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Review

Current evidence of extracorporeal shock wave therapy in chronic Achilles tendinopathy

Ludger Gerdesmeyer [a, e, *], Rainer Mittermayr [b], Martin Fuerst [a], Munjed Al Muderis [c], Richard Thiele [a], Amol Saxena [d], Hans Gollwitzer [e]

[a] Dept. Orthopaedic Surgery and Traumatology, University Schleswig Holstein, Campus Kiel, Arnold Heller Strasse 3, 24105 Kiel, Germany
[b] Stosswellenzentrum-wien.at, AUVA Trauma Center Meidling, Ludwig Boltzmann Institute dir exp. and clin. Traumatology, Austria
[c] Suite G3B, Norwest Private Hospital, 9 Norbrik Drive, Bella Vista, NSW 2153, Australia
[d] Palo Alto Medical Foundation, 795 El Camino Real, Palo Alto, CA 94301, USA
[e] Technical University of Munich, Dept. Orthopedics and Traumatology, Ismaninger Straße 22, D-81675 Munich, Germany

HIGHLIGHTS

- This review shows efficacy of extracorporeal shock wave therapy.
- Focused and radial shock waves both show efficacy in chronic Achilles tendinopathy.
- All treatments should be done without local anesthesia.

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ABSTRACT

Chronic Achilles tendinopathy has been described as the most common overuse injury in sports medicine. Several treatment modalities such as activity modification, heel lifts, arch supports, stretching exercises, nonsteroidal anti-inflammatories, and eccentric loading are known as standard treatment mostly without proven evidence. After failed conservative therapy, invasive treatment may be considered. Extracorporeal shock wave therapy (ESWT) has been successfully used in soft-tissue pathologies like lateral epicondylitis, plantar fasciitis, tendinopathy of the shoulder and also in bone and skin disorders. Conclusive evidence recommending ESWT as a treatment for Achilles tendinopathy is still lacking. In plantar fasciitis as well as in calcific shoulder tendinopathy shock wave therapy is recently the best evaluated treatment option. This article analysis the evidence based literature of ESWT in chronic Achilles tendinopathy. Recently published data have shown the efficacy of focused and radial extracorporeal shock wave therapy.

The treatment of tendinopathies by ESWT has emerged as an alternative option if conservative treatment fails prior to surgical interventions. Its use in tendinopathy is mentioned about 20 years ago and its efficacy and low morbidity is well demonstrated in nearby all publications so far [1,2]. Foot pathologies such as Achilles tendinopathy or plantar fasciitis are widely established shock wave indications [1,3–5].

Achilles tendinopathy is known as a very frequently occurring tendon pathology which mostly afflicts professional and recreational athletes, as well as, sedentary. They often complain of tendon pain by string exercises or weight laded movements. Common reasons of such a tendinopathy are gradual wear and tear from overuse or aging. Beside an increased risk in patients doing repetitive movements in their jobs, sports, or daily activities all patients can be targeted by simply damaging the tendon due to trauma or overuse. There is still some basic research discussion ongoing debating the microbiological morphology with goes along with clinical symptoms such as weight loaded wear pain [6–12].

Initially it was reported to be a tendon disorder which has multiple suggested pathology which are based on poor scientific evidence. Later publications have clarified the difference between an Achilles tendinitis and an Achilles tendinosis. An Achilles tendinitis (tendonitis) occurs when there is a clinical presence of

* Corresponding author. Dept. Orthopaedic Surgery and Traumatology University Schleswig Holstein Campus Kiel Arnold Heller Strasse D-24105 Kiel, Germany.
E-mail address: Gerdesmeyer@aol.com (L. Gerdesmeyer).

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pain and swelling [7–9,12,13]. Local neuroinflammation processes were seen on a biopsy specimen of a diseased tendon. On the other hand, an Achilles tendinosis refers to a degenerative process of the tendon without histologic or clinical signs of intratendinous inflammation. Some authors suggested that tendinosis is a failure of the cell matrix to adapt to repetitive trauma caused by an imbalance between the degeneration and synthesis of the matrix [8,9,14,15].

Intrinsic risk factors include hyperpronation, varus deformity of the forefoot, leg length discrepancy, and limited mobility of the subtalar joint. Extrinsic risk factors include excessive mechanical overload and training errors such as increased interval training, excessive hill training, and increased mileage [8,9,14–17]. Other risk factors include poor technique, fatigue, obesity, and advanced age. From a functional perspective, it is helpful to classify Achilles tendinopathy as insertional, those which occur at the bone-tendon junction, or noninsertional, those that occur more proximally [8,9,13]. Insertional tendinopathy tends to occur in more active persons, whereas noninsertional tendon injury tends to occur in older, less athletic, and overweight persons. Traditional nonoperative treatment of insertional Achilles tendinopathy consists of rest, anti-inflammatory medications, physical therapy modalities, heel lift orthosis, custom orthosis, and immobilization [4,5,11–13,18–20]. In the majority of cases, nonoperative measures are effective. Surgery for insertional Achilles tendinopathy is reserved for chronic cases.

Risk factors for Achilles tendinopathy include biomechanical abnormalities of the lower extremity such as hyperpronation and leg length discrepancy as well as systemic conditions such as obesity, hypertension, diabetes, and endocrinopathies. Extrinsic factors include increase in interval training, excessive hill training, a sudden increase in training intensity, change of surface (soft to hard), excessive mileage, and inappropriate or worn-out footwear [8,9]. Advanced age, male gender, steroid use, and fluoroquinolones are also associated with this condition. From an anatomic perspective, the decreased vascularity of the Achilles tendon may predispose the tendon to damage or rupture. Damage to the Achilles tendon usually results from chronic overuse. It is the result of accumulative impact loading and repetitive microtrauma to the tendon [8,9]. Injury begins with inflammatory changes around the tendon (peritendinitis) while the tendon itself remains normal. In the majority of patients, the Achilles tendon does not have a tendon sheath but rather a paratenon. The paratenon is the site of inflammation associated with peritendinitis. Peritendinitis may progresses to tendinosis characterized either by degenerative and inflammatory changes within the tendon or by degenerative changes within the tendon and associated inflammation of the peritendinous tissue, respectively. Interestingly, inflammatory changes are present, however, inflammatory mediators are absent making the term Achilles tendonitis a misnomer. Tendinopathy is more of a generic term used to encompass intrinsic and/or extrinsic damage to the tendon. From an anatomic standpoint, tendinopathy describes fraying of the tendon due to a failed healing response of the extracellular matrix [8,9].

1. Shock wave therapy in Achilles tendinopathy

In 2006 John Furia published his results of a prospective match paired controlled study [21]. The aim of this trial was to determine extracorporeal shock wave therapy is an effective treatment for insertional Achilles tendinopathy and local anesthesia field block adversely could affects outcome. He has chooses a study design as a case control study of a level of evidence 3. A total of 35 were analyzed after shock wave treatment as 33 patients represent the control group assigned to get non invasive treatments accept shock wave treatment. Patients assigned to get ESWT received 1 application of high-energy extracorporeal shock wave therapy (3000 shocks; 0.21 mJ/mm^2; total energy flux density, 604 mJ/mm^2). The shock wave group was further stratified whether to get ESWT under local anesthesia (LA) or non local anesthesia (NLA) such as regional nerve blocks. (LA subgroup, 12 patients, NLA subgroup, 23 patients). The evaluation was by visual analog score and by Roles and Maudsley score at baseline and up to one year. One month, 3 months, and 12 months after treatment, the mean visual analog score for the control and ESWT groups were 8.2 and 4.2 ($P < 0.001$), 7.2 and 2.9 ($P < 0.001$), and 7.0 and 2.8 ($P < 0.001$), respectively. Twelve months after treatment, the number of patients with successful Roles and Maudsley scores was statistically greater in the ESWT group compared with the control group ($P > .0002$), with 83% of ESWT group patients having a successful result, and the mean improvement in visual analog score for the LA subgroup was significantly less than that in the NLA subgroup ($P < 0.001$). The percentage of patients with successful Roles and Maudsley scores did not differ among the LA and NLA subgroups. (Table 1). Finally the author concludes that Extracorporeal shock wave therapy is an effective treatment for chronic insertional Achilles tendinopathy and local field block anesthesia may decrease the effectiveness of this procedure.

With regards to safety aspects only 5 minor complications occurred. Two patients had pain during the treatment which resolved after completion of the procedure. Two patients had transitory reddening of the skin that also resolved without intervention. One patient developed transitory numbness on the plantar aspect of the heel that resolved within 24 h without treatment. No significant adverse effect related to ESWT was found (Fig. 1).

In 2005 Costa et al. published their results of a randomized placebo controlled trial of shock wave therapy for chronic Achilles tendon pain [22].

Forty-nine patients were enrolled in this double-blind randomized placebo-controlled trial which has a level 1 of evidence. All patients had tenderness exacerbated by dorsiflexion of the ankle. No patients were excluded because of their clinical findings. Three patients had pain at the insertion of the tendon. The remaining patients had midsubstance swelling consistent with underlying tendinosis. Patients were included regardless of previous treatment or of any underlying degenerative joint disease. The inclusion criteria were: older than 18 years with Achilles tendon pain present for at least 4 months. The exclusion criteria were: pregnancy, local malignancy, coagulopathy, or a pacemaker. In contrast to other recently published ESWT studies in chronic Achilles tendinopathy the authors have did sample size calculation. In the absence of previous comparable work on the Achilles tendon, anecdotal data with at least 50% pan reduction after EST were used to determine the sample size of the trial. With a power of 90%, and a significance of 5%, this was estimated to be equated to 20 patients in each group (Fig. 2).

The patients of the Costa study were assigned to get ESWT once a month for 3 months. The primary outcome measure was a reduction in Achilles tendon pain during walking.

43 patients could be followed up to year after ESWT.

With regards to shock wave focusing the application was just based on the personal experience of the author. This was done in the absence of evidence to guide the number and frequency of treatment.

The visual analog pain scale (VAS) for pain at rest, pain during walking, and pain during sport participation was defined as primary criteria as well as a set of questionnaires such as the Functional Index of Lower Limb Activity (FIL) and the Euro-Qol (EQol) generalized health status questionnaire.

Results of the Costa study do not provide any evidence for use of

Table 1
ESWT evidence on Achilles tendinopathy (insertional and non insertional).

Authors	Article	Sample	Groups	Generator	Device	Impulses	No treatment	AE	Energy	FU	Significance	Conclusion
Focused												
Furia	Am. J. Sports Med. 2006	68	High-ESWT vs control	EM	Dornier	3000	1	No	0.21	3, 6, 12 mo	S	High ESWT is better than conservative Tx, negative effect of LA
Costa	CORR	49	High-ESWT vs placebo	EM	Storz Modulith_x0001_ SLK	2000	3	2	0.2 vs 0	3, 12 mo	NS	NSS on Pain but clinical relevant effect size was found
Furia	Am. J. Sports Med. 2008	68	High-ESWT vs control	EM	Dornier	3000	1	No	0.21	3,6,12 mo	S	High-ESWT: effective in chronic non insertional Achilles tendinopathy
Rasmussen	Acta orthopaedica 2008	48	High vs placebo	Piezo	Wolf	2000	4	No	0.12–0.51 vs 0	3 mo	S	ESWT an excellent option in Achilles tendinopahy
Rompe 2007	Am. J. Sports Med. 2007	46	Radial ESWT vs wait and see vs eccentric exercises	Radial	EMS medical	2000	3	No	0.1	6 wks, 16 wks	S	Radial ESWT an excellent option in Achilles tendinopahy
Rompe 2008	Am. J. Sports Med. 2008	68	Radial ESWT vs ESWT + eccentric exercises	Radial	EMS medical	2000	3	No	0.1 vs 0	6 wks, 16 wks	S	Radial ESWT + eccentric exercises are effective in Achilles tendinopahy

(AE: Adverse evend; ESWT: Extracorporeal Shockwave Treatment; EM: electromagnetic; wks: weeks; mo: months; NS: not statistically significant, S: significant).

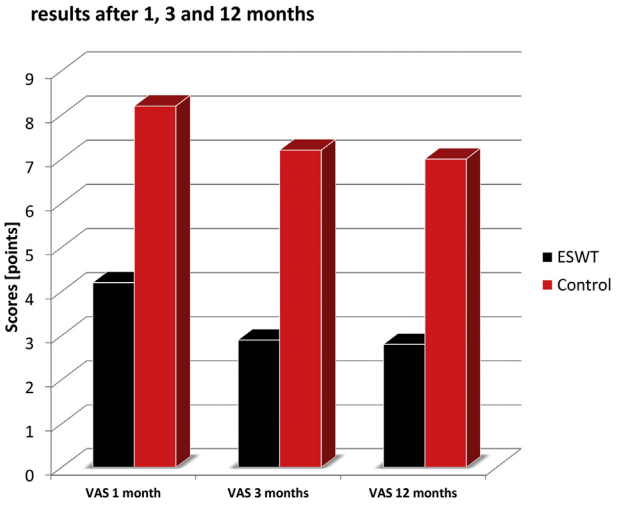

Fig. 1. Furia et al.: Am J Sport Med 2006.

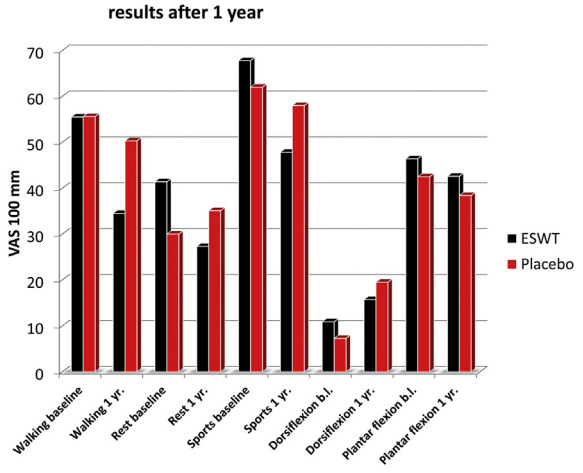

Fig. 2. Costa et al.: CORR 2005.

shock wave therapy for treatment of chronic Achilles tendon pain. Neither the VAS pain scores for pain at rest or during sport participation showed any difference between the groups. The baseline score for pain during walking was 55 for both groups. The score after the intervention was 34 points in the treatment group and 50 in the control group (p_0.127; CI −4.7–36.2). There were no differences between the groups in ROM at the ankle or differences in the FIL or EQol scores.

However, the confidence intervals do include a potentially clinically relevant treatment effect. Complications in the treatment group included two tendon ruptures, suggesting caution in treating older patients with shock wave therapy.

Finally the authors stated that they found no significant difference in pain relief between the shock wave therapy group and the control group. Two patients aged 62 und 65 were reported to have adverse events such as tendon ruptures in the treatment group.

The conclusion was not to use shock wave therapy for treatment of patients with chronic Achilles tendon pain. However, the confidence intervals include the potential for a clinically relevant treatment effect.

In 2008 John Furia again published another case controlled trial on non insertional Achilles tendinopathy [23].

He analyzed whether high-energy extracorporeal shock wave

therapy has been shown to be an effective treatment for chronic insertional Achilles tendinopathy or not. The study design was a case controlled study; according level 3 of evidence. A total of 34 patients all suffering from chronic non insertional Achilles tendinopathy were treated with a single dose of high-energy shock wave therapy (shock wave therapy group; 3000 shocks; 0.21 mJ/mm^2; which was calculated as a total energy flux density of 604 mJ/mm^2. As control 34 patients got a nonsurgical therapy. All shock wave therapy procedures were performed using regional anesthesia. The primary criteria was determined as change on the visual analog score and Roles and Maudsley score compared to baseline. One month, 3 and 12 months after ESWT, the mean VAS scores for the control and shock wave therapy groups were 8.4 and 4.4 ($P < 0.001$), 6.5 and 2.9 ($P < 0.001$), and 5.6 and 2.2 ($P < 0.001$), respectively. 12 month after completing the ESWT the number of excellent, good, fair, and poor results for the shock wave therapy and control groups were 12 and 0 ($P < 0.001$), 17 and 9 ($P < 0.001$), 5 and 17 ($P < 0.001$), and 0 and 8 ($P < 0.001$), respectively. The authors recommended ESWT as an excellent option in chronic non-insertional Achilles tendinopathy (Fig. 3).

An excellent paper of shockwave therapy for chronic Achilles tendinopathy was published by Rasmussen et al. in 2008. The design was a double-blind, randomized clinical trial of efficacy at level 1 of evidence [24].

All patients had chronic symptoms of Achilles tendinopathy longer than 3 months. The inclusion criteria were an area of swelling moving with dorsiflexion and plantarflexion of the ankle, tenderness in neutral position or slightly plantarflexed, and tenderness exacerbated by dorsiflexion of the ankle. All patients were treated conservatively prior ESWT. Local anesthetics were not used. ESWT sham or active treatment was given at 4 sessions once a week. For ESWT a Piezoson 100 was used at each session with 2000 shots each (0.12–0.51 mJ/mm^2, of focussed shock waves. Demographics, AOFAS score and pain were measured before and after treatment. The primary endpoint was AOFAS score.

48 patients were included with an average age of 47 (19–80) years. Patient demographics were similar in the both groups. All patients completed the treatment period. During the 3-month follow-up, 1 patient was excluded due to a knee arthroscopy and 2 patients did not attend the final 3-month follow-up. To replace missing values the last carried forward technique was done. The estimated standard deviation of 10 of the AOFAS score was set to be equal to the minimal relevant clinical difference. The AOFAS score after treatment increased more over time in the intervention group than in the control group ($p = 0.05$), from 70 (SD 6.8) to 88 (10) in the intervention group and from 74 (12) to 81 (16) in the control group (Figs. 2 and 3). Better results were seen in the intervention group at 8 and 12 weeks of follow-up ($p = 0.01$ and $p = 0.04$, respectively). Also pain was reduced in both groups, but there was no statistically significant difference between the groups. This study supports ESWT in chronic Achilles tendinopathy as an excellent option (Fig. 4).

In 2007 Jan Dirk Rompe et al. publish another study. The first time all radial shock wave therapy was addressed in Achilles tendinopathy [25]. The purpose of the study was to compare the effectiveness of 3 management strategies: group 1, eccentric loading; group 2, repetitive radial shock wave shock-wave therapy (rESWT); and group 3, wait and see in patients with chronic Achilles tendinopathy. The study quality was excellent because of the randomized controlled design at level 4 of evidence. A total of 75 patients were enrolled after fulfilling inclusion criteria and informed consent was given.

Patients were told to avoid pain-provoking activities for 12-week instead walking and cycling as was allowed. To apply shock waves a radial shock-wave device was used. Radial shock disperses radially from the application site into the tissue. The treatment took place in 3 sessions (2000 impulses each session) at weekly intervals. The application pressure was 3 bars (0.1 mJ/mm^2), the treatment frequency was 8 Hz. The placement was focused by clinical focusing (area of maximal tenderness) in a circumferential pattern, starting at the point of maximum pain level with no local anesthesia in all cases.

The primary criteria was defined as the VISA-A questionnaire, which was evaluated at each visit. This score was validated for Achilles tendon problems and contains 8 questions that cover the 3 domains of pain. General assessment was scored by the patient on a 6-point Likert scale, which measures the extent to which a person agrees or disagrees with a statement. The sample size calculation was based on10% loss to follow-up, a type I error rate of 0.05, and a power of 0.8. Finally 25 patients were estimated to be enrolled in each trial arm.

At baseline no significant difference were found in between all treatment. 16 weeks after rESWT group 1 (eccentric loading) and group 2 (rESWT) showed significantly better results (all $P < 0.01$) than before treatment. Patients from group 1 and group 2 achieved

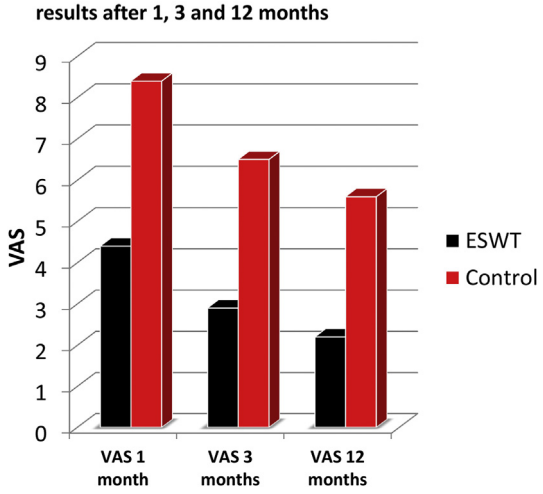

Fig. 3. Furia et al.: Am J Sport Med 2008.

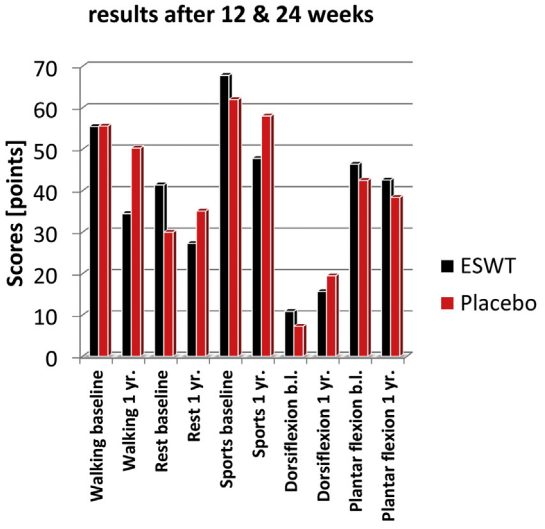

Fig. 4. Rasmussen et al.: Acta Orthopaedica 2008.

significantly better results compared to wait and see patients ($P < 0.001$; power = 0.99). There was no statistically significant difference between the results of group 1 patients and group 2 patients ($P = 0.259$; power = 0.13). The results of load-induced pain assessment showed same outcome as the VISA-A results with no significant difference at baseline. At 16 weeks follow up all groups showed better results than before treatment. Patients from groups 1 and 2 achieved significantly better results than patients from group 3 (all $P < 0.001$). Improvements from the pretreatment level were statistically significant in all groups (all $P < 0.001$) (Fig. 5).

The authors concluded that Eccentric training or SWT should be offered to patients with chronic recalcitrant tendinopathy of the main body of Achilles tendinopathy as an alternative to surgery.

Rompe and coauthors continued in shock wave research and published another study of radial shock waves in Achilles tendinopathy in 2008 [26]. Their study purposes that radial shock wave therapy and eccentric exercises are more effective than eccentric exercises alone. The study design was randomized prospective controlled. In all patients the diagnosis was midportion tendinopathy of the Achilles tendon defined by pain over the main body of the Achilles tendon 2–6 cm proximal to its insertion, swelling, and impaired function. Inclusion criteria for the study were diagnosis of chronic midportion Achilles tendinopathy for at least 6 months before treatment and failure of nonoperative management such as at least one injection of a local anesthetic and/or corticosteroid, a trial of anti-inflammatory medications, orthotics and/or a heel lift, and physiotherapy. The local medical ethics committee had approved the protocol and a computerized random-number generator was used to formulate an block randomized allocation schedule. For eccentric exercises the patients were instructed how to perform the eccentric exercises on an individual protocol. In group 2, (ESWT plus eccentric exercises) patients started with the training program. After 4 weeks, all patients received 3 sessions of rESWT ad on. The rESWT took place in 3 sessions at weekly intervals given by 2000 pulses per session at a pressure of 3 bar (equals to 0.1 mJ/mm^2 energy flux density) at a frequency of 8 Hz. Patient guided focusing was performed in all cases without any local anesthetics at all.

Again the primary criteria was defined as the VISA-A questionnaire and general assessment was scored by the patient on a 6-point Likert scale measuring the extent to which a person agrees or disagrees with a statement at 6 weeks and 16 weeks follow up (Fig. 6).

At the 4-month follow-up, both groups showed better results

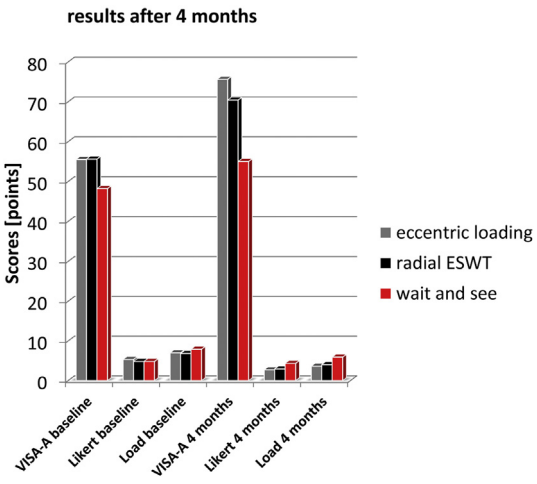

Fig. 5. Rompe et al.: Am J Sports Med 2007.

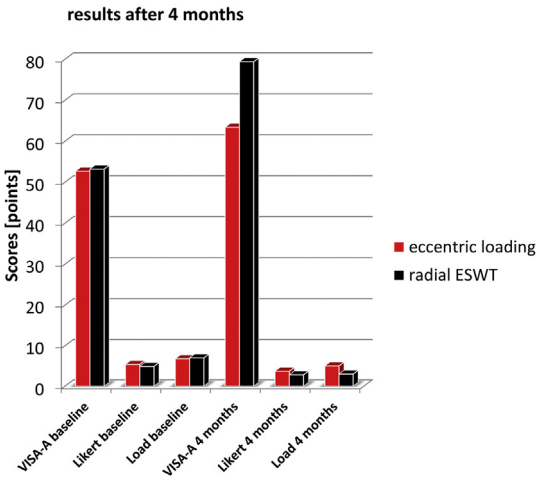

Fig. 6. Rompe et al.: Am J Sports Med 2008.

than pre treatment on the VISA-A questionnaire (group 1: 73 ± 19; group 2: 87 ± 16). Patients from group 1 and from group 2 differed significantly ($P = 0.0016$; post hoc power: .96). Similar the outcome scoring at 16 weeks follow up on the Likert scale. Nineteen out of 34 (56%) patients in group 1 and 28 out of 34 patients (82%) in group 2 reported completely recovered or much improved on the Likert scale. Patients from group 2 (eccentric exercises plus radial ESWT) achieved significantly better results than patients from group 1 ($P = 0.001$). There were no serious complications. In all patients, transient reddening of the skin occurred after low-energy radial ESWT, but no bruising without any device-related complications.

According to the data the authors concluded that eccentric training plus SWT should be offered to patients with chronic recalcitrant midportion tendinopathy of the Achilles tendon.

2. Conclusion

Recently published data have shown the high evidence of efficacy of extracorporeal shock wave therapy in chronic Achilles tendinopathy. Randomized placebo controlled trials have confirmed excellent results with regards to function and pain. So far no differentiation can be done between different treatment modalities such as application pressure, energy flux density or frequency. Further studies have to focus on this missing evidence to further improve the outcome after ESWT. Shock wave therapy as published up to day seems to be the most effective option in chronic Achilles tendinopathy.

Ethical approval

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Conflict of interest statement

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Guarantor

Prof. Dr. med. Ludger Gerdesmeyer MD, PhD
Dept. Orthopaedic Surgery and Traumatology

University Schleswig Holstein
Campus Kiel
Arnold Heller Strasse D-24105 Kiel Tel.: +49 431 597 5505 e-mail: Gerdesmeyer@aol.com.

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