

**SHOCKWAVE THERAPY**  
**Evidence Based Indications**  
**Scientific Studies: An Overview**

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**The Effects of Extracorporeal Shock Wave Therapy on Spastic Muscle of the Wrist Joint in Stroke Survivors: Evidence from Neuromechanical Analysis.**

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<b>Authors</b>	Leng Y, Lo WLA, Hu C, Bian R, Xu Z, Shan X, Huang D, Li L.
<b>Published</b>	Frontiers in Neuroscience Jan 21;14: 1-16
<b>Date</b>	Jan 2021
<b>Place of origin</b>	Department of Rehabilitation Medicine, The First Affiliated Hospital, Sun Yat-sen University, Guangzhou, China
<b>Background</b>	Spasticity cannot always be adequately managed despite the diversity of treatment regimens. The common side effects of drugs and the invasiveness of local treatment are undesirable. Thus, effective and non-invasive intervention methods for spasticity are urgently needed, particularly for the intervention that target the peripheral muscular factor that contributes to muscle spasticity
<b>Objective</b>	The study aimed to assess the neural and peripheral contribution to spasticity post stroke by combining biomechanical modelling method with mechanical muscle properties and muscle composition information from electrical impedance measurement. This was followed by an investigation of the effects and underlying mechanism of rESW on spasticity.
<b>Tested products</b>	Chattanooga® Intelect RPW
<b>Study design &amp; methods</b>	<p>A single-blinded randomized controlled study.</p> <p>Subjects: people with first occurrence of stroke were randomly allocated to rESW intervention or control group.</p> <ul style="list-style-type: none"><li>• Intervention group: received one session of radial pressure wave immediately after baseline assessment. Participants then received 1 week of routine rehabilitation therapy at the same frequency and intensity with the control group.</li><li>• Control group: received 5 sessions of regular rehabilitation treatment within a week.</li></ul> <p>27 subjects completed the study.</p>

**RPW Protocol**

- 1,500 shots with a pressure of 1.5 bars and wave irradiation of 4 Hz.
- The treated area focused on the muscle belly of the radial carpi flexor.
- The energy applied was 0.038 mJ/mm<sup>2</sup>

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## Outcome measures

- Neural and peripheral contribution of spasticity were assessed by the parameters of Neural component (NC), Elastic component (EC), and Viscosity component (VC) measured by the NeuroFlexor method.
- Mechanical muscle properties of tone (F) and stiffness (S) were assessed by myotonometer.
- Electrical impedance myography (EIM) measured the parameters of resistance (R), reactance (X), and Phase angle ( $\theta$ ) [ $\theta = \arctan (X/R)$ ].
- Severity of muscle spasm was clinically assessed by the Modified Ashworth Scale (MAS).
- Upper limb function was assessed the Fugl-Meyer Assessment (FMA) scale.

All outcome measures were recorded at baseline, immediately post rESW and at 1-week follow-up.

- The differences between the paretic and non-paretic side were assessed by t-test
- The effectiveness of rESW treatment were analyzed by repeated-measures one-way analysis of variance (ANOVA) at different time points

## Results

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### Baseline measurements:

- NC, EC, and VC of the Neuroflexor method, F and S from myotonometer were all significantly higher on the paretic side than those from the non-paretic side.
- R, X, and  $\theta$  from electrical impedance were significantly lower on the paretic side than the non-paretic side.

### Immediately after rESW intervention:

- VC, F, and S were significantly reduced, and X was significantly increased.
- MAS score was significantly decreased

## Conclusion

- The observed changes in upper limb muscle properties adds further support to the theory that both the neural and peripheral components play a role in muscle spasticity.
- ESW intervention may be more effective in addressing the peripheral component of spasticity in terms of muscle mechanical properties changes.
- The clinical management of post stroke spasticity should take into consideration of both the neural and non-neural factors in order to identify optimal intervention regime.

**Key message**

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Radial Pressure Wave Therapy appears to be effective in addressing the peripheral component of spasticity.

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## Three Sessions of Radial Extracorporeal Shockwave Therapy Gives No Additional Benefit Over "Minimal-Dose" Radial Extracorporeal Shockwave Therapy for Patients With Chronic Greater Trochanteric Pain Syndrome: A Double-Blinded, Randomized, Controlled Trial

<b>Authors</b>	Wheeler PC, Dudson C, Calver R, Goodall D, Gregory KM, Singh H, Boyd KT.
<b>Published</b>	Clinical Journal Sport Medicine 00:1–12
<b>Date</b>	Jan 2021
<b>Place of origin</b>	Department of Sport and Exercise Medicine, University Hospitals of Leicester NHS Trust, Leicester, United Kingdom
<b>Objective</b>	To investigate the outcomes following 3 weekly sessions of radial extracorporeal shockwave therapy (rESWT) in patients with chronic greater trochanteric pain syndrome (GTPS) presenting to an NHS Sports Medicine Clinic in the United Kingdom
<b>Tested products</b>	Chattanooga Intelect RPW
<b>Study design &amp; methods</b>	Double-blinded randomized controlled trial.

### Subjects:

- 120 patients in an NHS Sports Medicine clinic presenting with symptoms of GTPS who had failed to improve with a minimum of 3 months of rehabilitation.
- Mean age was  $60.6 \pm 11.5$  years; 82% were female, and the mean duration of symptoms was  $45.4 \pm 33.4$  months (range, 6 months to 30 years).

### Methods: subjects were randomized equally to one of two groups

- The first (intervention) group received 3 rESWT sessions performed at weekly intervals using the “recommended dose” of rESWT.
- The second (control) group received 3 sessions at weekly intervals with “minimal dose” of rESWT using the lowest possible energy dose from this rESWT machine.

### Interventions:

- All patients received a structured home exercise program involving flexibility, strength, and balance exercises
- The intervention group had rESWT performed following the manufacturer’s representative recommendations, 2000 shocks at 20Hz and to use a “maximal comfortably tolerated” level, rather than a single specified pressure setting.
- This level was individual and varied between sessions depending on comfort. In this study, the mean value of the pressure waves generated in the intervention group was 2.3 (+ 0.3), 2.8 (+ 0.3), and 3.3 (+ 0.4) bar for the first, second, and third treatment sessions, respectively.

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- The members of the control group received a “minimal dose” using a frequency of 20.0 Hz, with 500 shocks per treatment (as opposed to 2000 in the intervention group) and a 1.4 bar pressure (approximately half that of the intervention group.) Participants were blinded in both groups.

**Main outcome measures:**

- Local hip pain - the primary outcome measure was the between-group changes in self-reported “average pain” (as recorded on a 0-10 numerical ratings scale) between baseline and 6 months
- Validated hip PROMs (Oxford hip score)
- Non-arthritic hip score
- Victorian Institute of Sport assessment questionnaire (VISA-G)
- Other measures of function including sleep (Pittsburgh sleep quality index) and mood (hospital anxiety and depression scale).

Follow-up was at 6 weeks, 3 months, and 6 months.

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**Results**

- Results were available for 98% of patients at the 6-month period.
- There were no differences found in any of the baseline pain/stiffness scores or baseline PROMs studied between the 2 groups.
- There were statistically significant within-group improvements for all of the different hip-related measures that were examined at all time points studied and compared with baseline values.
- Fewer benefits were seen in other outcome measures, including activity or mood.
- The between-group analyses showed no statistically significant time x group interaction effects identified for any of the hip PROMs or measures of self-reported pain or stiffness at any of the follow-up periods.

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**Conclusion**

- There were no time x group interaction effects seen between the groups at any time point, indicating that in the 3 sessions, the “recommended-dose” rESWT had no measurable benefit compared with “minimal dose” rESWT in this group of patients with GTPS.
- The underlying reason remains unclear; it may be that rESWT is ineffective in the treatment of patients with chronic GTPS, that “minimal dose” rESWT is sufficient for a therapeutic effect, or that a greater number of treatment sessions are required for maximal benefit.
- These issues need to be considered in further research.

**Comments:**

This study was not able to show an additional effect of the “higher dose” (more shocks, higher pressure) compared to a minimal dose of 500 shocks @ 1.4 bar.

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**There are some possible explanations:**

- The fact that both groups significantly improved with RPW treatment could be attributed to spontaneous improvement - although this is unlikely because all patients had been using standard rehab during at least 3 months without effect.
- Another explanation could be that for GTP syndrome, minimal dose is sufficient to obtain significant improvement of pain & PROM scores and applying higher doses has no additional advantage.
- Another reason could be that more sessions are needed to observe an advantage of higher dose application.

The lack of a control group receiving sham RPW is a limitation of this study.

Having a difference in two parameter settings in the two groups (number of shocks and bar pressure) makes it difficult to know the relative contribution of each parameter.

**Key message**

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500 pulses @ 1.4 bar ("minimal dose") RPW treatment provided significant improvement of pain and PROM in GTPS. More shocks and higher pressure did not provide additional benefit.

## Focused, radial and combined shock wave therapy in treatment of calcific shoulder tendinopathy.

<b>Authors</b>	Abo Al-Khair MA, El Khouly RM, Khodair SA, Al Sattar Elsergany MA, Hussein MI, Eldin Mowafy ME.
<b>Published</b>	Phys Sportsmed. Dec 6:1-8
<b>Date</b>	Dec 2020
<b>Place of origin</b>	Physical Medicine, Rheumatology and Rehabilitation, Faculty of Medicine, Tanta University, Tanta, Egypt
<b>Background</b>	Extracorporeal shock-wave therapy has been used in the treatment of many musculoskeletal disorders such as; proximal plantar fasciitis, lateral epicondylitis, calcific shoulder tendonitis, and patellar tendinopathy with high success rates. It was found that ESWT can help reduction of inflammation, destruction of calcifications, tissue regeneration, and chronic pain relief
<b>Objective</b>	The aim of this work is to compare the clinical, functional, and ultrasonographic outcomes of focused, radial, and combined extracorporeal shock-wave therapy (ESWT) in the treatment of calcific shoulder tendinopathy.
<b>Tested products</b>	Storz SD1 Device
<b>Study design &amp; methods</b>	Randomized control study

### Method

- 45 patients with calcific shoulder tendinopathy, their ages ranged from 30 to 68 (50.93 ± 9.44) years
- Classified according to the line of treatment into three groups
- All received four sessions of ESWT 1 week apart
- Group I: 15 patients received focused shock waves (F-SW) 1500 shocks
- Group II: 15 patients received radial shock waves (R-SW) 2000 shocks
- Group III: 15 patients received combined focused and radial shock waves (C-SW).
- All patients were evaluated by musculoskeletal ultrasound (MSK US) before treatment, at 1 week and at 3 months after the last session.

<b>Results</b>	<ul style="list-style-type: none"><li>• In the three studied groups, there was a significant improvement in shoulder pain, active range of motion (ROM), and shoulder function by shoulder disability questionnaire (SDQ) at 1 week after the end of treatment and after 3 months follow up.</li><li>• Moreover, there was a significant sonographic reduction in calcification size in the three groups.</li></ul>
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- At the end of the study, the best improvement as regards a decrease of calcification size was obtained in group III when compared with group I and group II.

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**Conclusion**

These results demonstrated clinical, functional, and sonographic improvement in all groups. The best therapy in calcific shoulder tendinopathy appears to be combined focused and radial ESWT compared to interventions alone. Level 1 Evidence Randomized control study.

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**Key message**

Both FSW and RPW can provide improvements in reducing calcification in the rotator cuff. Combining FSW and RPW has been shown to provide even better results



## Extracorporeal shock wave therapy versus local corticosteroid injection for the treatment of carpal tunnel syndrome: a meta-analysis.

<b>Authors</b>	Li W, Dong C, Wei H, Xiong Z, Zhang L, Zhou J, Wang Y, Song J, Tan M.
<b>Published</b>	J Orthop Surg Res. 23;15(1):556
<b>Date</b>	Nov 2020
<b>Place of origin</b>	Beijing University of Chinese Medicine, Beijing, 100029, China
<b>Background</b>	Many studies have demonstrated the effectiveness of extracorporeal shock wave therapy (ESWT) and local corticosteroid injection (LCI) for the treatment of carpal tunnel syndrome (CTS), and some studies showed that the effect of ESWT was superior to LCI. We performed this meta-analysis to compare the clinical effects across the two therapies
<b>Objective</b>	A meta-analysis of related RCTs to compare the efficacy of ESWT and LCI to provide greater evidence for clinical decision-making.
<b>Tested products</b>	Focused (x3) and Radial Pressure wave (x2) devices
<b>Study design &amp; methods</b>	Systematic review and meta-analysis

### Method

- Relevant randomized controlled trials (RCTs) comparing ESWT and LCI for the treatment of CTS were searched in electronic database.
- A total of 5 RCT studies with 204 patients were included from the electronic database.

### Inclusion criteria

- Published clinical RCT
- Patients with a clear diagnosis of CTS, and the age, gender, and nationality were not limited
- ESWT was used as an intervention measure, and CTS was used as a control measure
- Complete comparison data between ESWT and CTS could be obtained.

### Exclusion criteria

- CTS caused by trauma, fracture, tumor, infection, endocrine system disease, etc., or combined with diabetes, peripheral polyneuropathy, coagulation disorder, thrombosis, mental system disease, etc.
- Patients who had received carpal tunnel surgery
- Patients who had received oral hormones, non-steroidal anti-inflammatory drugs, and splint fixation before being enrolled
- Animal experiments

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## Outcomes

- The Cochrane risk bias tool was used for quality assessment.
- After data extraction and quality assessment of the included studies, a meta-analysis was performed using RevMan 5.3 software.
- Mean differences (MDs), odds ratios (ORs), and 95% confidence intervals (CIs) were analyzed.

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## Results

- The meta-analysis results showed that two therapies were not significantly different in terms of visual analog scale (VAS) score ( $P = 0.65$ ), Boston Carpal Tunnel Questionnaire (BQ) score ( $P = 0.14$ ), sensory distal latency ( $P = 0.66$ ), and nerve conduction velocity (NCV) of the sensory nerve ( $P = 0.06$ ).
- There were significant differences between the results of motor distal latency ( $P < 0.0001$ ), compound muscle action potential (CMAP) amplitude ( $P < 0.00001$ ), and sensory nerve action potential (SNAP) amplitude ( $P = 0.004$ ).

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## Conclusion

In terms of pain relief and function improvement, the effects of ESWT and LCI are not significantly different. In terms of electrophysiological parameters, LCI has a stronger effect on shortening motor distal latency; ESWT is superior to LCI in improving action potential amplitude. ESWT is a noninvasive treatment with fewer complications and greater patient safety. In light of the heterogeneity and limitations, these conclusions require further research for definitive conclusions to be drawn.

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## Key message

ESWT for Carpal Tunnel Syndrome proves to have fewer complications and greater patient safety than a local corticosteroid injection

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## The effects of shockwave therapy on musculoskeletal conditions based on changes in imaging: a systematic review and meta-analysis with meta-regression.

<b>Authors</b>	Al-Abbad H, Allen S, Morris S, Reznik J, Biroš E, Paulik B, Wright A.
<b>Published</b>	BMC Musculoskelet Disord. 2020 Apr 28;21(1):275.
<b>Date</b>	Apr 2020
<b>Place of origin</b>	School of Physiotherapy and Exercise Science, Curtin University, Perth, WA, Australia.
<b>Background</b>	Shockwave therapy (SWT) is a commonly used intervention for a number of musculoskeletal conditions with varying clinical outcomes. However, the capacity of SWT to influence pathophysiological processes and the morphology of affected tissues remains unclear.
<b>Objective</b>	The objective of the current review is to evaluate changes in imaging outcomes of musculoskeletal conditions following SWT.
<b>Study design &amp; methods</b>	Systematic review with meta-analysis.

### Methods:

- A comprehensive search of Medline, Embase, Cochrane Controlled Trials Register, CINAHL and SportDiscus was conducted from inception to October 2018.
- Prospective clinical trials evaluating the effectiveness of SWT based on changes in imaging outcomes were eligible for inclusion. Articles were evaluated independently for risk of bias using the Cochrane Risk of Bias list and the Methodological Index for Non-Randomized Studies.
- Random-effects meta-analysis and meta-regression with a priori determined covariates was conducted for each condition to determine potential predictors of SWT effects.

### Outcomes:

- Changes in measures derived from imaging methods such as MRI, ultrasonography, CT, DEXA or plain radiography reflecting morphological changes in affected musculoskeletal tissues following SWT were the primary evaluated outcomes for this review.
- The measures of effect were pre to post-imaging changes, demonstrating presence, grade, signal intensity or size of the tissue lesion.

## Results

63 studies were included, with data from 27 studies available for effect size pooling.

Meta-analyses and meta-regression on imaging outcomes were performed for rotator cuff calcific tendinitis (n = 11), plantar fasciitis (n = 7) and osteonecrosis of the femoral head (n = 9).

There was an overall reduction in the size of measured lesion following SWT

- for calcium deposit diameter (MD 8.44 mm (95%CI -4.30, 12.57),  $p < 0.001$ )
- for plantar fascia thickness (MD 0.92 mm (95%CI -0.03, 1.81),  $p = 0.04$ )
- for lesion size in femoral head osteonecrosis (MD 4.84% (95%CI -0.06, 9.75),  $p = 0.05$ )

Meta-regression showed no influence of SWT dosage parameters, however, baseline lesion size was an independent predictor for changes in imaging outcomes.

## Conclusion

SWT altered the morphology of musculoskeletal conditions, potentially reflecting changes in underlying pathophysiological processes. The parameters of SWT dosage are not significant predictors of changes in imaging outcomes. Lack of adequate reporting of imaging outcomes limited the conclusions that could be drawn from the current review.

## Key message

Imaging outcomes showed reduction of the calcium deposit diameter in rotator cuff tendinitis, of plantar fascia thickness in plantar fasciitis and of the lesion size in femoral head osteonecrosis, reflecting an influence of shock wave therapy on the underlying pathophysiological process of those conditions.

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**Comparison of the effectiveness of ESWT and ultrasound treatments in myofascial pain syndrome: randomized, sham-controlled study.**

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<b>Authors</b>	Aktürk S, Kaya A, Çetintaş D, Akgöl G, Gülkesen A, Kal GA, Güçer T.
<b>Published</b>	J Phys Ther Sci. 2018 Mar; 30(3): 448–453.
<b>Date</b>	Mar 2018
<b>Place of origin</b>	Faculty of Medicine, İnönü University: Malatya, Turkey.
<b>Objective</b>	To compare effectiveness of extracorporeal shock wave therapy (ESWT), ultrasound (US) and sham ESWT in the treatment of myofascial pain syndrome (MPS).
<b>Tested products</b>	Storz Masterpulse MP 200
<b>Study design &amp; methods</b>	<p>Randomized, sham-controlled study.</p> <p><b>Subjects:</b> 60 MPS patients aged 18-60 years</p> <p><b>Methods:</b> the patients were randomized equally into 3 groups.</p> <ul style="list-style-type: none"><li>• Group 1 received ESWT for 4 session with 3 day-intervals (200-300 pulses/TP, 1.6-3.0 bar with D20 transmitter).</li><li>• Group 2 received 4 sessions of sham ESWT.</li><li>• Group 3 received 10 sessions of US therapy.</li></ul> <p>All patients were recommended an exercise program.</p> <p><b>Outcomes:</b></p> <ul style="list-style-type: none"><li>• Pressure pain threshold (PPT)</li><li>• Pain score (PS) with digital palpation (0-3)</li><li>• Visual analogue scale (VAS)</li><li>• Patients evaluation using SF-36 and HADS (hospital anxiety and depression scale)</li></ul> <p>The patients were evaluated before-post and 6 weeks after treatment.</p>
<b>Results</b>	<ul style="list-style-type: none"><li>• A significant posttreatment difference was found in VAS, PPT and SF-36 subparameters in group 1.</li><li>• In group 2, a significant difference was not found in any parameter.</li><li>• In group 3, a significant difference was detected in parameters of VAS and PPT.</li><li>• A significant difference was found between groups 1 and 2 as for subtitles of PPT, VAS, SF-36.</li></ul>
<b>Conclusion</b>	These results suggest that ESWT is as effective as US. ESWT and US are significantly more effective than sham ESWT.
<b>Key message</b>	<p>Both Ultrasound and RPW treatment of myofascial trigger points provided significant improvement of symptoms.</p> <p>Real RPW was significantly more effective than placebo RPW which did not yield any improvement.</p>

## **Radial Shock Wave Devices Generate Cavitation**

**Authors** [Nikolaus B. M. Császár](#),<sup>1</sup> [Nicholas B. Angstman](#),<sup>1</sup> [Stefan Milz](#),<sup>1</sup> [Christoph M. Sprecher](#),<sup>2</sup> [Philippe Kobel](#),<sup>3</sup> [Mohamed Farhat](#),<sup>3</sup> [John P. Furia](#),<sup>4</sup> and [Christoph Schmitz](#)<sup>1,\*</sup>

**Published** <https://doi.org/10.1371/journal.pone.0140541>

**Date** Oct 2015

**Place of origin** USA

**Background** Conflicting reports in the literature have raised the question whether radial extracorporeal shock wave therapy (rESWT) devices and vibrating massage devices have similar energy signatures and, hence, cause similar bioeffects in treated tissues.

**Objective** To compare effectiveness of extracorporeal shock wave therapy (ESWT), ultrasound (US) and sham ESWT in the treatment of myofascial pain syndrome (MPS).

**Tested products** Storz Masterpulse MP 200 / EMS Swiss Dolorclast

**Study design & methods** Randomized, sham-controlled study.

We used laser fiber optic probe hydrophone (FOPH) measurements, high-speed imaging and x-ray film analysis to compare fundamental elements of the energy signatures of two rESWT devices (Swiss DolorClast; Electro Medical Systems, Nyon, Switzerland; D-Actor 200; Storz Medical, Tägerwillen, Switzerland) and a vibrating massage device (Vibracare; G5/General Physiotherapy, Inc., Earth City, MO, USA). To assert potential bioeffects of these treatment modalities we investigated the influence of rESWT and vibrating massage devices on locomotion ability of *Caenorhabditis elegans* (*C. elegans*) worms.

**Results**

- FOPH measurements demonstrated that both rESWT devices generated acoustic waves with comparable pressure and energy flux density. Furthermore, both rESWT devices generated cavitation as evidenced by high-speed imaging and caused mechanical damage on the surface of x-ray film. The vibrating massage device did not show any of these characteristics. Moreover, locomotion ability of *C. elegans* was statistically significantly impaired after exposure to radial extracorporeal shock waves but was unaffected after exposure of worms to the vibrating massage device..

**Conclusion** The results of the present study indicate that both energy signature and bioeffects of rESWT devices are fundamentally different from those of vibrating massage devices.

**Key message** Prior ESWT studies have shown that tissues treated with sufficient quantities of acoustic sound waves undergo cavitation build-up, mechanotransduction, and ultimately, a biological alteration that “kick-starts” the healing response. Due to their different treatment indications and contra-indications rESWT devices cannot be equated to vibrating massage devices and should be used with due caution in clinical practice.

**Extracorporeal shock wave promotes activation of anterior cruciate ligament remnant cells and their paracrine regulation of bone marrow stromal cells' proliferation, migration, collagen synthesis, and differentiation**

**Authors** Lu CC., Chou SH., Shen PC., Chou PH., Ho ML., Tien YC.

**Published** Bone Joint Res. 2020 Aug 11. doi: 10.1302/2046-3758.98.BJR-2019-0365.R1.

**Date** AUG 2020

**Abstract**

**Aims:** Proliferation, migration, and differentiation of anterior cruciate ligament (ACL) remnant and surrounding cells are fundamental processes for ACL reconstruction; however, the interaction between ACL remnant and surrounding cells is unclear. We hypothesized that ACL remnant cells preserve the capability to regulate the surrounding cells' activity, collagen gene expression, and tenogenic differentiation. Moreover, extracorporeal shock wave (ESW) would not only promote activity of ACL remnant cells, but also enhance their paracrine regulation of surrounding cells.

**Methods:** Cell viability, proliferation, migration, and expression levels of Collagen-I (COL-I) A1, transforming growth factor beta (TGF- $\beta$ ), and vascular endothelial growth factor (VEGF) were compared between ACL remnant cells untreated and treated with ESW (0.15 mJ/mm<sup>2</sup>, 1,000 impulses, 4 Hz). To evaluate the subsequent effects on the surrounding cells, bone marrow stromal cells (BMSCs)' viability, proliferation, migration, and levels of Type I Collagen, Type III Collagen, and tenogenic gene (*Scx*, *TNC*) expression were investigated using coculture system.

**Results:** ESW-treated ACL remnant cells presented higher cell viability, proliferation, migration, and increased expression of COL-I A1, TGF- $\beta$ , and VEGF. BMSC proliferation and migration rate significantly increased after coculture with ACL remnant cells with and without ESW stimulation compared to the BMSCs alone group. Furthermore, ESW significantly enhanced ACL remnant cells' capability to upregulate the collagen gene expression and tenogenic differentiation of BMSCs, without affecting cell viability, TGF- $\beta$ , and VEGF expression.

**Conclusion:** ACL remnant cells modulated activity and differentiation of surrounding cells. The results indicated that ESW enhanced ACL remnant cells viability, proliferation, migration, and expression of collagen, TGF- $\beta$ , VEGF, and paracrine regulation of BMSC proliferation, migration, collagen expression, and tenogenesis. Cite this article: *Bone Joint Res* 2020;9(8):458-468.

**Effectiveness of extracorporeal shock wave therapy in patients with tennis elbow: A meta-analysis of randomized controlled trials**

**Authors** Zheng C., Zeng D., Chen J., Liu S., Li J., Ruan Z., Liang W.

**Published** Medicine (Baltimore). 2020 Jul 24;99(30):e21189. doi: 10.1097/MD.00000000000021189.

**Date** JUL 2020

**Abstract**

**Background:** The aim of the present study was to investigate the effectiveness of Extracorporeal Shock Wave (ECSW) in the treatment of lateral epicondylitis (LE) of humerus.

**Hypothesis:** ECSW therapy in people with LE effectively reduces the pain and gains functional rehabilitation.

**Materials/methods:** Databases of PubMed, EMBASE, Web of Science and the Cochrane Library from inception to April 2020 was searched to identify all relevant RCTs comparing ECSW therapy with any other conservative treatment, including injection and local anesthetic versus placebo or control in patients aged 18 with LE. The primary outcome is the mean overall pain score at 12 weeks after treatment. Another secondary outcome mainly included Thomsen test, 50% pain reduction, grip strength and adverse effect at 12 weeks after treatment.

**Results:** Nine studies were included in the meta-analysis. Compared with the placebo group, ECSW cannot significantly reduce the pain score (mean deviation [MD] = -4.23, 95% confidence interval [CI]: -8.78 to 0.32, P = .07), but make more people acquire 50% pain reduction (MD = 1.38, 95% CI: 1.09 to 1.75, P = .008). There was no significant difference between ECSW and control in decreasing the pain score of Thomsen test (MD = -3.22, 95% CI: -14.06 to 7.62, P = .56). ECSW was more effective in Grip strength as compared with control at 12 weeks-3 months (MD = 3.52, 95% CI: 2.43 to 4.60, P < .00001) **CONCLUSIONS:** Results suggested that ECSW cannot effectively reduce the mean overall pain, but it showed more people acquire 50% pain reduction and might be a better option for the treatment of LE. Because of study limitations, additional high level of evidence, more rigorously designed large-samples and high-quality randomized controlled trials are needed to guide clinical practice.



**Extracorporeal shock wave therapy versus other therapeutic methods for chronic plantar fasciitis.**

**Authors** Sun K., Zhou H., Jiang W.

**Published** Foot Ankle Surg. 2020 Jan;26(1):33-38. doi: 10.1016/j.fas.2018.11.002. Epub 2018 Nov 13.  
© 2018 European Foot and Ankle Society.

**Date** Nov 2018

**Abstract**

**Background:** To conduct a meta-analysis comparing the efficacy of general ESWT with that of other therapies and to assess its effectiveness in chronic plantar fasciitis.

**Methods:** A literature search was performed in PubMed, Embase, Web of Science and the Cochrane Library for information from the earliest date of data collection to March 2018. Studies comparing the benefits and risks of extracorporeal shock wave therapy with those of other therapies for chronic plantar fasciitis were included. Statistical heterogeneity was quantitatively evaluated by a  $X^2$  test with the significance set as  $P < 0.10$  or  $I^2 > 50\%$ .

**Results:** Thirteen trials consisting of 1,185 patients were included (637 patients were treated with ESWT; 548 patients, with OT). The results showed that patients treated with ESWT had increased success or improvement rates, an increased modified Roles & Maudsley (RM) score, a reduction of pain scales, reduced return to work time, and fewer complications than patients treated with other therapy methods ( $P < 0.1$ ).

**Conclusions:** Compared with patients who received other therapies for chronic plantar fasciitis, patients treated with ESWT responded better, had less complications and showed a clear difference in efficacy between ESWT and other therapy in chronic plantar fasciitis.

**Level of evidence:** Level IV, therapeutic study.

## Elastosonographic Evaluation After Extracorporeal Shockwave Treatment in Plantar Fasciopathy

**Authors** Alviti F., D'Ercole C., Schillizzi G., Mangone M., Bernetti A., Ioppolo F., Di Sante L., Minafra P., Santilli V., Elia D., Vallone G., D'Ambrosio F., Cantisani V.

**Published** Med Ultrason. 2019 Nov 24;21(4):399-404. doi: 10.11152/mu-1976.  
PMID: 31765447

**Date** Nov 2019

### Abstract

**Aim:** To assess the ultrasound features in patients with plantar fasciopathy before and after extracorporeal shock waves therapy (ESWT), using conventional grey-scale imaging and both strain (SE) and shear wave (SWE) elastosonographic evaluation.

**Material and method:** Consecutive patients of both sexes attending our outpatient's clinic, with diagnosis of unilateral plantar fasciopathy, were enrolled. Patients were treated with 3 sessions of ESWT once a week and underwent clinical and ultrasound evaluation at baseline and at one and three months after treatment. Roles and Maudsley score (RM), visual analogue scale (VAS) and 17-Italian Foot Function Index (FFI), were used to assess pain and functional improvement.

**Results:** Twenty patients (11 female and 9 male) were enrolled in the study. Contralateral asymptomatic healthy plantar fascia was used as a control. At baseline, SWE velocity (SWEv) showed statistically significant difference between affected 3.8 (1.5; 5.1) m/s and healthy side 4.7 (4.07; 7.04) m/s, ( $p=0.006$ ); no significant difference was found for strain ratio values ( $p=0.656$ ). SWEv post hoc test results showed a significant difference from baseline 3.8 (1.5-5.1) m/s and three month 5.23 (4.55-6.74) m/s follow up visit ( $p=0.003$ ). Significant statistical negative correlation was found between the SWEv and VAS ( $p=0.001$ ) and positive correlation between the SWEv and FFI ( $p=0.012$ ).

**Conclusion:** SWE was effective in assessing plantar fascia elasticity and its alteration in fasciopathy. Furthermore, on the basis of the correlation with pain and functional scales, this technique appears to be a useful additional technique to conventional ultrasound for monitoring the efficacy of treatment.

**A comparative study of the efficacy of ultrasonics and extracorporeal shock wave in the treatment of tennis elbow: a meta-analysis of randomized controlled trials.**

**Authors** Yan C., Xiong Y., Chen L., Endo Y., Hu L., Liu M., Liu J., Xue H., Abududilibaier A., Mi B., Liu G.

**Published** Med Ultrason. 2019 Nov 24;21(4):399-404. doi: 10.11152/mu-1976.  
PMID: 31765447

**Date** AUG 2019

**Abstract**

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**Background:** Tennis elbow or lateral epicondylitis is a common source of pain among craftsmen. Although it cannot be completely resolved, extracorporeal shock wave therapy (ESWT) and ultrasonics (US) have been found to be effective for tennis elbow as highlighted in previously published randomized controlled trials (RCTs) and reviews. However, the efficacy of these two therapies in treating tennis elbow is unknown. This meta-analysis compares the effectiveness of ESWT and US in relieving pain and restoring the functions of tennis elbow following tendinopathy.

**Methods:** RCTs published in the PubMed, Embase, Cochrane Library, and SpringerLink databases comparing ESWT and US in treating tennis elbow were identified by a software and manual search. The risk of bias and clinical relevance of the included studies were assessed. Publication bias was explored using funnel plot and statistical tests (Egger's test and Begg's test). The major outcomes of the studies were analyzed using the Review Manager 5.3.

**Results:** Five RCTs comprising five patients were included in the present meta-analysis. The results revealed a significantly lower VAS score of pain in the ESWT group (1 month: MD = 4.47,  $p = 0.0001$ ; 3 months: MD = 20.32,  $p < 0.00001$ ; and 6 months: MD = 4.32,  $p < 0.0001$ ) compared to US. Besides, the grip strength was markedly higher 3 months after the intervention in ESWT (MD = 8.87,  $p < 0.00001$ ) than in the US group. Although no significant difference was observed in the scores of the elbow function after 3 months of treatment (SMD = 1.51,  $p = 0.13$ ), the subjective scores of elbow functions were found to be better in the ESWT group (SMD = 3.34;  $p = 0.0008$ ) compared to the US group.

**Conclusions:** Although there was no significant difference in the elbow function evaluation scores between ESWT and US, the superiority of the ESWT group in the VAS of pain (both at 1 month, 3 months, and 6 months follow-ups) raised grip strength in ESWT group and the scores for subjective evaluation of efficacy indicated that ESWT offers more effective therapy for lateral epicondylitis than US therapy.

## **Enhancement of the Effectiveness of Extracorporeal Shock Wave Therapy with Topical Corticosteroid in Treatment of Chronic Plantar Fasciitis: A Randomized Control Clinical Trial**

<b>Authors</b>	Babak Vahdatpour, Arghavan Mokhtarian, Seyed Ahmad Raeissadat <sup>1</sup> , Farnaz Dehghan, Nafiseh Nasr, Mahsa Mazaheri.
<b>Published</b>	2018 Advanced Biomedical Research   Published by Wolters Kluwer - Medknow PMID: 29862211
<b>Date</b>	FEB 2018

### **Abstract**

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**Background:** Chronic recalcitrant plantar fasciitis is a disabling condition. We presumed if shock wave could increase the permeability of skin and facilitate penetration of topical corticosteroid through the skin; the combinational therapeutic effect would be stronger than using shock wave alone. The study purpose was to utilize the synergistic effect of shock wave and topical corticosteroid in treatment of plantar fasciitis.

**Materials and Methods:** Patients in both groups ( $n = 40$ ) received four sessions of shock wave with the same protocol at weekly intervals. At 30 min before each session, we used an occlusive dressing of topical clobetasol for the intervention group and Vaseline oil for the control group. Pain severity was assessed with visual analog scale (VAS) and modified Roles and Maudsley score (RMS) at baseline and 1 month and 3 months after intervention. Plantar fascia (PF) thickness was measured with ultrasonography at baseline and 3 months after intervention.

**Results:** One month after intervention, VAS morning showed significant improvement in intervention group ( $P = 0.006$ ) and RMS showed better improvement in intervention group ( $P = 0.026$ ). There was no significant difference between the two groups after 3 months in RMS or VAS score. PF thickness was decreased significantly in both groups, but it was not significant between the two groups ( $P = 0.292$ ).

**Conclusions:** This combinational therapy yielded earlier pain reduction and functional improvement than using shock wave alone; topical corticosteroid could enhance the effectiveness of shockwave in short-term in the treatment of recalcitrant plantar fasciitis.

**Rehabilitation treatment of spastic cerebral palsy with radial extracorporeal shock wave therapy and rehabilitation therapy**

**Authors** Yongjie Lin, Guowei Wang, Bingchen Wang.  
Lin et al.

**Published** Lin et al. Medicine (2018) 97:51  
PMID: 30572548 [Indexed for MEDLINE]

**Date** 2018

**Abstract**

This aims to investigate the effect of combined use of radial extracorporeal shock wave therapy (rESWT) and conventional rehabilitation therapy on postoperative rehabilitation of children with spastic cerebral palsy. Children with spastic cerebral palsy 6 weeks after multistage surgery were randomly divided into treatment group (received rESWT and conventional rehabilitation therapy) and control group (received conventional rehabilitation only). Before treatment, 2 weeks and 1 month after treatment, the Gross Motor Function Measure (GMFM), modified Ashworth Scale (MAS) of the hamstrings and triceps, plantar area and plantar pressure were examined for efficacy assessment. A total of 82 children with spastic cerebral palsy were recruited, including 43 children in treatment group and 39 children in control group. There was no significant difference in the age, MAS score, and GMFM score between the 2 groups before treatment. There were statistically significant differences between the 2 groups at 2 weeks and 4 weeks after treatment, including the MAS score, GMFM score, plantar area and plantar pressure ( $P < .05$ ). Within groups, there were also significant differences at different times ( $P < .05$ ). The rESWT combined with rehabilitation can quickly and effectively relieve paralysis of lower extremities, reduce the tension of hamstrings and calf muscles, relieve muscle spasm, and rapidly improve limb function in children with spastic cerebral palsy.

## Effectiveness and Safety of Shockwave Therapy in Tendinopathies

<b>Authors</b>	Vasileios Dedes, Apostolos Stergioulas, Georgios Kipreos, Ariadni Maria Dede, Athanasios Mitseas, Georgios I. Panoutsopoulos.
<b>Published</b>	Lin et al. Medicine (2018) 97:51 PMID: 30572548 [Indexed for MEDLINE]
<b>Date</b>	March 21 2018; Accepted: May 22, 2018 PMID: 30061805

### Abstract

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**Introduction:** People suffering from tendinopathies exhibit reduced mobility due to the pain caused by the movement of the tendons involved. Recently, shockwave therapy has been used as a treatment option, which is non-invasive, simpler, faster and safer.

**Aims:** To record the intensity of the pain, the functionality of the upper and lower limbs and quality of life before treatment with shock waves, immediately after the treatment and the 4-week follow-up.

**Methodology:** The sample consisted of 384 patients, suffering from a tendinopathy. 326 patients constituted the shockwave intervention groups and 58 patients made up the control groups. The researchers created a self-administered questionnaire (University of Peloponnese Pain, Functionality and Quality of Life Questionnaire) in which the intensity of pain, functionality and quality of life were evaluated on a five-point Likert scale, before, immediately after the treatment and at a 4-week follow-up.

**Results:** The pain reduction and the improvement of functionality and quality of life after shockwave treatment increased by at least two points on the five-point Likert scale both post-treatment ( $p < 0,001$ ) and at a 4-week follow-up ( $p < 0,001$ ) compared to post-treatment in elbow tendinopathy, Achilles tendinopathy, plantar fasciitis and rotator cuff tendinopathy.

**Conclusions:** Shockwave therapy significantly reduced the pain that accompanies tendinopathies and improves functionality and quality of life. It might be first choice because of its effectiveness and safety.

## **The Role of Extracorporeal Shockwave Treatment in Musculoskeletal Disorders**

**Authors** Daniel Moya, MD, Silvia Ram´on, MD, PhD, Wolfgang Schaden, MD, Ching-Jen Wang, MD, Leonardo Guiloff, MD, and Jai-Hong Cheng, MD.

**Published** THE JOURNAL OF BONE & JOINT SURGERY d J B J S .ORG VOLUME 100-A d NUMBER 3 d  
FEBRUARY 7, 2018  
PMID: 29406349 [Indexed for MEDLINE]

**Date** FEBRUARY 2018

### **Abstract**

- Increasing evidence suggests that extracorporeal shockwave treatment (ESWT) is safe and effective for treating several musculoskeletal disorders.
- Two types of technical principles are usually included in ESWT: focused ESWT (F-ESWT) and radial pressure waves (RPW). These 2 technologies differ with respect to their generation devices, physical characteristics, and mechanism of action but share several indications.
- Strong evidence supports the use of ESWT in calcifying tendinopathy of the shoulder and plantar fasciitis.
- The best evidence for the use of ESWT was obtained with low to medium energy levels for tendon disorders as well as with a high energy level for tendon calcification and bone pathologies in a comprehensive rehabilitation framework.

**Comparison the Effect of Extra Corporeal Shockwave Therapy with Low Dosage Versus High Dosage in Treatment of the Patients with Lateral Epicondylitis**

**Authors** Parisa Taheri, Masoud Emadi and Jafar Poorghasemian.

**Published** Adv Biomed Res. 2017; 6: 61. Published online 2017 May 29. doi: 10.4103/2277-9175.207148  
PMID: 28603702

**Date** MAY 2017

**Abstract**

**Background:** One of the most common reasons of elbow and forearm pain is lateral epicondylitis diagnosed based on clinical examination. The extracorporeal shock wave therapy is applied for less invasive treatments with different dosages. This study aimed to investigate the effects of high- and low-dose ESW in treating the lateral epicondylitis.

**Materials and methods:** This clinical trial was done in Al Zahra medical center on 40 patients who were selected randomly and divided into two groups. After VAS, the first group was treated by Duolith SD1 shock wave, energy of 0.25 mj/mm<sup>2</sup>, 1000 shocks; the second was treated by focus with the energy of 0.10 mj/mm<sup>2</sup>, 1000 shocks per session for 15 minutes with weekly intervals in three sessions. The patients were also treated with drugs (NSAIDs) and the visual analog scale (VAS) was reassessed 1 week after the last session and 12 weeks after finishing the treatment.

**Results:** The mean of pain intensity during study was decreased in the two groups but reduction of pain intensity in the low-dose groups was higher than the high-dose groups ( $P = 0.001$ ). Changes in other parameters including wrist extension test, middle finger extension test and PG was also similar.

**Conclusion:** Extra corporeal shockwave therapy can be effective in treating lateral epicondylitis, but its effects usually appear in after 2 or 3 months and using the low dose of this treating method has more desirable therapeutic effects.



## **Extracorporeal Shock Wave Therapy Accelerates Regeneration After Acute Skeletal Muscle Injury.**

**Authors** Zissler, A; Steinbacher, P; Zimmermann, R; Pittner, S; Stoiber, W; Bathke, AC; Sanger, AM.

**Published** Am J Sports Med. 2017 Mar;45(3):676-684.  
PMID: 27729321 [PubMed - in process]

**Date** MARCH 2017

### **Abstract**

**Background:** Muscle injuries are among the most common sports-related lesions in athletes; however, optimal treatment remains obscure. Extracorporeal shock wave therapy (ESWT) may be a promising approach in this context, because it has gained increasing importance in tissue regeneration in various medical fields.

**Hypothesis:** ESWT stimulates and accelerates regenerative processes of acute muscle injuries.

**Study design:** Controlled laboratory study.

**Methods:** Adult Sprague-Dawley rats were divided into 4 experimental groups (2 ESWT+ groups and 2 ESWT- groups) as well as an uninjured control group ( $n \geq 6$  in each group). An acute cardiotoxin-induced injury was set into the quadriceps femoris muscle of rats in the experimental groups. A single ESWT session was administered to injured muscles of the ESWT+ groups 1 day after injury, whereas ESWT- groups received no further treatment. At 4 and 7 days after injury, 1 each of the ESWT+ and ESWT- groups was euthanized. Regenerating lesions were excised and analysed by histomorphometry and immunohistochemistry to assess fibre size, myonuclear content, and recruitment of satellite cells.

**Results:** The size and myonuclear content of regenerating fibres in ESWT+ muscle was significantly increased compared with ESWT- muscle fibres at both 4 and 7 days after injury. Similarly, at both time points, ESWT+ muscles exhibited significantly higher contents of pax7-positive satellite cells, mitotically active H3P<sup>+</sup> cells, and, of cells expressing the myogenic regulatory factors, myoD and myogenin, indicating enhanced proliferation and differentiation rates of satellite cells after ESWT. Mitotic activity at 4 days after injury was doubled in ESWT+ compared with ESWT- muscles.

**Conclusion:** ESWT stimulates regeneration of skeletal muscle tissue and accelerates repair processes.

**Clinical relevance:** We provide evidence for accelerated regeneration of damaged skeletal muscle after ESWT. Although further studies are necessary, our findings support the view that ESWT is an effective method to improve muscle healing, with special relevance to sports injuries.

## **Radial extracorporeal shockwave therapy for the treatment of finger tenosynovitis (trigger digit).**

**Authors** Malliaropoulos, N; Jury, R; Pyne, D; Padhiar, N; Turner, J; Korakakis, V; Meke, M; Lohrer, H.

**Published** Open Access J Sports Med. 2016 Oct 31;7:143-151.  
PMID: 27843364 [PubMed - indexed for MEDLINE]

**Date** OCT 2016

### **Abstract**

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#### **Introduction**

Stenosing tenosynovitis that is characterized by the inability to flex the digit smoothly, usually leads to prolonged rehabilitation or surgery.

#### **Study design**

This case series is a retrospective cohort study.

#### **Purpose**

The aim of this case series was to evaluate the effectiveness of radial extracorporeal shockwave therapy (rESWT) for the treatment of stenosing tenosynovitis of the digital flexor tendon (trigger digit).

#### **Methods**

A retrospective analysis of 44 patients (49 fingers) treated with an individually adapted rESWT protocol was conducted. Trigger digit pain and function were evaluated at baseline and 1-, 3-, and 12-months posttreatment. Recurrence and pretreatment symptom duration were analyzed.

#### **Results**

Significant reductions in pain scores and functional improvement were found between baseline and all follow-up assessments ( $P < 0.001$ ). Pretreatment symptom duration was significantly correlated with the number of rESWT sessions required ( $r = 0.776$ ,  $P < 0.001$ ) and 1-year posttreatment pain score ( $r = 0.335$ ,  $P = 0.019$ ).

#### **Conclusion**

This study provides initial evidence that rESWT is an effective treatment for trigger digit, but randomised controlled trials are required to provide further evidence of this effect.

## **Extracorporeal Shock Wave Therapy Accelerates Regeneration After Acute Skeletal Muscle Injury**

**Authors** Zissler, A; Steinbacher, P; Zimmermann, R; Pittner, S; Stoiber, W; Bathke, A C; Sanger, A M.

**Published** Am J Sports Med. 2017 Mar;45(3):676-684. doi: 10.1177/0363546516668622. Epub 2016 Oct 13.  
PMID: 27729321

**Date** OCT 2016

### **Abstract**

**Background:** Muscle injuries are among the most common sports-related lesions in athletes; however, optimal treatment remains obscure. Extracorporeal shock wave therapy (ESWT) may be a promising approach in this context, because it has gained increasing importance in tissue regeneration in various medical fields.

**Hypothesis:** ESWT stimulates and accelerates regenerative processes of acute muscle injuries.

**Study design:** Controlled laboratory study.

**Methods:** Adult Sprague-Dawley rats were divided into 4 experimental groups (2 ESWT+ groups and 2 ESWT- groups) as well as an uninjured control group (n ≥ 6 in each group). An acute cardiotoxin-induced injury was set into the quadriceps femoris muscle of rats in the experimental groups. A single ESWT session was administered to injured muscles of the ESWT+ groups 1 day after injury, whereas ESWT- groups received no further treatment. At 4 and 7 days after injury, 1 each of the ESWT+ and ESWT- groups was euthanized. Regenerating lesions were excised and analyzed by histomorphometry and immunohistochemistry to assess fiber size, myonuclear content, and recruitment of satellite cells.

**Results:** The size and myonuclear content of regenerating fibers in ESWT+ muscle was significantly increased compared with ESWT- muscle fibers at both 4 and 7 days after injury. Similarly, at both time points, ESWT+ muscles exhibited significantly higher contents of pax7-positive satellite cells, mitotically active H3P<sup>+</sup> cells, and, of cells expressing the myogenic regulatory factors, myoD and myogenin, indicating enhanced proliferation and differentiation rates of satellite cells after ESWT. Mitotic activity at 4 days after injury was doubled in ESWT+ compared with ESWT- muscles.

**Conclusion:** ESWT stimulates regeneration of skeletal muscle tissue and accelerates repair processes.

**Clinical relevance:** We provide evidence for accelerated regeneration of damaged skeletal muscle after ESWT. Although further studies are necessary, our findings support the view that ESWT is an effective method to improve muscle healing, with special relevance to sports injuries.

**Repetitive shock wave therapy improves muscular microcirculation.**

**Authors** Kisch, T; Wuerfel, W; Forstmeier, V; Liodaki, E; Stang, FH; Knobloch, K; Mailaender, P; Kraemer, R.

**Published** J Surg Res. 2016 Apr;201(2):440-5.  
PMID: 27020830 [PubMed - indexed for MEDLINE]

**Date** April 2016

**Abstract**

**Background:** Extracorporeal shock wave therapy (ESWT) is mainly applied in tendon as well as bone problems based on stem-cell activation and healing acceleration. The effect of ESWT on muscle tissue is much less understood to date. However, from a clinical perspective, muscle injuries are of distinct interest especially in elite athletes such as soccer players.

**Material and methods:** A total of 26 rats were randomized into two groups. Group A received a single application of high-energetic focused ESWT (0.3 mJ/mm<sup>2</sup>, 4 Hz, 1000 impulses, 10 J), whereas group B underwent the same procedure every 10 min for three sessions (3 × 0.3 mJ/mm<sup>2</sup>, 4 Hz, 3 × 1000 impulses, totaling 30 J). Blood flow at a depth of 8 mm was measured continuously and noninvasively by a combined Laser-Doppler-Imaging and photospectrometric technique (Oxygen-to-see, O2C, LEA Medizintechnik, Germany).

**Results:** One minute after the application of high-energy ESWT blood flow in group A increased by 16.5% (P = 0.007). Thereafter, it decreased from minute 2 after application and remained significantly unchanged to baseline value until the end of the measuring period at 50 min (P = 0.550). Group B showed a similar significant increase in blood flow of 16.4% (P = 0.049) and a decrease afterward, too. After the second focused ESWT blood flow was boosted to 26.6% (P = 0.004), remaining significantly elevated until the third application was initiated. Muscular blood flow was increased to 29.8% after the third focused ESWT (P < 0.001), remaining significantly increased for another 10 min.

**Conclusions:** Focused ESWT enhances blood flow in the muscle of rats. Moreover, repetitive ESWT extended this beneficial effect.