VAS-FA	**6**	**No difference at 6/12** ESWT short period of effect at 1-3/12 (insertional tendinopathy)

Abbreviations: AOFAS, American Orthopaedic Foot & Ankle Society; AT, Achilles tendinopathy; EQol-5D, EuroQol- 5 Dimension; ESWT, extracorporeal shockwave therapy; FIL, functional index of lower limb activity; NRS, numerical rating scale; rESWT, radial extracorporeal shockwave therapy; VAS, visual analog scale; VAS-FA, visual analog scale–foot and ankle; VISA-A, Victorian Institute of Sport Assessment–Achilles questionnaire.

[a]Randomized controlled trials (RCTs) reporting on insertional Achilles tendinopathy are bolded.

[b]Reported only combined 1-year follow-up data for both groups. No exact figures or statistical analysis given.

[c]Reported only general assessment data at 1-year follow-up, scored on a 6-point Likert scale. No pain or functional scores given and no statistical analysis.

[d]High-energy ESWT (focused 0.25-0.4 mJ/mm^2 + rESWT 1.8-2.6 mJ/mm^2).

the baseline scores of the groups.[46] In fact, the only group of researchers who calculated score change from baseline for every patient and aimed to apply the difference-in-differences model never actually reported the figures for this change or the treatment effect for any of the groups.[38,39] Instead, like all other studies, they only reported the mean group scores (at baseline and follow-up) and the mean difference between the intervention and control groups, casting a shadow of doubt about the usefulness of such approach. Moreover, the difference-in-differences model (which is mainly used in economics, law, and recently to evaluate changes in health care policy[11,20,25]) requires a preassumption of parallel trends between the 2 groups *prior to the intervention*, an assumption that is only imperially tested at the best.[11,20] A more robust approach that deals with such confounders is to use a linear regression model (analysis of covariance), which adjusts each patient's follow-up score for his or her baseline scores. Such model also has greater statistical power to detect treatment effect.[46]

A variety of statistical approaches for comparison of means have been used in earlier RCTs (2-sample *t* test,[9,45] Mann-Whitney *U* test,[9] Wilcoxon test,[38,39] 1-way ANOVA,[38,39] and/or repeated-measures ANOVA[35,45]). Some authors[38,39] inappropriately analyzed data from their designs by collapsing across or ignoring one of the random factors so that such familiar procedures could be used,[22] which is perhaps oversimplistic. Participants in any particular study should be treated as a random factor, meaning that they are thought to be a sample of participants that might have been used.[22] The mixed-model ANOVA used in this study is a powerful analytic approach for complex research designs involving 2 random factors (hereafter called participants and targets), which may be either crossed or nested, and 1 fixed factor (condition).[15,22] It is in essence a combination of between-unit ANOVA and a within-unit ANOVA.[15] Our study groups were "nested under" 1 categorical independent variable (participants) and were "crossed with" the other independent continuous variable (time). The goal was "to determine whether the mean condition difference (treatment outcome), given the variability of participants, is sufficiently large to permit the belief that it would continue to be found with other samples of participants."[22] Mixed-model ANOVA has substantial advantages over both traditional and repeated-measures ANOVA, as it allows handling of incomplete and unbalanced data and avoids information loss due to averaging over stimuli or participants.[21]

In a review of 46 studies, Murphy et al[30] found evidence to suggest that VISA-A was the only valid and reliable self-reported outcome measure of pain and function for patients with noninsertional AT. Whereas the minimum clinically important difference (MCID) established for VISA-A score in patients with insertional AT was 6.5 points,[29] the latter authors report that no clear consensus exists in case of noninsertional AT.[30] They suggest the utilization of either the above MCID or otherwise, using the most commonly reported MCID in clinical trials (10 points). The difference between the study and control groups in the present study at the 16-month follow-up (13.6 points; Table 2) exceeded both MCID reference values. The long-term benefit of incorporating ESWT in the treatment protocol of noninsertional AT demonstrated in this study is not merely statistically significant but also clinically relevant.

This study has several strengths. In the systematic review by Al-Abbad et al,[1] none of the studies had therapist blinding and only 2 reported participant blinding. Although the therapist in our study was not blinded, we managed to keep our participants blinded by using sham ESWT. While other studies[37-39] did not blind the outcome assessor, we avoided this detection bias by having an independent blinded assessor. This is the first study to report longer-term (mean, 16 months) detailed outcome scores of pain and function with complete follow-up of all patients. Alternatively, this study has some limitations. First, there was a lack of outcome data in the interim period between posttreatment (at 4 weeks) and the final follow-up. We recommend keeping constant track of the outcome scores throughout the whole study period, although this might affect participant compliance. Second, the assessor in our study translated the VISA-A score to the patients due to the unavailability of a validated Arabic version of this evaluation tool. Given the fact that the assessor was blinded, this should not have resulted in any misinterpretation or bias.

Conclusion

Combining calf eccentric loading with stretching exercises resulted in significant improvements in the pain and functional scores in patients with noninsertional AT. Adding ESWT to this combined treatment protocol resulted in significantly greater improvement in both scores in the short and long term. The latter program is strongly recommended for treating chronic noninsertional AT.

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ORCID iDs

Nasr Awad Abdelkader, PhD, https://orcid.org/0000-0001-8629-211X

Emad S. B. Saweeres, FRCS (Tr & Orth), MD, https://orcid.org/0000-0002-6187-4305

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