

## Shock wave therapy in Orthopedics

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Achillodynia	Extracorporeal shockwave therapy (eswt) in achilles tendinopathy. a long-term follow-up observational study	M. C. Vulpiani, D. Trischitta, P. Trovato, M. Vetrano, and A. Ferretti	J Sports Med Phys Fitness, 49(2):171–6, Jun 2009.	Shock wave treatment was applied with an electromagnetic shock wave generator. The protocol consisted in an average of four sessions (minimum three, maximum five), at a 2/7-day interval. In each session 1 500-2 500 impulses were administered with an energy varying between 0.08 and 0.40 mJ/mm <sup>2</sup> . All patients were evaluated before therapy and two months after the last ESWT session. Also, all patients were assessed and evaluated at medium-term (6 to 12 months), and 121 patients also at long-term (13 to 24 months). RESULTS: Authors obtained satisfactory results in 47.2% of cases (60 out of 127 tendons) at two-months follow-up, which increased to 73.2% at medium-term follow-up (93 out of 127 tendons), and then reaching 76% in the last evaluation (92 out of 121 tendons). CONCLUSIONS: The outcome of the described shock wave treatment appears to be satisfactory and confirms the role of this alternative treatment in the management of the tendon disorders.
Achillodynia	Shock-wave treatment was more effective than eccentric training for chronic insertional achilles tendinopathy	L. Hart	Clin J Sport Med, 19(2):152–3, Mar 2009.	—
Achillodynia	Shockwave therapy for chronic achilles tendinopathy: a double-blind, randomized clinical trial of efficacy	S. Rasmussen, M. Christensen, I. Mathiesen, and O. Simonson	Acta Orthop, 79(2):249–256, April 2008	This was a randomized, double-blind, placebo-controlled trial. Patients assigned to nonoperative treatment of chronic achilles tendinopathy were randomized to receive either active ESWT or sham ESWT over 4 weeks. There were 48 patients (28 men) with a mean age of 47 (19-80) years. American Orthopaedic Foot and Ankle Society (AOFAS) score and pain were assessed before treatment, during the 4-week treatment period, and at 4, 8, and 12 weeks of follow-up. RESULTS: Both groups improved during the treatment and follow-up period. The mean AOFAS score increased from 74 (SD 12) to 81 (16) in the placebo group and from 70 (6.8) to 88 (10) in the intervention group (p = 0.05). Better results were seen in the intervention group at 8 and 12 weeks of follow-up (p = 0.01 and p = 0.04, respectively). Interpretation: Extracorporeal shock-wave therapy appears to be a supplement for the treatment of chronic Achilles tendinopathy.
Achillodynia	High-energy extracorporeal shock wave therapy as a treatment for chronic noninsertional achilles tendinopathy	J. P. Furia	Am J Sports Med, 36(3):502–508, 2008	Thirty-four patients with chronic noninsertional Achilles tendinopathy were treated with a single dose of high-energy shock wave therapy (shock wave therapy group; 3000 shocks; 0.21 mJ/mm <sup>2</sup> ; total energy flux density, 604 mJ/mm <sup>2</sup> ). Thirty-four patients with chronic noninsertional Achilles tendinopathy were treated not with shock wave therapy but with additional forms of nonoperative therapy (control group). All shock wave therapy procedures were performed using regional anesthesia. Evaluation was by change in visual analog score and by Roles and Maudsley score. RESULTS: One month, 3 months, and 12 months after treatment, the mean visual analog scores for the control and shock wave therapy groups were 8.4 and 4.4 (P < .001), 6.5 and 2.9 (P < .001), and 5.6 and 2.2 (P < .001), respectively. At final follow-up, the number of excellent, good, fair, and poor results for the shock wave therapy and control groups were 12 and 0 (P < .001), 17 and 9 (P < .001), 5 and 17 (P < .001), and 0 and 8 (P < .001),

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				respectively. A chi(2) analysis revealed that the percentage of patients with excellent ("1") or good ("2") Roles and Maudsley scores, that is, successful results, 12 months after treatment was statistically greater in the shock wave therapy group than in the control group (P < .001). CONCLUSION: Shock wave therapy is an effective treatment for chronic noninsertional Achilles tendinopathy.
Achillodynia	High-energy extracorporeal shock wave therapy as a treatment for insertional achilles tendinopathy	J. P. Furia	Am J Sports Med, 34(5):733–740, 2006	Thirty-five patients with chronic insertional Achilles tendinopathy were treated with 1 dose of high-energy extracorporeal shock wave therapy (ESWT group; 3000 shocks; 0.21 mJ/mm <sup>2</sup> ; total energy flux density, 604 mJ/mm <sup>2</sup> ), and 33 were treated with nonoperative therapy (control group). All extracorporeal shock wave therapy procedures were performed using a local anesthesia field block (LA subgroup, 12 patients) or a nonlocal anesthesia (NLA subgroup, 23 patients). Evaluation was by visual analog score and by Roles and Maudsley score. RESULTS: 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 < .001), 7.2 and 2.9 (P < .001), and 7.0 and 2.8 (P < .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 (F = 16.77 vs F = 53.95, P < .001). The percentage of patients with successful Roles and Maudsley scores did not differ among the LA and NLA subgroups. CONCLUSION: Extracorporeal shock wave therapy is an effective treatment for chronic insertional Achilles tendinopathy. Local field block anesthesia may decrease the effectiveness of this procedure.
Achillodynia	Extracorporeal shock waves promote healing of collagenase-induced achilles tendinitis and increase tgf-beta1 and igf-i expression	Y.-J. Chen, C.-J. Wang, K. D. Yang, Y.-R. Kuo, H.-C. Huang, Y.-T. Huang, Y.-C. Sun, and F.-S. Wang	J Orthop Res, 22(4):854–861, 2004	Rats with the collagenase-induced Achilles tendinitis were given a single ESW treatment (0.16 mJ/mm <sup>2</sup> energy flux density) with 0, 200, 500 and 1000 impulses. Achilles tendons were subjected to biomechanical (load to failure and stiffness), biochemical properties (DNA, glycosaminoglycan and hydroxyproline content) and histological assessment. ESW with 200 impulses restored biomechanical and biochemical characteristics of healing tendons 12 weeks after treatment. However, ESW treatments with 500 and 1000 impulses elicited inhibitory effects on tendinitis repair. Histological observation demonstrated that ESW treatment resolved edema, swelling, and inflammatory cell infiltration in injured tendons. Lesion site underwent intensive tenocyte proliferation, neovascularization and progressive tendon tissue regeneration. Tenocytes at the hypertrophied cellular tissue and newly developed tendon tissue expressed strong proliferating cell nuclear antigen (PCNA) after ESW treatment, suggesting that physical ESW could increase the mitogenic responses of tendons. Moreover, the proliferation of tenocytes adjunct to hypertrophied cell aggregate and newly formed tendon tissue coincided with intensive TGF-beta1 and IGF-I expression. Increasing TGF-beta1 expression was noted in the early stage of tendon repair,

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				and elevated IGF-I expression was persisted throughout the healing period. Together, low-energy shock wave effectively promoted tendon healing. TGF-beta1 and IGF-I played important roles in mediating ESW-stimulated cell proliferation and tissue regeneration of tendon.
Achillodynia	Extracorporeal shock wave treatment of the achilles tendinitis: Experimental and preliminary clinical results	L. Perlick, R. Schiffmann, C. N. Kraft, T. Wallny, and O. Diedrich	Z Orthop Ihre Grenzgeb, 140(3):275– 280, 2002	The achilleus tendons of common pigs treated with 1500 impulses twice using an energy varying from 0.23 - 0.54 mJ/mm <sup>2</sup> were histologically examined. The clinical results of two patient groups of which the first (n = 28) was treated with 2000 impulses (0.23 mJ/mm <sup>2</sup> once and the second (n = 26) underwent surgery for achilleus tendopathy were compared. RESULTS: The in-vitro model demonstrated that an EFD of 0.42 and 0.54 mJ/mm <sup>2</sup> can lead to tendon lesions. One year follow-up showed good and excellent results in 69 % and satisfactory results in 15 % of the operated group and good and excellent results in 29 % and satisfactory results in 43 % of the ESWT group. We could show a time-dependent effect of the shock wave treatment on the clinical outcome. CONCLUSIONS: Follow-ups show acceptable results with little side effects when an energy flow density (EFD) under 0.23 mJ/mm <sup>2</sup> is used. ESWT offers a non-invasive therapeutic concept that can seriously be contemplated before operative treatment, but lower success rates in comparison to the operative results can be expected.
Achillodynia	Use of extracorporeal shockwave therapy (eswt)in sports orthopedics	T. Steinacker and M. Steuer	Sportverletz Sportschaden, 15(2):45–49, 2001.	From 11/97 to 10/99 409 patients have been treated with the extracorporeal shockwave therapy (ESWT) in the sport orthopaedic ambulance. An ultrasound controlled treatment was applied in the low and middle energy range, using energy densities of 0.09 to 0.36 mJ/mm <sup>2</sup> . The ESWT came into application as an operation avoiding procedure after exhausting the conventional conservative therapy measures. Among the 409 patients, 65 persons were competitive sportsmen. Besides the established indications for the application of the shock wave therapy, this method also has been applied with specific sport orthopaedic indications like achillodynia, patella-top-syndrome, medial shin-syndrome, morbus Schlatler or tendinosis of the shoulder. The results were collected three months after the application of the ESWT using a standardized questionnaire. The performed examination exhibits that for conservatively treated tendinoses of the competitive sportsmen, similarly good therapy results concerning the application of ESWT can be reached compared with the classical orthopaedic shockwave therapy. Therefore, for the treatment of a tendinosis, a shock wave therapy should always be taken into account to avoid long exercise and competition breaks due to operative interventions.
Achillodynia	Dose-related effects of shock waves on rabbit tendo achillis. a sonographic and histological study	J. D. Rompe, C. J. Kirkpatrick, K. Kullmer, M. Schwitalle, and O. Krischek	J Bone Joint Surg Br, 80(3):546–552, 1998	We used 42 female New Zealand white rabbits randomly divided into four groups as follows: group a received 1000 shock-wave impulses of an energy flux density of 0.08 mJ/mm <sup>2</sup> , group b 1000 impulses of 0.28 mJ/mm <sup>2</sup> , group c 1000 impulses of 0.60 mJ/mm <sup>2</sup> , and group d was a control group. Sonographic and histological evaluation showed no changes in group a, and transient swelling of the tendon with a minor inflammatory reaction in group b. Group c had formation of

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				paratendinous fluid with a significant increase in the anteroposterior diameter of the tendon. In this group there were marked histological changes with increased eosin staining, fibrinoid necrosis, fibrosis in the paratenon and infiltration of inflammatory cells. We conclude that there are dose-dependent changes in the tendon and paratenon after extracorporeal shock-wave therapy and that energy flux densities of over 0.28 mJ/mm should not be used clinically in the treatment of tendon disorders.
Epicondylitis	Resistant tennis elbow: shock-wave therapy versus percutaneous tenotomy.	Y. Radwan, G. Elsobhi, W. Badawy, A. Reda, and S. Khalid	Int Orthop, 2007.	Fifty-six patients who suffered from chronic persistent tennis elbow of more than six months duration were randomly assigned to two active treatment groups. Group 1 (n = 29) received high-energy extracorporeal shock wave treatment (ESWT; 1,500 shocks) at 18 kV (0.22 mJ/mm <sup>2</sup> ) without local anaesthesia; group 2 (n = 27) underwent percutaneous tenotomy of the common extensor origin. Both groups achieved improvement from the base line at three weeks, six weeks, 12 weeks and 12 months post-intervention. The success rate (Roles and Maudsley score: excellent and good) at three months in the ESWT group was 65.5% and in the tenotomy group was 74.1%. ESWT appeared to be a useful noninvasive treatment method that reduced the necessity for surgical procedures.
Epicondylitis	Extracorporeal shock wave therapy in patients with lateral epicondylitis.	A. T. Ozkut, V. Kilincoglu, N. K. Ozkan, A. Eren, and M. Ertas	Acta Orthop Traumatol Turc, 41(3):207-210, 2007	The study included 13 elbows of 12 patients (8 women, 4 men; mean age 40 years) who did not benefit from conservative therapy for lateral epicondylitis and refused surgical therapy. Under fluoroscopic guidance, extracorporeal shock wave therapy of 1200 pulses at 15-20 kV was administered at a mean of three sessions (range 3 to 7 sessions) with two-day intervals. No immobilization was applied after sessions. The patients were questioned about pain during rest and during dorsiflexion of the wrist against resistance before and after three and 12 months of treatment. The results were evaluated using the Roles and Maudsley pain scores. At the end of 12 months, the patients were asked to lift weight with the shoulder in flexion and the wrist in extension to measure grip strengths in comparison with the unaffected side. RESULTS: The mean pain score which was 3.4 before treatment decreased to 2 after treatment. The mean grip strength of the affected extremities was 82.1% of the normal side. At final follow-ups, nine patients (10 elbows) (75%) stated that the treatment was beneficial; all these patients achieved at least 85% of grip strength of the normal side. Two patients (16.7%) reported no benefit from therapy and had a poor pain score. The result was fair in one patient (8.3%) who expressed dissatisfaction and had partial relief after the procedure. This patient achieved 60% of grip strength of the unaffected side. CONCLUSION: Extracorporeal shock wave therapy is an alternative method for patients who do not benefit from conservative treatment and refuse surgical treatment.

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Epicondylitis	Extracorporeal shock wave therapy without local anesthesia for chronic lateral epicondylitis	F. A. Pettrone and B. R. McCall	J Bone Joint Surg Am, 87(6):1297–1304, 2005	A total of 108 of the 114 randomized patients completed all treatments and the twelve weeks of follow-up required by the protocol. Sixty-one patients completed one year of follow-up, whereas thirty-four patients crossed over to receive active treatment. A significant difference ( $p = 0.001$ ) in pain reduction was observed at twelve weeks in the intent-to-treat cohort, with an improvement in the pain score of at least 50% seen in 61% (thirty-four) of the fifty-six patients in the active treatment group who were treated according to protocol compared with 29% (seventeen) of the fifty-eight subjects in the placebo group. This improvement persisted in those followed to one year. Functional activity scores, activity-specific evaluation, and the overall impression of the disease state all showed significant improvement as well ( $p < 0.05$ ). Crossover patients also showed significant improvement after twelve weeks of active treatment, with 56% (nineteen of thirty-four) achieving an improvement in the pain score of at least 50% ( $p < 0.0001$ ). CONCLUSIONS: These results demonstrate that low-dose shock wave therapy without anesthetic is a safe and effective treatment for chronic lateral epicondylitis.
Epicondylitis	Safety and efficacy of extracorporeal shock wave therapy for chronic lateral epicondylitis	J. P. Furia.	Am J Orthop, 34(1):13–19, 2005	Efficacy and safety of extracorporeal shock wave therapy (ESWT) were investigated in 36 patients with chronic lateral epicondylitis--9 patients receiving and 27 patients not receiving worker's compensation. All patients were treated with a single application of 3200 shock waves. Twelve weeks after treatment, the mean visual analog scale score for the entire group improved from 8.0 to 2.5 ( $P < .05$ ), and the mean RAND 36-Item Health Survey (Physical Functioning) score improved from 65.6 to 88.0 ( $P < .05$ ). Outcomes for 28 elbows (77.8%) were rated excellent or good on the Roles and Maudsley scale. There were no significant differences in outcome measures among the subgroups. There were no significant complications. ESWT is an effective treatment for chronic lateral epicondylitis. Worker's compensation status did not affect outcomes.
Epicondylitis	Extrakorporale Stoßwellentherapie (ESWT) aus orthopädischer und traumatologischer Sicht	V. Auersperg, C. Dohnalek, R. Dorotka, M. Sabeti-Aschraf, W. Schaden, and S. Wanke	Journal für Mineralstoffwechsel, 11(4):19–28, December 2004	It may be said that in Class 1A studies (EBM criteria) ESWT has proved its effectiveness and uncomplicated nature in the discussed indications. Even if some studies view ESWT controversially, we believe that in view of the many positive case studies and low rate of side effects ESWT should be authorised as a therapy, and should be applied in particular after un- successful conservative therapy, especially if this means that an operation can be avoided.
Epicondylitis	Repetitive low-energy shock wave treatment for chronic lateral epicondylitis in tennis players	J. D. Rompe, J. Decking, C. Schoellner, and C. Theis	Am J Sports Med, 32(3):734–743, 2004	Seventy-eight patients enrolled in a placebo-controlled trial. All patients were tennis players with recalcitrant MRI-confirmed tennis elbow of at least 12 months' duration. Patients were randomly assigned to receive either active low-energy extracorporeal shock wave treatment given weekly for 3 weeks (treatment group 1) or an identical placebo extracorporeal shock wave treatment (sham group 2). Main outcome measure was pain during resisted wrist extension at 3 months; secondary measures were >50% reduction of pain and the Upper Extremity Function Scale. RESULTS: At 3 months, there was a significantly higher improvement in pain during resisted wrist extension in group 1 than in group 2

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				(mean [SD] improvement, 3.5 [2.0] and 2.0 [1.9]; P =.001 for between-group difference of improvement) and in the Upper Extremity Function Scale (mean [SD] improvement, 23.4 [14.8] and 10.9 [14.9]; P <.001 for between-group difference of improvement). In the treatment group, 65% of patients achieved at least a 50% reduction of pain, compared with 28% of patients in the sham group (P =.001 for between-group difference). CONCLUSION: Low-energy extracorporeal shock wave treatment as applied is superior to sham treatment for tennis elbow.
Epicondylitis	Shock wave therapy for patients with lateral epicondylitis of the elbow: a one- to two-year follow-up study	C.-J. Wang and H.-S. Chen	Am J Sports Med, 30(3):422-425, 2002	HYPOTHESIS: Shock wave therapy is an effective treatment for patients with lateral epicondylitis of the elbow and long-term results will be as favorable as short-term ones. STUDY DESIGN: Case series. METHODS: The effect of shock wave therapy was investigated in 57 patients with lateral epicondylitis of the elbow. Forty-three patients (24 men and 19 women with an average age of 46 years) with 1 to 2 years of follow-up were included in this study. In addition, six patients were treated with a sham procedure as a control group. Each patient was treated with 1000 impulses of shock wave therapy at 14 kV to the affected elbow. A 100-point scoring system was used for evaluating pain, function, strength, and elbow range of motion. RESULTS: Twenty-seven elbows (61.4%) were free of complaints, 13 (29.5%) were significantly better, 3 (6.8%) were slightly better, and 1 (2.3%) was unchanged. In the control group, the results were unchanged in all six patients. There were no device-related problems and no systemic or local complications. CONCLUSIONS: Shock wave therapy is a safe and effective modality in the treatment of patients with lateral epicondylitis of the elbow

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Epicondylitis	Treatment of lateral epicondylitis of the elbow with shock waves	J. Y. Ko, H. S. Chen, and L. M. Chen	Clin Orthop Relat Res, (387):60–67, 2001	In a prospective clinical study, the effectiveness of shock wave treatment for lateral epicondylitis in 56 elbows in 53 patients (27 men and 26 women) with an average age of 46 years was investigated. Three patients received treatment for both elbows. Each elbow was treated with 1,000 impulses of shock waves at 14 kV. A 100-point scoring system was used for evaluation including 40 points for pain, 30 points for function, 20 points for strength, and 10 points for elbow motion. The intensity of pain was measured using a visual analogue scale from 0 to 10. The overall results were 13.2% excellent, 44.7% good, 36.8% acceptable, and 5.3% unchanged in 35 patients with 12 weeks followup; 30.8% excellent, 42.3% good, and 26.9% acceptable in 25 patients with 24 weeks followup. Considerable improvement was observed from 6 weeks to 6 months after the treatment. None of the patients' symptoms became worse. The results of nine patients who also received a second treatment were good in three patients, acceptable in five patients, and unchanged in one patient. There was no device-related problems, systemic, or local complications. Shock wave therapy may offer a new and safer nonoperative treatment for patients with lateral epicondylitis of the elbow.
Epicondylitis	Extracorporeal shock wave therapy in patients with tennis elbow and painful heel	D. S. Hammer, S. Rupp, S. Ensslin, D. Kohn, and R. Seil	Arch Orthop Trauma Surg, 120(5-6):304–307, 2000	The aim of this study was to evaluate the effect of extracorporeal shock wave therapy (ESWT) in tennis elbow and painful heel. Nineteen patients with tennis elbow and 44 patients with painful heel in which conservative treatment had failed underwent ESWT. Both groups received 3000 shock waves of 0.12 mJ/mm <sup>2</sup> three times at weekly intervals. After a follow-up of 5 and 6 months respectively, pain measured on a visual analogue scale (VAS) decreased significantly in both groups. The success rate (excellent and good results) was 63% in tennis elbows and 70% in painful heels. ESWT seems to be a useful conservative alternative in the treatment of both conditions.
Epicondylitis	Shock-wave therapy for tennis and golfer's elbow—1 year follow-up	O. Kirschek, C. Hopf, B. Nafe, and J. D. Rompe	Arch Orthop Trauma Surg, 119(1-2):62–66, 1999	After 12 months we found a significant difference between the two groups: there were only 7 patients with excellent or good results and in 14 cases a poor result for medial epicondylitis, but 18 times the results were good or excellent and only 8 times they were poor for lateral epicondylitis ( $P = 0.02$ , Table 2). Among the 14 patients with a poor outcome for medial epicondylitis, 8 reported much pain and took pain killers frequently. Six reported constant pain and were markedly limited in their activities. In 10 cases the dominant arm was affected. Among the eight patients with a poor outcome for lateral epicondylitis, six had moderately severe pain and used medication, and two had constant pain. In seven patients the dominant arm was affected. In the follow-up 2 patients with a golfer's elbow had complete pain relief; in the group with tennis elbow, 11 patients were free of pain. Six patients in group I were satisfied with the shock-

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				wave therapy after 1 year, and 16 were dissatisfied. In the second group there were 15 satisfied and 8 dissatisfied patients after 1 year
Plantar fasciitis	Comparison of radial versus focused extracorporeal shock waves in plantar fasciitis using functional measures	H. Lohrer, T. Nauck, N. V. Dorn-Lange, J. Schöll, and J. C. Vester	Foot Ankle Int, 31(1):1–9, Jan 2010	The overall result ("Crude Pooling") shows "small" superiority of the focused extracorporeal shock wave therapy (MW = 0.55, LB-CI = 0.4644). Adjusted for age the focused treatment exhibited "more than small" superiority (MW = 0.59, LB-CI > 0.5) and this result is statistically significant (LB-CI = 0.5067, benchmark for equality = 0.5). CONCLUSION: This study provides some evidence for focused extracorporeal shock wave treatment being superior to radial extracorporeal shock wave therapy for recalcitrant plantar fasciitis.
Plantar fasciitis	Extracorporeal shock wave therapy for chronic painful heel syndrome: a prospective, double blind, randomized trial assessing the efficacy of a new electromagnetic shock wave device	H. Gollwitzer, P. Diehl, A. von Korff, V. W. Rahlfs, and L. Gerdesmeyer	J Foot Ankle Surg, 46(5):348–357, 2007	Both groups received 3 applications of 2000 shockwave impulses, each session 1 week apart. The primary outcome was the change in composite heel pain (morning pain, pain with activities of daily living, and pain upon application of pressure with a focal force meter) as quantified using a visual analog pain scale at 12 weeks after completion of the interventions compared with baseline. Secondary endpoints included changes in morning pain, pain with activities of daily living, and pain upon application of pressure with a focal force meter, as measured on a visual analog pain scale, as well as the change in the Roles and Maudsley score, at 12 weeks after the baseline measurement. Active extracorporeal shockwave therapy resulted in a 73.2% reduction in composite heel pain, and this was a 32.7% greater reduction than that achieved with placebo. The difference was not statistically significant (1-tailed Wilcoxon Mann-Whitney U test, P = .0302), but reached clinical relevance (Mann-Whitney effect size = 0.6737). In regard to the secondary outcomes, active extracorporeal shockwave therapy displayed relative superiority in comparison with the sham intervention. No relevant adverse events occurred in either intervention group. The results of the present study support the use of electromagnetically generated extracorporeal shockwave therapy for the treatment of refractory plantar heel pain.
Plantar fasciitis	Extracorporeal shock wave therapy in the treatment of chronic tendinopathies	A. Sems, R. Dimeff, and J. P. Iannotti	J Am Acad Orthop Surg, 14(4):195–204, 2006	Results have been mixed in the management of lateral epicondylitis, however, and this therapy has not been effective in managing noncalcific tendinosis of the supraspinatus. Extracorporeal shock wave therapy has consistently been more effective with patient feedback, which enables directing the shock waves to the most painful area (clinical focusing), rather than with anatomic or image-guided focusing, which are used to direct the shock wave to an anatomic landmark or structure.
Plantar fasciitis	Effectiveness of extracorporeal shockwave treatment in 353 patients with chronic plantar fasciitis	D. M. Norris, K. M. Eickmeier, and B. R. Werber	J Am Podiatr Med Assoc, 95(6):517–24, 2005	A 16-question post-treatment survey was sent to 874 patients after extracorporeal shockwave treatment for chronic plantar fasciitis. Of the 377 surveys returned, 353 were used for analysis. These patients were treated by 169 physicians in 19 states using either electrohydraulic or electromagnetic extracorporeal shockwave equipment. Seventy-six percent of the patients underwent treatment after having had continued pain for a year or longer. Seventy percent of patients who rated their pretreatment pain level as severe

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Plantar fasciitis	Electrohydraulic high-energy shock-wave treatment for chronic plantar fasciitis	J. A. Ogden, R. G. Alvarez, R. L. Levitt, J. E. Johnson, and M. E. Marlow	J Bone Joint Surg Am, 86-A(10):2216–2228, 2004	Treatment was successful in seventeen of the twenty phase-1 patients at three months. This improved to nineteen (95%) of twenty patients at one year and was maintained at five years. In phase 2, three months after treatment, sixty-seven (47%) of the 144 actively treated patients had a completely successful result compared with forty-two (30%) of the 141 placebo-treated patients ( $p = 0.008$ ). At one year, sixty-five of the sixty-seven actively treated, randomized patients maintained a successful result. Thirty-six (71%) of the remaining fifty-one nonrandomized patients had a successful result at three months. For all 289 patients who had one or more actual treatments, 222 (76.8%) had a good or excellent result. No patient was made worse by the procedure. CONCLUSIONS: The application of electrohydraulic high-energy shock waves to the heel is a safe and effective noninvasive method to treat chronic plantar fasciitis, lasting up to and beyond one year.
Plantar fasciitis	Shock wave application for chronic plantar fasciitis in running athletes. a prospective, randomized, placebo-controlled trial	J. D. Rompe, J. Decking, C. Schoellner, and B. Nafe	Am J Sports Med, 31(2):268–275, 2003	After 6 months, self-assessment of pain on first walking in the morning was significantly reduced from an average of 6.9 to 2.1 points on a visual analog scale in the treatment group and from an average of 7.0 to 4.7 points in the sham group. The mean difference between groups was 2.6 points. After 12 months, there was a further reduction of pain in both groups, to an average 1.5 points in the treatment group, and to 4.4 points in the sham group. CONCLUSION: Three treatments with 2100 impulses of low-energy shock waves were a safe and effective method for treatment of chronic plantar fasciitis in long-distance runners.
Plantar fasciitis	Extracorporeal shock wave therapy (eswt) in patients with chronic proximal plantar fasciitis: a 2-year follow-up	D. S. Hammer, F. Adam, A. Kreutz, D. Kohn, and R. Seil	Foot Ankle Int, 24(11):823–828, 2003	Group 1 (25 heels) was treated immediately with three sessions of ESWT (3000 shock waves/session of 0.2 mJ/mm <sup>2</sup> ) at weekly intervals. The patients of group 2 (24 heels) continued nonsurgical treatment (iontophoresis with diclofenac and an oral nonsteroidal anti-inflammatory drug) for 12 weeks. After this period they were treated using the protocol of group 1. No significant difference of pain and walking time after further nonsurgical treatment (3 months) was seen in group 2. At 12 weeks after ESWT, the pain estimation on the visual analogue scale (VAS) for activities of daily living diminished significantly by 62.9% in group 1 and by 63.0% in group 2. The comfortable walking time had increased significantly in both groups. Two years after ESWT, pain during activities of daily living

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				decreased by 94% in group 1 and by 90% in group 2 on the VAS and the comfortable walking time had increased significantly in both groups.
Plantar fasciitis	Extracorporeal shock wave therapy for the treatment of chronic plantar fasciitis: indications, protocol, intermediate results, and a comparison of results to fasciotomy	L. S. J. Weil, T. S. Roukis, L. S. Weil, and A. H. Borrelli	J Foot Ankle Surg, 41(3):166–172, 2002	Eighty-two percent of the patients treated with extracorporeal shock wave therapy were successfully treated as compared to 83% with a percutaneous plantar fasciotomy. The mean score on the 11-point visual analog scale for satisfied patients was 7.9 preoperatively and 2.95 within 7 days postoperatively. After 3 months, the mean visual analog score was 4.2 or 50% of the preoperative value after a mean of 8.4 months following treatment. Eighty-three percent of the patients treated stated that shock wave therapy improved their symptoms. There were no complications encountered in any patient in this study. Extracorporeal shock wave therapy is an effective treatment, which significantly reduces the symptoms associated with chronic plantar fasciitis and compares favorably to the results achieved with surgical intervention in the form of a percutaneous plantar fasciotom
Plantar fasciitis	Extracorporeal shockwave therapy (eswt) in patients with chronic proximal plantar fasciitis	D. S. Hammer, S. Rupp, A. Kreutz, D. Pape, D. Kohn, and R. Seil	Foot Ankle Int, 23(4):309–313, 2002	Treatment of Group 1 (25 heels) started immediately with three sessions of ESWT (3000 shockwaves/session of 0.2 mJ/mm <sup>2</sup> ) at weekly intervals. In the patients of Group 2 (24 heels) treatment was continued for 12 weeks. After this period they were treated using the protocol of Group 1. No significant difference of pain and walking time after further non-ESWT treatment (three months) was seen. Six months after ESWT pain decreased by 64% to 88% on the visual analog scale (VAS) and the comfortable walking time had increased significantly in both groups.
Plantar fasciitis	Extracorporeal shockwave therapy in symptomatic heel spurs. an overview	M. Buch, U. Knorr, L. Fleming, G. Theodore, A. Amendola, C. Bachmann, C. Zingas, and W. E. Siebert	Orthopäde, 31(7):637–644, 2002	In patients treated conservatively without success, a single shock wave application can improve the condition significantly compared with placebo treatment (p = 0.0149). The Roles and Maudsley score also showed a significant improvement between the groups, with 61.6% good or excellent results in the verum group and 39.7% in the placebo group (p = 0.0128). Therapy-related side effects (local swelling, petechia) are rare. The data presented in this study led to FDA approval in January 2002 of the shock wave device used.
Plantar fasciitis	Shock wave therapy for chronic proximal plantar fasciitis.	J. A. Ogden, R. Alvarez, R. Levitt, G. L. Cross, and M. Marlow.	Clin Orthop Relat Res, (387):47–59, 2001.	Each treated patient satisfied numerous inclusion and exclusion criteria before he or she was accepted into this study, which was approved by the Food and Drug Administration as a randomized, double-blind evaluation of the efficacy of shock wave therapy for this disorder. Overall, at the predetermined evaluation period 3 months after one treatment, 56% more of the treated patients had a successful result by all four of the evaluation criteria when compared with the patients treated with a placebo. This difference was significant and corroborated the fact that this difference in the results was specifically attributable to the shock wave treatment, rather than any natural improvement caused by the natural history of the condition.
Plantar fasciitis	Treatment of painful heel syndrome with shock waves.	H. S. Chen, L. M. Chen, and T. W. Huang.	Clin Orthop Relat Res, (387):41–46, 2001.	The overall results were no complaints in 20.6%, significantly better in 52.9%, slightly better in 17.6%, and unchanged in 8.8% of 64 patients (68 heels) with 12 weeks followup; no complaints in 59.3%, significantly better in 27.7 %, slightly

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				better in 13% of 52 patients (54 heels) with 6 months followup. None of patients' symptoms became worse. Seventeen patients (18 heels) who did not respond favorably to the first treatment had significantly better results after a second treatment. There were no device-related problems, and no systemic or local complications. Shock wave treatment is a new modality of therapy that is safe and effective in the treatment of patients with painful hell syndrome.
Shoulder	Extracorporeal shock wave therapy for calcifying tendinitis of the shoulder	C.-J. Hsu, D.-Y. Wang, K.-F. Tseng, Y.-C. Fong, H.-C. Hsu, and Y.-F. Jim	J Shoulder Elbow Surg, 17(1):55–59, 2008	The ESWT results were good to excellent in 87.9% of shoulders (29/33) and fair in 12.1% (4/33), and the control results were fair in 69.2% (9/13) and poor in 30.1% (4/13). Among ESWT patients, calcium deposits were completely eliminated in 7 cases (21.2%), partially eliminated in 11 (36.3%), and unchanged in 15 (45.4%). In contrast, elimination was partial in 2 control patients (15.3%) and unchanged in 11 (84.7%). There was no significant difference between Gartner type I and type II groups in the Constant score ( $P > .05$ ). ESWT shows promise for pain relief and functional restoration of calcific tendinitis with negligible complications.
Shoulder	High-energy extracorporeal shock-wave therapy for calcifying tendinitis of the rotator cuff: a randomised trial	J.-D. Albert, J. Meadeb, P. Guggenbuhl, F. Marin, T. Benkalfate, H. Thomazeau, and G. Chales	J Bone Joint Surg Br, 89(3):335–341, 2007	The improvement from the baseline level was significant in the high-energy group, with a mean gain of 12.5 (-20.7 to 47.5) points ( $p < 0.0001$ ). The improvement was not significant in the low-energy group. Total or subtotal resorption of the calcification occurred in six patients (15%) in the high-energy group and in two patients (5%) in the low-energy group. High-energy shock-wave therapy significantly improves symptoms in refractory calcifying tendinitis of the shoulder after three months of follow-up, but the calcific deposit remains unchanged in size in the majority of patients.
Shoulder	Shock wave therapy for calcific tendinitis of the shoulder: a prospective clinical study with two-year follow-up	C.-J. Wang, K. D. Yang, F.-S. Wang, H.-H. Chen, and J.-W. Wang	Am J Sports Med, 31(3):425–430, 2003	The overall results in the study group were 60.6% excellent (20 of 33 shoulders), 30.3% good (10), 3.0% fair (1), and 6.1% poor (2), and those of the control group were 16.7% fair (1 of 6 shoulders) and 83.3% poor (5). The symptom recurrence rate in the study group was 6.5%. Dissolution of calcium deposits was complete in 57.6% of the study group, partial in 15.1%, and unchanged in 27.3%. Fragmentation was seen in 16.7% of the control group patients; in 83.3% deposits were unchanged. No recurrence of calcium deposits was observed during the 2 years that the study group was followed. CONCLUSIONS: Shock wave therapy is a safe and effective noninvasive treatment for patients with calcific tendinitis of the shoulder.
Shoulder	Treatment of calcifying tendinitis of the shoulder with shock wave therapy	C. J. Wang, J. Y. Ko, and H. S. Chen	Clin Orthop Relat Res, (387):83–89, 2001	The overall results of 20 patients (21 shoulders) with 12 weeks followup were no complaints in 23.8%, significantly improved in 38.1%, some improvement in 14.3%, and unchanged in 23.8%. Considerable improvement was observed between 6 and 12 weeks. The results of seven patients with 24 weeks followup were no complaints in two patients, significantly improved in three, and unchanged in two patients. Radiographs showed complete elimination of the calcium deposits in six patients (28.6%), incomplete elimination in two patients (9.5%), and three patients (14.3%) had fragmentation of the calcium deposits. There was no recurrence of calcium deposits observed at 24 weeks. There was a

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				correlation between the functional improvement and the elimination of calcium deposits. There were no device-related problems, systemic or local complications. Low-energy shock wave therapy may offer a new and safer additional nonoperative treatment for patients with calcifying tendinitis of the shoulder.
Nonunion	Extracorporeal shock waves stimulate osteoblast activities	R. Tamma, S. dell'Endice, A. Notarnicola, L. Moretti, S. Patella, V. Patella, A. Zallone, and B. Moretti	Ultrasound Med Biol, 35(12):2093–100, Dec 2009	Osteoblasts in culture flasks were treated with ESWT pulses (500 impulses of 0.05 mJ/mm <sup>2</sup> ) generated by an electromagnetic device. Using western blot analysis 3h after ESWT, an increased expression of Bax was found, indicating a fast pro-apoptotic effect of treatment on some of the osteoblasts. Activation of the cyclin E2/CDK2 is the complex that regulates the G1-S transition and is essential for cell proliferation. It was evident 24 to 72h after treatment, indicating a proliferative stimulus. A decreased expression of osteoprotegerin (OPG) and receptor activator NF kappa B ligand (RANKL) 24 and 48h after ESW, followed by a later increase of OPG, paired with a much smaller increase of RANKL, was evident by real-time polymerase chain reaction (PCR). The decreased RANKL/OPG ratio suggests inhibition of osteoclastogenesis. We can conclude that ESWT induces bone repair through the proliferation and differentiation of osteoblasts and the reduction of their secretion of pro-osteoclastogenic factors.
Nonunion	Osteogenesis induced by extracorporeal shockwave in treatment of delayed osteotendinous junction healing.	L. Qin, L. Wang, M. Wan-Nar Wong, C. Wen, G. Wang, G. Zhang, K.-M. Chan, W.-H. Cheung, and K.-S. Leung.	J Orthop Res, Jul 2009.	Micro-CT results showed that new bone volume was 1.18 +/- 0.61 mm <sup>3</sup> in the ESW group with no measurable new bone in the DH group at postoperative week 8. Scar tissue formed at the OTJ healing interface of the DH group, whereas ESW triggered high expression of VEGF in hypertrophic chondrocytes at week 8 and regeneration of the fibrocartilage zone at week 12 postoperatively. The accelerated osteogenesis could be explained by acceleration of endochondral ossification. In conclusion, ESW was able to induce osteogenesis at OTJ with delayed healing with enhanced endochondral ossification process and regeneration of fibrocartilage zone. These findings formed a scientific basis to potential clinical application of ESW for treatment of delayed OTJ healing
Nonunion	Extracorporeal shock wave treatment in nonunions of long bone fractures.	Z.-H. Xu, Q. Jiang, D.-Y. Chen, J. Xiong, D.-Q. Shi, T. Yuan, and X.-L. Zhu.	Int Orthop, 33(3):789–93, Jun 2009.	The total successful rate of bony union was 75.4%. ESWT was successful in hypertrophic nonunions and seemed to have no evident effect in atrophic nonunions. We believe that extracorporeal shock wave therapy may be a good choice for nonunions of long bone fracture especially in hypertrophic nonunions.
Nonunion	The effects of shockwave on bone healing and systemic concentrations of nitric oxide (no), tgf-beta1, vegf and bmp-2 in long bone non-unions.	C.-J. Wang, K. D. Yang, J.-Y. Ko, C.-C. Huang, H.-Y. Huang, and F.-S. Wang.	Nitric Oxide, 20(4):298–303, Jun 2009.	At 6 months, bony union was radiographically confirmed in 78.6%, and persistent non-union in 21.4%. Patients with bony union showed significantly higher serum NO level, TGF-beta1, VEGF and BMP-2 at 1 month after treatment as compared to patients with persistent non-union. Shockwave-promoted bone healing was associated with significant increases in serum NO level and osteogenic growth factors. The elevations of systemic concentration of NO level and the osteogenic factors may reflect a local stimulation of shockwave in bone healing in long bone

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				non-unions.
Nonunion	Extracorporeal shock wave therapy in treatment of delayed bone-tendon healing.	L. Wang, L. Qin, H.-b. Lu, W.-h. Cheung, H. Yang, W.-n. Wong, K.-m. Chan, and K.-s. Leung.	Am J Sports Med, 36(2):340–347, 2008.	Radiographic measurements showed 293.4% and 185.8% more new bone formation at the patella-patellar tendon healing junction in the shock wave group at weeks 8 and 12, respectively. Significantly better bone mineral status was found in the week 12 shock wave group. Histologically, the shock wave group showed more advanced remodeling in terms of better alignment of collagen fibers and thicker and more mature regenerated fibrocartilage zone at both weeks 8 and 12. Mechanical testing showed 167.7% and 145.1% higher tensile load and strength in the shock wave group at week 8 and week 12, respectively, compared with controls. CONCLUSION: Extracorporeal shock wave promotes osteogenesis, regeneration of fibrocartilage zone, and remodeling in the delayed bone-to-tendon healing junction in rabbits.
Nonunion	The effects of extracorporeal shockwave on acute high-energy long bone fractures of the lower extremity.	C.-J. Wang, H.-C. Liu, and T.-H. Fu.	Arch Orthop Trauma Surg, 127(2):137–142, 2007 Feb.	At 12 months, the rate of non-union was 11% for the study group versus 20% for the control group ( $P < 0.001$ ). Significantly, better rate of fracture healing was noted in the study group than the control group at 3, 6 and 12 months ( $P < 0.001$ ). CONCLUSION: Extracorporeal shockwave is effective on promoting fracture healing and decreasing the rate of non-union in acute high-energy fractures of the lower extremity.
Nonunion	Extracorporeal shock wave therapy for resistant stress fracture in athletes: a report of 5 cases.	M. Taki, O. Iwata, M. Shiono, M. Kimura, and K. Takagishi.	Am J Sports Med, 35(7):1188–1192, 2007.	These reports demonstrate that ESWT is a noninvasive and effective method to treat intractable stress fracture in athletes. Furthermore, in young athletes with growth plates (like case 2) and in cases of postoperative pseudarthroses (like cases 4 and 5), there are indications that this treatment can be promising.
Nonunion	Shock wave treatment shows dose-dependent enhancement of bone mass and bone strength after fracture of the femur.	C.-J. Wang, K. D. Yang, F.-S. Wang, C.-C. Hsu, and H.-H. Chen.	Bone, 34(1):225–230, 2004.	While the BMD values of the high-energy group were significantly higher than the control group ( $P = 0.021$ ), the BMD values between the low-energy and control groups were not statistically significant ( $P = 0.358$ ). The high-energy group showed significantly more callus formation ( $P < 0.001$ ), higher ash content ( $P < 0.001$ ) and calcium content ( $P = 0.003$ ) than the control and low-energy groups. With regard to bone strength, the high-energy group showed significantly higher peak load ( $P = 0.012$ ), peak stress ( $P = 0.015$ ) and modulus of elasticity ( $P = 0.011$ ) than the low-energy and control groups. Overall, the effect of shock wave treatment on bone mass and bone strength appears to be dose dependent in acute fracture healing in rabbits.
Nonunion	Extracorporeal shock wave therapy of nonunion or delayed osseous union.	W. Schaden, A. Fischer, and A. Sailler.	Clin Orthop Relat Res, (387):90–94, 2001.	In 87 patients (75.7%), one treatment with shock waves resulted in bony consolidation with a simultaneous decrease in symptoms. Besides negligible local reactions (swelling, hematomas, petechial hemorrhages), no complications were observed. The treatment was noninvasive, and personnel and technical requirements were not problematic. The authors concluded that the application of extracorporeal shock wave therapy should be the first choice of treatment for patients with nonunions and delayed bone fracture healing.