PHP_2.01.40	Extracorporeal Shock Wave Treatment for Plantar Fasciitis and Other Musculoskeletal Conditions		
Original Policy Date:	December 1, 2025	**Effective Date:**	December 1, 2025
Section:	2.0 Medicine	**Page:**	Page 1 of 57

State Guidelines

As of the publication of this policy, there are no applicable Medi-Cal guidelines (Provider Manual or All Plan Letter). Please refer to the Policy Statement section below.

Policy Statement

In the absence of any State Guidelines, please refer to the criteria below.

I. Extracorporeal shock wave therapy using either a high- or low-dose protocol or radial extracorporeal shock wave therapy is considered **investigational** as a treatment of musculoskeletal conditions, including but not limited to:
   A. Achilles tendinitis
   B. Avascular necrosis of the femoral head
   C. Delayed union and nonunion of fractures spasticity
   D. Patellar tendinitis
   E. Plantar fasciitis
   F. Stress fractures
   G. Tendinitis of the elbow (lateral epicondylitis)
   H. Tendinopathies including tendinitis of the shoulder

Policy Guidelines

Coding

See the Codes table for details.

Description

Extracorporeal shock wave therapy (ESWT) is a noninvasive method used to treat pain with shock or sound waves directed from outside the body onto the area to be treated (e.g., the heel in the case of plantar fasciitis). Shock waves are generated at high- or low-energy intensity, and treatment protocols can include more than 1 treatment. ESWT has been investigated for use in a variety of musculoskeletal conditions.

Summary of Evidence

For treatment of plantar fasciitis using extracorporeal shock wave therapy (ESWT), numerous randomized controlled trials (RCTs) were identified, including several well-designed, double-blind RCTs, that evaluated ESWT for the treatment of plantar fasciitis. Several systematic reviews and meta-analyses have been conducted, covering numerous studies, including studies that compared ESWT with corticosteroid injections and other treatment modalities. Relevant outcomes are symptoms, functional outcomes, quality of life, medication use, and treatment-related morbidity. Pooled results were inconsistent. Some meta-analyses reported that ESWT reduced pain, while others reported nonsignificant pain reduction. Reasons for the differing results included lack of uniformity in the definitions of outcomes and heterogeneity in ESWT protocols (focused vs. radial, low-vs. high-intensity/energy, number and duration of shocks per treatment, number of treatments, and differing comparators). Some studies reported significant benefits in pain and functional improvement at 3 months, but it is not evident that the longer-term disease natural history is altered with ESWT. The evidence is insufficient to determine that the technology results in an improvement in the net health outcome.

For individuals who have lateral epicondylitis who receive ESWT, the most direct evidence on the use of ESWT to treat lateral epicondylitis comes from multiple small RCTs. Relevant outcomes are symptoms, functional outcomes, quality of life, medication use, and treatment-related morbidity. The RCTs did not consistently show outcome improvements beyond those seen in control groups. The highest quality trials tend to show no benefit, and systematic reviews have generally concluded that the evidence does not support a treatment benefit over placebo or no treatment. The evidence is insufficient to determine that the technology results in an improvement in the net health outcome.

For individuals who have shoulder tendinopathy who receive ESWT, a number of small RCTs, summarized in several systematic reviews and meta-analyses, comprise the evidence. Relevant outcomes are symptoms, functional outcomes, quality of life, medication use, and treatment-related morbidity. Network meta-analyses focused on 3 outcomes: pain reduction, functional assessment, and change in calcific deposits. One network meta-analysis separated trials using high-energy focused shock wave (H-FSW), low-energy focused shock wave, and radial shock wave (RSW). It reported that the most effective treatment for pain reduction was ultrasound-guided needling, followed by RSW and H-FSW. The only treatment showing a benefit in functional outcomes was H-FSW. For the largest change in calcific deposits, the most effective treatment was ultrasound-guided needling followed by RSW and H-FSW. Although some trials have reported a benefit for pain and functional outcomes, particularly for high-energy ESWT for calcific tendinopathy, many available trials have been considered poor quality. For non-calcific tendinopathy, 1 meta-analysis found that ESWT exhibited a small improvement in shoulder pain compared to sham ESWT at short-term follow-up (≤3 months). However, ESWT was not superior to sham ESWT in improving function at short- or long-term follow up (≥12 months), and ESWT was not superior to other treatments. More high-quality trials are needed to determine whether ESWT improves outcomes for shoulder tendinopathy. The evidence is insufficient to determine that the technology results in an improvement in the net health outcome.

For individuals who have Achilles tendinopathy who receive ESWT, the evidence includes systematic reviews of RCTs and RCTs published after the systematic review. Relevant outcomes are symptoms, functional outcomes, quality of life, medication use, and treatment-related morbidity. In a recent systematic review, a pooled analysis found that ESWT reduced both short- and long-term pain compared with nonoperative treatments, although reviewers warned that results were inconsistent across the RCTs and that there was heterogeneity across patient populations and treatment protocols. A RCT published after the systematic review compared ESWT with hyaluronan injections and reported improvements in both treatment groups, although the improvements were significantly higher in the injection group. A RCT found no difference in pain scores between low-energy ESWT and sham controls at week 24, but ESWT may provide short therapeutic effects at weeks 4 to 12. Another RCT found scores were statistically and clinically improved with ESWT compared with sham control at 1 month and 16 months on measures of pain and function. A recent RCT found that activity-related pain was lower with ESWT at 6 weeks compared to ultrasound therapy, but there was no difference in pain at rest. The evidence is insufficient to determine that the technology results in an improvement in the net health outcome.

For individuals who have patellar tendinopathy who receive ESWT, the evidence includes systematic reviews and RCTs. Relevant outcomes are symptoms, functional outcomes, quality of life, medication use, and treatment-related morbidity. Systematic reviews and trials have reported inconsistent results and were heterogeneous in treatment protocols and lengths of follow-up. The evidence is insufficient to determine that the technology results in an improvement in the net health outcome.

For individuals who have medial tibial stress syndrome who receive ESWT, the evidence includes a small RCT and a small nonrandomized cohort study. Relevant outcomes are symptoms, functional outcomes, quality of life, medication use, and treatment-related morbidity. The RCT showed no difference in self-reported pain measurements between study groups. The nonrandomized trial reported improvements with ESWT, but selection bias limited the strength of the conclusions. The evidence is insufficient to determine that the technology results in an improvement in the net health outcome.

For individuals who have osteonecrosis of the femoral head who receive ESWT, the evidence includes systematic reviews of small, mostly nonrandomized studies. Relevant outcomes are symptoms, functional outcomes, quality of life, medication use, and treatment-related morbidity. Many of the studies were low quality and lacked comparators. While most studies reported favorable outcomes with ESWT, limitations such as heterogeneity in the treatment protocols, patient populations, and lengths of follow-up make conclusions on the efficacy of ESWT for osteonecrosis uncertain. The evidence is insufficient to determine that the technology results in an improvement in the net health outcome.

For individuals who have nonunion or delayed union who receive ESWT, the evidence includes systematic reviews, relatively small RCTs with methodologic limitations (e.g., heterogeneous outcomes and treatment protocols), and case series. Relevant outcomes are symptoms, functional outcomes, quality of life, medication use, and treatment-related morbidity. The available evidence does not permit conclusions on the efficacy of ESWT in fracture nonunion, delayed union, or acute long bone fractures. The evidence is insufficient to determine that the technology results in an improvement in the net health outcome.

For individuals who have spasticity who receive ESWT, the evidence includes RCTs and systematic reviews, primarily in patients with stroke and cerebral palsy. Relevant outcomes are symptoms, functional outcomes, quality of life, medication use, and treatment-related morbidity. Several studies have demonstrated improvements in spasticity measures after ESWT, but most studies have small sample sizes and single center designs. More well-designed controlled trials in larger populations are needed to determine whether ESWT leads to clinically meaningful improvements in pain and/or functional outcomes for spasticity. The evidence is insufficient to determine that the technology results in an improvement in the net health outcome.

Additional Information
Not applicable.

Related Policies

- Bone Morphogenetic Protein

Benefit Application

Blue Shield of California Promise Health Plan is contracted with L.A. Care Health Plan for Los Angeles County and the Department of Health Care Services for San Diego County to provide Medi-Cal health benefits to its Medi-Cal recipients. In order to provide the best health care services and practices, Blue Shield of California Promise Health Plan has an extensive network of Medi-Cal primary care providers and specialists. Recognizing the rich diversity of its membership, our providers are given training and educational materials to assist in understanding the health needs of their patients as it could be affected by a member's cultural heritage.

The benefit designs associated with the Blue Shield of California Promise Medi-Cal plans are described in the Member Handbook (also called Evidence of Coverage).

Regulatory Status

Selected ESWT devices that have been approved or cleared by FDA are included in Table 1.

Table 1. Food and Drug Administration-approved Extracorporeal Shock Wave Therapy Devices

Device Name	Approval Date	Delivery System Type	Indication
OssaTron® device (HealthTronics)	2000	Electrohydraulic delivery system	• Chronic proximal plantar fasciitis, i.e., pain persisting >6 mo and unresponsive to conservative management • Lateral epicondylitis
Epos™ Ultra (Dornier)	2002	Electromagnetic delivery system	Plantar fasciitis
Sonocur® Basic (Siemens)	2002	Electromagnetic delivery system	Chronic lateral epicondylitis (unresponsive to conservative therapy for >6 mo)
Orthospec™ Orthopedic ESWT (Medispec)	2005	Electrohydraulic spark-gap system	Chronic proximal plantar fasciitis in patients ≥18 y
Orbasone™ Pain Relief System (Orthometrix)	2005	High-energy sonic wave system	Chronic proximal plantar fasciitis in patients ≥18 y
Duolith® SD1 Shock Wave Therapy Device (Storz Medical AG)	2016	Electromagnetic delivery system	Chronic proximal plantar fasciitis in patients ≥18 y with history of failed alternative conservative therapies >6 mo

Both high-dose and low-dose protocols have been investigated. A high-dose protocol consists of a single treatment of high-energy shock waves (1300 mJ/mm^2). This painful procedure requires anesthesia. A low-dose protocol consists of multiple treatments, spaced 1 week to 1 month apart, in which lower dose shock waves are applied. This protocol does not require anesthesia. The FDA labeled indication for the OssaTron and Epos Ultra devices specifically describes a high-dose protocol, while the labeled indication for the Sonocur device describes a low-dose protocol.

In 2007, Dolorclast® (EMS Electro Medical Systems), a radial ESWT, was approved by the FDA through the premarket approval process. Radial ESWT is generated ballistically by accelerating a bullet to hit an applicator, which transforms the kinetic energy into radially expanding shock waves. Radial ESWT is described as an alternative to focused ESWT and is said to address larger treatment areas, thus providing potential advantages in superficial applications like tendinopathies. The FDA approved indication is for the treatment of patients 18 years and older with chronic proximal plantar fasciitis and a history of unsuccessful conservative therapy.

Health Equity Statement

Blue Shield of California Promise Health Plan's mission is to transform its health care delivery system into one that is worthy of families and friends. Blue Shield of California Promise Health Plan seeks to advance health equity in support of achieving Blue Shield of California Promise Health Plan's mission.

Blue Shield of California Promise Health Plan ensures all Covered Services are available and accessible to all members regardless of sex, race, color, religion, ancestry, national origin, ethnic group identification, age, mental disability, physical disability, medical condition, genetic information, marital status, gender, gender identity, or sexual orientation, or identification with any other persons or groups defined in Penal Code section 422.56, and that all Covered Services are provided in a culturally and linguistically appropriate manner.

Rationale

Background

Chronic Musculoskeletal Conditions

Chronic musculoskeletal conditions (e.g., tendinitis) can be associated with a substantial degree of scarring and calcium deposition. Calcium deposits may restrict motion and encroach on other structures, such as nerves and blood vessels, causing pain and decreased function. One hypothesis is that disruption of calcific deposits by shock waves may loosen adjacent structures and promote resorption of calcium, thereby decreasing pain and improving function.

Plantar Fasciitis

Plantar fasciitis is a common ailment characterized by deep pain in the plantar aspect of the heel, particularly on arising from bed. While the pain may subside with activity, in some patients, the pain persists, interrupting activities of daily living. On physical examination, firm pressure will elicit a tender spot over the medial tubercle of the calcaneus. The exact etiology of plantar fasciitis is unclear, although repetitive injury is suspected. Heel spurs are a common associated finding, although it is unproven that heel spurs cause the pain. Asymptomatic heel spurs can be found in up to 10% of the population.

Tendinitis and Tendinopathies

Common tendinitis and tendinopathy syndromes are summarized in Table 2. Many tendinitis and tendinopathy syndromes are related to overuse injury.

Table 2. Tendinitis and Tendinopathy Syndromes

Disorder	Location	Symptoms	Conservative Therapy	Other Therapies
Lateral epicondylitis ("tennis elbow")	Lateral elbow (insertion of wrist extensors)	Tenderness over lateral epicondyle and proximal wrist extensor muscle mass; pain with resisted wrist extension with elbow in full extension; pain with passive terminal wrist flexion with elbow in full extension	• Rest • Activity modification • NSAIDs • Physical therapy • Orthotic devices	Corticosteroid injections; joint debridement (open or laparoscopic)
Shoulder tendinopathy	Rotator cuff muscle tendons, most commonly supraspinatus	Pain with overhead activity	• Rest • Ice • NSAIDs • Physical therapy	Corticosteroid injections
Achilles tendinopathy	Achilles tendon	Pain or stiffness 2 to 6 cm above the posterior calcaneus	• Avoidance of aggravating activities • Ice when symptomatic • NSAIDs • Heel lift	Surgical repair for tendon rupture
Patellar tendinopathy ("jumper's knee")	Proximal tendon at lower pole of patella	Pain over anterior knee and patellar tendon; may progress to tendon calcification and/or tear	• Ice • Supportive taping • Patellar tendon straps • NSAIDs	

NSAIDs: nonsteroidal anti-inflammatory drugs.

Fracture Nonunion and Delayed Union

The definition of a fracture nonunion remains controversial, particularly the duration necessary to define nonunion. One proposed definition is a failure of progression of fracture healing for at least 3 consecutive months (and at least 6 months after the fracture) accompanied by clinical symptoms of delayed/nonunion (pain, difficulty weight bearing). The following criteria to define nonunion were used to inform this review:

- at least 3 months since the date of fracture;
- serial radiographs have confirmed that no progressive signs of healing have occurred;
- the fracture gap is 1 cm or less; and
- the patient can be adequately immobilized and is of an age likely to comply with nonweight-bearing limitation.

The delayed union can be defined as a decelerating healing process, as determined by serial radiographs, together with a lack of clinical and radiologic evidence of union, bony continuity, or bone reaction at the fracture site for no less than 3 months from the index injury or the most recent intervention. (In contrast, nonunion serial radiographs show no evidence of healing.)

Other Musculoskeletal and Neurologic Conditions

Other musculoskeletal conditions include medial tibial stress syndrome, osteonecrosis (avascular necrosis) of the femoral head, coccydynia, and painful stump neuromas. Neurologic conditions include spasticity, which refers to a motor disorder characterized by increased velocity-dependent stretch reflexes. It is a characteristic of upper motor neuron dysfunction, which may be due to a variety of pathologies.

Treatment

Most cases of plantar fasciitis are treated with conservative therapy, including rest or minimization of running and jumping, heel cups, and nonsteroidal-anti-inflammatory drugs. Local steroid injection may also be used. Improvement may take up to 1 year in some cases.

For tendinitis and tendinopathy syndromes, conservative treatment often involves rest, activity modifications, physical therapy, and anti-inflammatory medications (Table 1).

Extracorporeal Shock Wave Therapy

Also known as orthotripsy, extracorporeal shock wave therapy (ESWT) has been available since the early 1980s for the treatment of renal stones and has been widely investigated for the treatment of biliary stones. ESWT uses externally applied shock waves to create a transient pressure disturbance, which disrupts solid structures, breaking them into smaller fragments, thus allowing spontaneous passage and/or removal of stones. The mechanism by which ESWT might have an effect on musculoskeletal conditions is not well-defined.

Other mechanisms are also thought to be involved in ESWT. Physical stimuli are known to activate endogenous pain control systems, and activation by shock waves may "reset" the endogenous pain receptors. Damage to endothelial tissue from ESWT may result in increased vessel wall permeability, causing increased diffusion of cytokines, which may, in turn, promote healing. Microtrauma induced by ESWT may promote angiogenesis and thus aid healing. Finally, shock waves have been shown to stimulate osteogenesis and promote callous formation in animals, which is the basis for trials of ESWT in delayed union or nonunion of bone fractures.

There are 2 types of ESWT: focused and radial. Focused ESWT sends medium- to high-energy shockwaves of single pressure pulses lasting microseconds, directed on a specific target using ultrasound or radiographic guidance. Radial ESWT (RSW) transmits low- to medium-energy shockwaves radially over a larger surface area. The U.S. Food and Drug Administration (FDA) approval was first granted in 2002 for focused ESWT devices and in 2007 for RSW devices.

Literature Review

The most clinically relevant outcome measures of extracorporeal shock wave treatment (ESWT) used for musculoskeletal conditions are pain and functional limitations. Pain is a subjective, patient-reported measure. Therefore, pain outcomes require quantifiable pre- and post-treatment measures. Pain is most commonly measured with a visual analog scale (VAS). Quantifiable pre- and posttreatment measures of functional status are also used, such as the 12-Item Short-Form Health Survey and 36-Item Short-Form Health Survey. Minor adverse events of ESWT are common but transient, including local pain, discomfort, trauma, bleeding, and swelling. More serious adverse events of ESWT may potentially include neurologic damage causing numbness or tingling, permanent vascular damage, or rupture of a tendon or other soft tissue structure.

Evidence reviews assess the clinical evidence to determine whether the use of a technology improves the net health outcome. Broadly defined, health outcomes are length of life, quality of life, and ability to function including benefits and harms. Every clinical condition has specific outcomes that are important to patients and to managing the course of that condition. Validated outcome measures are necessary to ascertain whether a condition improves or worsens; and whether the magnitude of that change is clinically significant. The net health outcome is a balance of benefits and harms.

To assess whether the evidence is sufficient to draw conclusions about the net health outcome of a technology, 2 domains are examined: the relevance and the quality and credibility. To be relevant, studies must represent 1 or more intended clinical use of the technology in the intended population and compare an effective and appropriate alternative at a comparable intensity. For some conditions, the alternative will be supportive care or surveillance. The quality and credibility of the evidence depend on study design and conduct, minimizing bias and confounding that can generate incorrect findings. The randomized controlled trial (RCT) is preferred to assess efficacy; however, in some circumstances, nonrandomized studies may be adequate. Randomized controlled trials are rarely large enough or long enough to capture less common adverse events and long-term effects. Other types of studies can be used for these purposes and to assess generalizability to broader clinical populations and settings of clinical practice.

Musculoskeletal and Neurologic Conditions
Plantar Fasciitis

Clinical Context and Therapy Purpose

The purpose of ESWT is to provide a treatment option that is an alternative to or an improvement on existing therapies, such as conservative therapy (e.g., stretching, heel supports), nonsteroidal anti-inflammatory therapy, and local corticosteroid injection, in individuals with plantar fasciitis.

The following PICO was used to select literature to inform this review.

Populations

The relevant population of interest is individuals with plantar fasciitis.

Interventions

The therapy being considered is ESWT.

ESWT is a noninvasive method used to treat pain with shock or sound waves directed from outside the body onto the area to be treated (e.g., the heel). Shock waves are generated at high- or low-energy intensity, may be radial or focused, and treatment protocols can include more than 1 treatment. ESWT has been investigated for use in a variety of musculoskeletal conditions.

Comparators

Comparators of interest include conservative therapy (e.g., stretching, heel supports), nonsteroidal anti-inflammatory therapy, and local corticosteroid injection.

Outcomes

The general outcomes of interest are pain symptoms, functional outcomes, quality of life, medication use, and treatment-related morbidity (Table 3).

Table 3. Outcomes of Interest for Individuals with Plantar Fasciitis

Outcomes	Details	Timing
Pain reduction	• VAS assessment, with successful pain reduction of 50% to 60% or ≥4 cm reduction in score • Roles and Maudsley pain scores of "good" or "excellent" • Pain comparison both to baseline and to control group measurements • Patient-assessed and investigator-assessed pain levels	Generally measured for up to 12 weeks
Functional improvement	• Roles and Maudsley function score of "good" or "excellent" • Patient ability to work and perform activities of daily living	Generally measured for up to 12 weeks
Quality of life	• Patient-reported satisfaction with treatment	Generally measured for up to 12 weeks

VAS: visual analog scale.

Study Selection Criteria

Methodologically credible studies were selected using the following principles:

- To assess efficacy outcomes, comparative controlled prospective trials were sought, with a preference for RCTs;
- In the absence of such trials, comparative observational studies were sought, with a preference for prospective studies;
- To assess longer term outcomes and adverse events, single-arm studies that capture longer periods of follow-up and/or larger populations were sought;
- Studies with duplicative or overlapping populations were excluded.

Review of Evidence

Systematic Reviews

A list of the systematic reviews and their associated studies are presented below in Table 4 with their key characteristics presented in Table 5.

Meta-analyses of RCTs published in 2013 have reported that ESWT for plantar fasciitis is better than or comparable to placebo in reducing pain[1,2,3] and improving functional status in the short-term (Tables 4 to 6).[1,2] However, the RCTs were subject to a number of limitations. They reported inconsistent results, and heterogeneity across them sometimes precluded meta-analysis of pooled data. Outcomes measured and trial protocols (e.g., dose intensities, type of shockwaves, the frequency of treatments) also lacked uniformity. Also, given that plantar fasciitis often resolves within a 6-month period, longer follow-up would be required to compare ESWT results with the natural resolution of the condition. The clinical significance of results reported at shorter follow-up (e.g., 3 months) is uncertain.

A systematic review and meta-analysis by Yin et al (2014) evaluated 7 RCTs or quasi-RCTs of ESWT for chronic (≥6 months) recalcitrant plantar fasciitis.[4] The treatment success rate of the 5 trials (n=448) that evaluated low-intensity ESWT showed it was more likely than the control to be successful (pooled relative risk, 1.69; 95% confidence interval [CI], 1.37 to 2.07; $p<.001$). In a pooled analysis of 2 trials (n=105) that evaluated high-intensity ESWT, there was no difference between ESWT and control in treatment success. A strength of this analysis was restricting the population to patients with at least 6 months of symptoms because this clinical population is more difficult to treat and less likely to respond to interventions. However, a weakness was the heterogeneity in the definition of "treatment success" across trials, which makes interpreting the pooled analysis challenging.

A meta-analysis by Lou et al (2017) evaluated the efficacy of ESWT without local anesthesia in patients with recalcitrant plantar fasciitis.[5] The literature search, conducted through September 2015, identified 9 trials for inclusion (N=1174). Meta-analyses focused on pain reduction at 12 weeks of follow-up: overall, at first step in the morning, and during daily activities. Three RCTs also provided data to analyze improvement in the Roles and Maudsley score to excellent or good at 12-week follow-up.

A meta-analysis by Sun et al (2017) evaluated the efficacy of all ESWT, then conducted subgroup analyses on the type of ESWT (focused shock wave [FSW], radial shock wave [RSW]).[6] The literature search, conducted through July 2016, identified 9 trials for inclusion (N=935). An outcome in all 9 trials was "therapeutic success" rate, defined as the proportion of patients experiencing a decrease in VAS pain score from baseline more than a threshold of either at least 50% or at least 60%. Only 4 studies provided data on reducing pain (3 FSW, 1 RSW). Pooled results are summarized in Table 6.

In a systematic review and meta-analysis, Li et al (2018) assessed RCTs to determine whether ESWT or corticosteroid injections are more effective in plantar fasciitis pain reduction (measured using VAS), treatment success, recurrence rate, function scores, and adverse events.[7] The review included 9 RCTs with a total of 658 cases in which 330 participants received ESWT and 328 received corticosteroid injection. Meta-analyses showed that corticosteroid injection is more effective than low-intensity ESWT at VAS reduction (3 months post-treatment: mean difference [MD], -1.67; 95% CI, -3.31 to -0.04; p=.04; I^2=85%). However, high-intensity ESWT is more effective than corticosteroid injection (2 to 3 months post-treatment: MD, 1.12; 95% CI, 0.52 to 1.72; p=.0003; I^2=59%). One study followed patients for 12 months post-treatment and found no significant difference in pain outcomes, and another found no significant difference in recurrence rates or functional scores between ESWT and corticosteroid injection. Four ESWT recipients in a single trial reported severe headache or migraine following the procedure; no severe adverse effects were reported for corticosteroid injection. Though corticosteroid injection is more readily available than ESWT, the authors reported that ESWT recipients had a faster return to full activities after the procedure. One limitation of this systematic review is the inclusion of only 9 trials with 658 cases, only 2 of which were followed up for as long as 1 year. Also, the doses of corticosteroid injection varied across studies, which may affect heterogeneity. This study is not included in the results summary table (Table 6) because its comparator is a corticosteroid injection rather than placebo.

A meta-analysis by Xiong et al (2019) compared the efficacy of shock wave therapy with corticosteroid injections for managing plantar fasciitis in terms of pain and functionality.[8] The analysis included 6 RCTs with 454 patients and revealed a significant difference in VAS score (MD, -0.96; 95% CI, -1.28 to -0.63; p<.00001; I^2=96%), favoring shock wave therapy. This analysis is also not included in the results summary table (Table 6) because its comparator is a corticosteroid injection rather than placebo.

Results of the meta-analyses must be interpreted with caution due to the following limitations: lack of uniform measurement of outcomes, heterogeneity in ESWT protocols (focused and radial, low- and high-intensity/energy, the number of shocks per treatment, treatment duration, and differing comparators), and lack of functional outcomes.

Systematic reviews and meta-analyses of RCTs published in 2024 have reported that ESWT for plantar fasciitis is comparable or worse than other modalities (prolotherapy, low-dye and sham-Kinesio taping, platelet-rich plasma injections [PRP], corticosteroid injections, low-level laser therapy, ultrasound therapy, photo-biomodulation, sham-ESWT and/or conventional therapy) in reducing pain (VAS) and improving function status (Foot Function Index [FFI]) at 3 and 6 months, but at 12 months or longer ESWT did not demonstrate significant improvement in VAS or FFI measurements.[9-14] Patients that received PRP injections demonstrated increased reduction in VAS scores and improved function compared to ESWT. However, the RCTs were subject to a number of limitations. They reported inconsistent results, and sufficient heterogeneity across them precluded meta-analysis or sub-analysis of pooled data. Outcomes measured, follow-up times, and trial protocols (e.g., dose intensities, type of shockwaves, the frequency of treatments) lacked uniformity. Given that plantar fasciitis often resolves within a 6-month period, a longer follow-up is necessary to compare ESWT results with the natural resolution of the condition. The clinical significance of results reported at shorter follow-up (e.g., 4-weeks, 6-weeks, 12-weeks, or 3 months) is uncertain. This study is not included in the results summary table (Table 6) because its comparator are other treatment modalities.

Table 4. Comparison of Systematic Reviews Assessing Extracorporeal Shock Wave Therapy for Plantar Fasciitis

Study	Aqil (2013)[2]	Dizon (2013)[1]	Zhiyun (2013)[3]	Yin (2014)[4]	Lou (2017)[5]	Sun (2017)[6]	Li (2018)[17]	Xiong (2019)[8]
Buchbinder (2002)		●						
Chow (2005)		●						
Eslamian (2016)							●	
Fariba (2016)								●
Gerdesmeyer (2008)	●	●		●	●	●		
Gollwitzer (2007)	●	●	●	●	●	●		
Gollwitzer (2015)					●			
Gollwitzer (2017)						●		
Greve (2009)		●					●	
Guevara (2018)							●	
Haake (2003)		●					●	
Hocaoglu (2017)							●	
Ibrahim (2010)	●	●		●		●		
Istemi (2010)								●
Kudo (2006)		●	●					
Lai (2018)							●	●
Malay (2006)	●	●	●		●	●		
Mardani-Kivi (2015)							●	
Mark (2005)								●
Marks (2008)	●			●		●		
Nayera (2012)								●
Ogden (2004)			●					
Porter (2005)							●	
Radwan (2012)				●				
Rompe (1996)						●		
Rompe (2002)						●		
Rompe (2003)	●			●				
Saber (2012)							●	
Sehriban (2017)								●
Sorrentino (2008)							●	
Speed (2003)	●	●		●	●	●		
Theodore (2004)		●	●					
Yucel (2010)							●	

[1]Only 7 trials mentioned in meta-analysis.

Table 5. Characteristics of Systematic Reviews and Meta-Analyses Assessing Extracorporeal Shock Wave Therapy for Plantar Fasciitis

Study	Dates	Trials	Participants	N (Range)	Design	Duration
Aqil (2013)[2]	2003–2010	7	PF patients with continued symptoms after 3 months of consecutive therapy	663 (25 to 243)	RCTs	12 weeks
Dizon (2013)[1]	2002–2010	11	Patients with chronic PF	1287 (32 to 272)	RCTs	Immediately after treatment to 1 year
Zhiyun (2013)[3]	2004–2007	5	Adults with recalcitrant PF; baseline pain ≥5 points on VAS	716 (40 to 293)	RCTs (double-blind)	12 weeks
Yin (2014)[4]	2003–2012	7	Adults with PF ≥6 months; single-site heel pain with local pressure at origin of proximal plantar fascia on the medial calcaneal tuberosity	550 (25 to 243)	RCTs	3 to 12 months
Lou (2017)[5]	2001-2015	91	Patients with recalcitrant PF	1174 (NA)	RCTs	Primary outcomes=12 weeks; studies up to >12 months
Sun (2017)[6]	1996–2015	9	Patients with chronic PF	935 (29 to 246)	RCTs	3 weeks to 6 months
Li (2018)[7]	2005–2018	9	Adults with PF and without injection history	658 (40 to 125)	RCTs	6 weeks to 1 year
Xiong (2019)[8]	2005-2018	6	Patients with PF	454 (40 to 125)	RCTs	-

NA: not available; PF: plantar fasciitis; RCT: randomized controlled trial; VAS: visual analog scale.

Table 6. Results of Systematic Reviews and Meta-Analyses Assessing Extracorporeal Shock Wave Therapy for Plantar Fasciitis Compared with Placebo

Study	60% VAS Score Reduction from Baseline (or >50% reduction and VAS score ≤4 cm)				Roles & Maudsley Score
	First Steps	Overall Heel Pain	Daily Activities	Composite	
Aqil (2013)[2]					
RR	1.30	-	1.44	-	-[1]
SMD	-	0.60		0.38	-
95% CI	1.04 to 1.62	0.34 to 0.85	1.13 to 1.84	0.05 to 0.72	-
Z score	2.29	4.64	2.96	2.27	-
p-value	<.02	<.001	.003	.02	-
Dizon (2013)[1]					
WMD	-0.77	-4.39	0.59	-	-
OR					0.57
95% CI	-1.30 to -0.25	-9.05 to 0.27	0.33 to 1.05	-	0.43 to 0.76
p-value	.004	.06	.07	-	.0001
Zhiyun (2013)[33]					
Success rate % (12 weeks)	-	46.5 to 62.5	-	-	-
OR	-	2.25	-	-	-
95% CI	-	1.66 to 3.06	-	-	-
Z score	-	5.19	-	-	-
p-value	-	<.0001	-	-	-
Yin (2014)[4]					
L-ESWT					
MD	-	1.51[2]	-		

Study	60% VAS Score Reduction from Baseline (or >50% reduction and VAS score ≤4 cm)				Roles & Maudsley Score
RR	-		-	-	1.41
95% CI	-	0.77 to 2.26	-	-	1.08 to 1.82
p-value	-	<.001	-	-	.01
H-ESWT					
MD	-	1.4	-	-	
RR	-		-	-	1.33
95% CI	-	0.57 to 2.23	-	-	0.94 to 1.9
p-value	-	.11	-	-	.11
Lou (2017)[5]					
RR	1.32	1.50	1.37	-	1.51
95% CI	1.11 to 1.56	1.27 to 1.77	1.14 to 1.65	-	1.26 to 1.81
Z score	3.19	4.84	3.31	-	4.51
p-value	.001	<.0001	.0009	-	<.0001
I^2 %	0	0	-		0
Sun (2017)[6]					
OR	-	-	-	2.58	-
SMD	-	1.01	-	-	-
95% CI	-	-0.01 to 2.03	-	1.97 to 3.39	-
Z score	-	1.94	-	6.88	-
p-value	-	.05	-	<.0001	-
I^2 %	-	96	-	38	-

CI: confidence interval; H-ESWT: high-intensity/energy shockwave therapy; L-ESWT: low-intensity/energy shockwave therapy; MD: mean difference; OR: odds ratio; RR: risk ratio; SMD: standard mean difference; VAS: visual analog scale; WMD: weighted mean difference.
Li (2018) and Xiong (2019) are not included in the results summary table because the comparator in the studies is corticosteroid injections rather than placebo.
[1] Aqil et al gathered data on 3 studies that measured Roles and Maudsley scores but did not statistically combine the results. However, all 3 studies showed statistically significant improvements for the ESWT group at 12 weeks.
[2] Yin et al compared ESWT value for pain relief before and after treatment.
[3] Zhivun compared H-ESWT to placebo.

Randomized Controlled Trials

Trials With Sham Controls

Several representative RCTs are discussed next (Tables 7 through 10).

Heide et al (2024) reported on results of a sham-controlled randomized trial evaluating radial extracorporeal shock wave therapy (rESWT), sham-rESWT, or conservative treatment (exercise, orthotic support) with advice at reducing pain for individuals with plantar fasciopathy.[15] Patients and outcome assessments (at baseline, 3-, 6-, and 12-months) were blinded, the primary analysis of heel pain via a numeric rating scale indicated no significant difference in pain reduction between treatment modalities. In patients with plantar fasciopathy, there was no additional benefit of rESWT.

Gollwitzer et al (2015) reported on results of a sham-controlled randomized trial, with patients and outcome assessments blinded, evaluating ESWT for plantar fasciitis present for at least 6 months and refractory to at least 2 nonpharmacologic and 2 pharmacologic treatments.[16] A total of 250 subjects were enrolled (126 in the ESWT group; 124 in the placebo group). The trial's primary outcome was an overall reduction of heel pain, measured by percentage change of the VAS composite score at 12 weeks. Median decrease for the ESWT group was -69.2% and -34.5% for the placebo group (effect size, 0.603; p=.003). Secondary outcomes included success rates defined as decreases in heel pain of at least 60% from baseline. Secondary outcomes generally favored the ESWT group. Most patients reported satisfaction with the procedure. Strengths of this trial included an intention-to-treat analysis, use of validated outcome measures, and at least some reporting of changes in success rates (rather than percentage decrease in pain) for groups. There was some potential for bias because treating physicians were unblinded.

Gerdesmeyer et al (2008) reported on a multicenter, double-blind RCT of radial extracorporeal shock wave therapy (RSW) conducted for U.S. Food and Drug Administration (FDA) premarket approval of the Dolorclast.[17] The trial randomized 252 patients, 129 to RSW and 122 to sham treatment. Patients had heel pain for at least 6 months and had failed at least 2 nonpharmacologic and 2 pharmacologic treatments. Over 90% of patients were compliant with the 3 weekly treatment schedule. Outcome measures were composite heel pain (pain on first steps of the day, with activity and as measured with Dolormeter), change in VAS pain score, and Roles and Maudsley score measured at 12 weeks and 12 months. Success was defined as a reduction of 60% or more in 2 of 3 VAS scores, or patient ability to work and complete activities of daily living, treatment satisfaction, and requiring no further treatment. Secondary outcomes at 12 weeks included changes in Roles and Maudsley score, 36-Item Short-From Health Survey Physical Component Summary score, 36-Item Short-Form Health Survey Mental Component Summary score, investigator's and patient's judgment of effectiveness, and patient recommendation of therapy to a friend. At 12-week follow-up, RSW resulted in a decrease of the composite VAS score by 72.1% versus 44.7% after placebo (p=.022). Success rates for the composite heel pain score were 61% and 42% (p=.002). Statistically significant differences were noted in all secondary measures. A number of limitations prevent definite conclusions from being reached including: the limited data on specific outcomes (e.g., presenting percent changes rather than actual results of measures); inadequate description of prior treatments; use of a composite outcome measure; no data on the use of rescue medication; and uncertainty in the clinical significance of changes in outcome measures.

In 2005, results were reported from the FDA-regulated trials delivering ESWT with the Orthospec and Orbasone Pain Relief System. In the RCT evaluating Orthospec, investigators conducted a multicenter, double-blind, sham-controlled trial randomizing 172 participants with chronic proximal plantar fasciitis failing conservative therapy to ESWT or to sham treatments.[18] At 3 months, the ESWT arm had lower investigator-assessed pain levels with the application of a pressure sensor (0.94 points lower on a 10-point VAS; 95% CI, 0.02 to 1.87). However, this improvement was not found for patient-assessed activity and function. In the trial supporting the FDA approval of Orbasone, investigators conducted a multicenter, randomized, sham-controlled, double-blind trial evaluating 179 participants with chronic proximal plantar fasciitis.[19] At 3 months, both active and sham groups improved in patient-assessed pain levels on awakening (by 4.6 and 2.3 points, respectively, on a 10-point VAS; absolute difference between groups, 2.3; 95% CI, 1.5 to 3.3). While ESWT was associated with more rapid and statistically significant improvement in a mixed-effects regression model, insufficient details were provided to evaluate the analyses.

Table 7. Summary of Key Characteristics of Randomized Controlled Trials Assessing Extracorporeal Shock Wave Therapy for Plantar Fasciitis

Study; Trial	Countries	Sites	Participants	Interventions	
				Active	*Comparator*
Gollwitzer (2015)[16]	US	5	Patients with ≥6 months PF; failed ≥4 non-surgical treatments, including ≥2 non-pharmacological and ≥2 pharmacological treatments; (N =250)	2000 impulses; maximum 0.25 mJ/mm^2 (4 impulses per second); up to 3 weekly sessions; (n=126)	Identical placebo handpiece for sham intervention; air-filled standoff prevented transmission of shockwaves; (n=124)
Gerdesmeyer (2008)[17]	US, EU	8	Patients with ≥6 months painful heel syndrome resistant to nonsurgical treatment; score ≥5 on 3 VAS scores; failed ≥2 non-pharmacological and 2 pharmacological treatments; sufficient washout period; (N =254)	2000 impulses radial shockwaves; energy flux density 0.16 mJ/mm^2 (8 impulses per second); 3 bi-weekly sessions; (n=129)	Identical placebo handpiece; same schedule as active group but with no energy administered; (n=122)

Study; Trial	Countries	Sites	Participants	Interventions	
FDA, Orbasone (2005)[19]	US	3	Patients ≥21 years; proximal PF ≥6 months and in prescribed stretching program; failed ≥4 conventional treatments; score ≥6 cm on VAS scale; (N =179)	Single treatment of 2000 pulses at 20 to 21 KV; frequency 110 pulses per minute; total energy density <1000 mJ/mm^2; injection of approx. 10 mL of 0.5% bupivacaine; (n=96)	Sham treatment with no water pumped into reflector head, preventing shockwave energy from reaching patient's foot; (n=83)
FDA, Orthospec (2005)[18]	US	3	Adults (non-pregnant) with proximal PF for >6 months; under treatment ≥4 months; VAS score upon first steps ≥5 cm; failed 2 pharmacological and 2 nonpharmacological treatments; washout period; (N =172)	Total of 3800 shocks; (n=115)	Total of 3800 shocks; contact membrane of device lined with internal foam insert to absorb shockwaves; (n=57)

EU: European Union; FDA: U.S. Food and Drug Administration; PF: plantar fasciitis; VAS: visual analog scale;.

Table 8. Summary of Key Results of Randomized Controlled Trials Assessing Extracorporeal Shock Wave Therapy for Plantar Fasciitis

Study	VAS Pain Score Improvement	Functional Improvement
Gollwitzer (2015)[16]		
p-value (MW effect size)[3]	.0027 (0.6026)	.0006 (0.6135)
Lower-bound 95% CI	0.5306	0.5466
ESWT mean % from baseline (95% CI)	-54.5 (-61.4 to -47.7)	-
Placebo mean % from baseline (95% CI)	-40.3 (-47.5 to -33.1)	-
ESWT mean score (95% CI)[4]	-	2.5 (2.3 to 2.7)
Placebo mean score (95% CI)	-	2.9 (2.7 to 3.1)
Gerdesmeyer (2008)[17]		
ESWT reduction in VAS composite %	72.1	-
Placebo reduction in VAS composite %	44.7	-
p-value	.0220	-
ESWT success rate %[1]	60.98	58.402
Placebo success rate %	42.24	41.52
p-value (MW effect size)	.0020 (-)	.0031 (0.5973)
FDA, Orbasone (2005)[19]		
ESWT 12-wk mean score (SE)	3.11 (0.30)	-
Range	0 to 9.8	-
Placebo 12-wk mean score (SE)	5.51 (0.35)	-
Range	0 to 10	-
p-value	.0002	-
% ESWT with 40% reduction in VAS	70.8	-
% Placebo with 40% reduction in VAS	36.6	-
FDA, Orthospec (2005)[18]		
ESWT mean change from baseline[6]	-2.51	-
Placebo mean change from baseline	-1.57	-
Difference	-0.94	-
95% CI	-1.87 to -0.02	-
p-value	.045	-
ESWT effectiveness rate %[7]	-	64.3
Placebo effectiveness rate %	-	57.1
p-value	-	.33

CI: confidence interval; ESWT: extracorporeal shockwave therapy; FDA: US Food and Drug Administration; MW: Mann-Whitney; SE: standard error; VAS: visual analog scale.

[1] Based on overall VAS score.

[2] Roles and Maudsley Score of "excellent" or "good."

[3] Based on composite VAS score.

4 Roles and Maudsley Score.
5 Based on pain at first steps VAS score.
6 Physician's assessment of pain at first steps VAS score.
7 Patient's assessment.

Tables 9 and 10 display notable limitations identified in each study.

Table 9. Study Relevance Limitations of Randomized Controlled Trials Assessing Extracorporeal Shock Wave Therapy for Plantar Fasciitis

Study	Population[a]	Intervention[b]	Comparator[c]	Outcomes[d]	Follow-Up[e]
Gollwitzer (2015)[16]					
Gerdesmeyer (2008)[17]					
FDA, Orbasone (2005)[19]	3. Allocation concealment unclear				
FDA, Orthospec (2005)[18]	3. Allocation concealment unclear	1. Few details provided			

FDA: US Food and Drug Administration.
The study limitations stated in this table are those notable in the current review; this is not a comprehensive gaps assessment.
a Population key: 1. Intended use population unclear; 2. Clinical context is unclear; 3. Study population is unclear; 4. Study population not representative of intended use.
b Intervention key: 1. Not clearly defined; 2. Version used unclear; 3. Delivery not similar intensity as comparator; 4. Not the intervention of interest.
c Comparator key: 1. Not clearly defined; 2. Not standard or optimal; 3. Delivery not similar intensity as intervention; 4. Not delivered effectively.
d Outcomes key: 1. Key health outcomes not addressed; 2. Physiologic measures, not validated surrogates; 3. No CONSORT reporting of harms; 4. Not establish and validated measurements; 5. Clinical significant difference not prespecified; 6. Clinical significant difference not supported.
e Follow-Up key: 1. Not sufficient duration for benefit; 2. Not sufficient duration for harms.

Table 10. Study Design and Conduct Limitations of Randomized Controlled Trials Assessing Extracorporeal Shock Wave Therapy for Plantar Fasciitis

Study	Allocation[a]	Blinding[b]	Selective Reporting[c]	Data Completeness[d]	Power[e]	Statistical[f]
Gollwitzer (2015)[16]						
Gerdesmeyer (2008)[17]						3. Confidence intervals not reported
FDA, Orbasone (2005)[19]	1. Allocation concealment unclear		1. Registration unclear		1. Power calculations not reported	3. Confidence intervals and p-values not reported
FDA, Orthospec (2005)[18]	1. Allocation concealment unclear		1. Registration unclear		1. Power calculations not reported	3. Confidence intervals not reported for function

FDA: US Food and Drug Administration.
The study limitations stated in this table are those notable in the current review; this is not a comprehensive gaps assessment.
a Allocation key: 1. Participants not randomly allocated; 2. Allocation not concealed; 3. Allocation concealment unclear; 4. Inadequate control for selection bias.
b Blinding key: 1. Not blinded to treatment assignment; 2. Not blinded outcome assessment; 3. Outcome assessed by treating physician.
c Selective Reporting key: 1. Not registered; 2. Evidence of selective reporting; 3. Evidence of selective publication.
d Data Completeness key: 1. High loss to follow-up or missing data; 2. Inadequate handling of missing data; 3.

High number of crossovers; 4. Inadequate handling of crossovers; 5. Inappropriate exclusions; 6. Not intent to treat analysis (per protocol for noninferiority trials).
e Power key: 1. Power calculations not reported; 2. Power not calculated for primary outcome; 3. Power not based on clinically important difference.
f Statistical key: 1. Intervention is not appropriate for outcome type: (a) continuous; (b) binary; (c) time to event; 2. Intervention is not appropriate for multiple observations per patient; 3. Confidence intervals and/or p values not reported; 4.Comparative treatment effects not calculated.

Trials With Active Comparators

Radwan et al (2012) compared ESWT with endoscopic plantar fasciotomy in 65 patients who had refractory plantar fasciitis and had failed at least 3 lines of treatment in the preceding 6 months.[20] Outcome measures included a 0-to-100 VAS assessing morning pain, the American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Scale score, and patient subjective assessment using the 4-item Roles and Maudsley score. Improvements were similar in both treatment groups at the 1-year follow-up; however, a larger proportion of patients in the surgery group continued to report success at years 2 and 3 compared with those of the ESWT group.

Randomized controlled trials comparing ESWT and RSW with corticosteroid injection and conservative treatment (exercise, orthotic support) have been performed, with mixed findings.[21,-24] As the follow-up period for these studies is 3 months or less, the clinical significance of these results is uncertain.[25] One RCT found that ESWT plus stretching exercises had similar efficacy to instrument-assisted soft-tissue mobilization plus stretching exercises through 8 weeks of follow-up, but at 6 months, soft-tissue mobilization was more effective than ESWT.[26]

In a double-blind RCT, Bahar-Ozdemier et al (2021) evaluated the effects of ESWT alone (n=15), ESWT plus low-dye kinesiotaping (n=15), and ESWT plus sham kinesiotaping (n=15) in 45 patients with plantar fasciitis.[27] Main outcome measures included VAS change, the heel tenderness index, and foot function index. Low-dye kinesiotaping plus ESWT was more effective on foot function improvement than ESWT and sham kinesiotaping or ESWT alone in the 4 week duration of follow-up. However, the combination did not provide a significant benefit on pain and heel tenderness due to plantar fasciitis.

Randomized controlled trials comparing ESWT with peloidotherapy (natural muds therapy), dry needling (DN), or low-level laser therapy (LLLT) have reported that ESWT is comparable or worse than the comparator at reducing pain and/or improving function in patients with plantar fasciitis.[28,29,30] Akdere et al (2024) compared the effectiveness of ESWT and peloidotherapy on pain (VAS scale and Heel Tenderness Index [HTI]), quality of life (Short Form 36 and Foot Ankle Outcome Score [FAOS]) and functional status (FAOS) at 1 month and demonstrated that both treatments had significantly improved outcomes for each metric when compared to baseline values. Dede et al (2024) compared the effectiveness of ESWT and DN on pain (VAS) and functional status (foot function index [FFI]) outcomes at baseline, 1-week, and 4-week and demonstrated that both treatments significantly reduced pain (VAS; $p<.01$) and improved function (FFI; $p<.01$) at 1 week. Furthermore, DN was better than ESWT for VAS ($p=.023$) and FFI ($p=.048$) at 4 weeks. Timurtas et al (2024) compared the short-term effectiveness of ESWT and LLLT on pain and function using FFI, including the pain, disability and activity subscales, and demonstrated that LLLT was significantly better at reducing pain and improving function ($p<.001$). As the follow-up period for these studies is 1 month or less, the clinical significance of these results is uncertain.

Section Summary: Plantar Fasciitis

Numerous RCTs were identified, including several well-designed double-blind RCTs, that evaluated ESWT for the treatment of plantar fasciitis. Several systematic reviews and meta-analyses have been conducted, covering numerous studies, including studies that compared ESWT with corticosteroid injections and other treatment modalities. Pooled results were inconsistent. Some meta-analyses reported that ESWT reduced pain, while others reported nonsignificant pain reduction. Reasons for the differing results included lack of uniformity in the definitions of outcomes and heterogeneity in ESWT protocols (focused vs. radial, low- vs. high-intensity/energy, number and duration of shocks per treatment, number of treatments, and differing comparators). Some studies reported significant benefits in pain and functional improvement at 3 months, but it is not evident that the longer-term disease natural history is altered with ESWT. Currently, it is not possible to conclude definitively that ESWT improves outcomes for patients with plantar fasciitis.

Lateral Epicondylitis

Clinical Context and Therapy Purpose

The purpose of ESWT is to provide a treatment option that is an alternative to or an improvement on existing therapies, such as conservative therapy (e.g., physical therapy) and nonsteroidal anti-inflammatory therapy, in individuals with lateral epicondylitis.

The following PICO was used to select literature to inform this review.

Populations

The relevant population of interest is individuals with lateral epicondylitis.

Interventions

The therapy being considered is ESWT.

Comparators

Comparators of interest include conservative therapy (e.g., physical therapy) and nonsteroidal anti-inflammatory therapy.

Outcomes

The general outcomes of interest are symptoms, functional outcomes, quality of life, medication use, and treatment-related morbidity (Table 11).

Table 11. Outcomes of Interest for Individuals with Lateral Epicondylitis

Outcomes	Details	Timing
Symptoms	• Pain improvement via VAS assessment • Thomsen Provocation Test score for pain • Roles and Maudsley pain scores of "good or excellent"	Generally measured for up to 12 weeks
Functional outcomes	• Change in UEFS • Roles and Maudsley function scores of "good" or "excellent" • Grip strength improvement	Generally measured for up to 12 weeks
Medication use	• Nonuse of pain medication	Generally measured for up to 12 weeks

UEFS: Upper Extremity Function Scale; VAS: visual analog scale.

Study Selection Criteria

Methodologically credible studies were selected using the following principles:

- To assess efficacy outcomes, comparative controlled prospective trials were sought, with a preference for RCTs;
- In the absence of such trials, comparative observational studies were sought, with a preference for prospective studies;
- To assess longer term outcomes and adverse events, single-arm studies that capture longer periods of follow-up and/or larger populations were sought;
- Studies with duplicative or overlapping populations were excluded.

Review of Evidence

Systematic Reviews

A Cochrane review by Buchbinder et al (2005) concluded, "there is 'Platinum' level evidence [the strongest level of evidence] that shock wave therapy provides little or no benefit regarding pain and function in lateral elbow pain."[31] A systematic review by Dingemanse et al (2014), which evaluated electrophysical therapies for epicondylitis, found conflicting evidence on the short-term benefits of ESWT.[32] No evidence demonstrated any long-term benefits with ESWT over placebo for epicondylitis treatment. A meta-analysis by Zheng et al (2020) of 9 studies concluded that ESWT does not reduce the mean overall pain compared with placebo in lateral epicondylitis of the humerus.[33] A systematic review and meta-analysis by Yoon et al (2020) of 12 studies revealed that ESWT lacks clinically important pain reduction or improvement in grip strength compared with sham stimulation or no additional treatment in patients with lateral epicondylitis.[34] A meta-analysis by Karanasios et al (2021) of 27 randomized trials (N=1871) found that ESWT (alone or as an additive intervention) compared with sham or other control treatment in patients with lateral elbow tendinopathy did not provide clinically meaningful improvement in pain intensity, elbow disability, or grip strength.[35] A systematic review and network meta-analysis by Liu et al (2022) of 40 RCTs found that ESWT was the optimal intervention for improving short-term and medium-term grip strength compared to several injection therapies.[36]

Some systematic reviews revealed a potential benefit of ESWT in patients with lateral epicondylitis when comparing with other treatment methods outside conservative and nonsteroidal anti-inflammatory therapy. A systematic review and meta-analysis by Yao et al (2020) of 13 studies revealed improved VAS scores (p=.0004) and grip strength (p<.00001) with ESWT compared with other methods including placebo, autologous blood injection, corticosteroid injection, physiotherapy, wrist-extensor splints, laser, and/or kinesiotaping.[37] A meta-analysis by Yan et al (2019) of 5 studies demonstrated improvement in VAS scores (p<.0001), grip strength (p<.00001), and subjective scores of elbow function (p=.0008) with ESWT compared with ultrasonics.[38] A meta-analysis by Xiong et al (2019) of 4 studies revealed improved VAS scores (p<.00001) and grip strength (p<.00001) with shock wave therapy compared with corticosteroid injections.[39] A systematic review and meta-analysis by Zhang et al (2024) of 6 studies reported improved VAS scores at 3 and 6 months (p<.00001), grip strength at 3 (p<.0005) and 6 (p<.005) months, and patient-rated tennis elbow evaluation (PRTEE) at 3 months (p<.00001) with shock wave therapy compared with corticosteroid injections.[40] In the short-term (1 month) the study revealed that corticosteroid injections improved VAS scores (p<.00001), grip strength (p<.00001), and PRTEE (p<.0001). Majidi et al (2024) performed a systematic review and meta-analysis of the use of ESWT to reduce pain in patients with various tendinopathies, including lateral epicondylitis (LE) comprising of 22 studies, and demonstrated that ESWT reduced the VAS score on average by 0.63 units (SMD: -0.63, 95% CI: -1.11 to -0.16; I2: 67.50%; P heterogeneity:.003).[14] It was noted that these studies were at high-risk of publication bias.

Randomized Controlled Trials

Multiple RCTs without a sham and using comparators other than conservative management or nonsteroidal anti-inflammatory therapy have been published and are summarized below.

Bilir et al (2024) evaluated and compared the short-term efficacies of high-intensity laser therapy (HILT) and focused extracorporeal shockwave therapy (FSWT) on pain, grip strength, and function in 47 patients with lateral epicondylitis.[41] A visual analog scale (VAS), quick Disabilities of the Arm, Shoulder, and Hand (QDASH), and hand grip strength test were used to evaluate the patients at baseline, 1-, and 6-weeks after treatment. There were significant improvements in VAS scores, QDASH scores, and grip strength for both treatment options at week 1 and 6 (p<.05) but no significant differences were observed between the 2 treatment options.

Perveen et al (2024) compared deep friction massage and ultrasonic therapy with extracorporeal shockwave therapy (ESWT) in 80 patients with lateral epicondylitis in a double-blind parallel-arm RCT.[42] Outcome measures were collected using the numeric pain rating score and patient-rated tennis elbow evaluation (PRTEE) questionnaire at baseline, 3-, and 7-weeks. PRTEE scores were significantly reduced for both treatments at 3- and 7-weeks (p<.001), however, when compared between treatments, ESWT demonstrated to be more effective than deep friction massage and ultrasonic therapy.

Król et al (2024) published results from a RCT comparing focused extracorporeal shock wave therapy (FSWT), ultrasound therapy, and sham-ultrasound in 60 patients with lateral epicondylitis (LE).[43] A numeric rating scale was used to measure pain, patient-rated tennis elbow evaluation (PRTEE) questionnaire was used to assess the disability of the affected limb, and a dynamometer was used to measure grip strength as well as other functionality attributes at baseline, 1-, 3-, 6-, and 12-weeks. A gradual reduction in pain was seen at each follow-up for FSWT with a significant reduction at weeks 6 and 12 (p≤.05), however, this significant reduction was reported for both ultrasound therapy and ultrasound sham therapy at 6- and 12-weeks (p≤.05). Furthermore, FSWT and ultrasound therapy had significant improvement in both grip strength and PRTEE scores at 6- and 12-weeks (p≤.05). FSWT demonstrated better pain reduction and function compared to ultrasound therapy but had comparable effects on grip strength. This RCT is not included in the summary tables because the comparator is ultrasound as opposed to conservative or nonsteroidal anti-inflammatory therapy. All 3 groups received deep friction massage prior to receiving their respective treatments.

Çetin et al (2024) conducted a prospective study that randomized 52 patients with lateral epicondylitis (LE) to local massage, corticosteroid injection, or extracorporeal shock wave therapy (ESWT) to evaluate these treatments regarding VAS scores, Disabilities of the Arm Shoulder, and Hand (DASH) scores, and DASH-Work Model scores.[44] Outcomes were measured at baseline, 2-weeks, 3-, and 6-months. ESWT demonstrated statistically significant improvement for each outcome throughout the follow-up periods when compared to baseline measurements and was considered superior to local massage and corticosteroid injection (p<.001).

Relevant RCTs with sham groups are summarized in Tables 12 through 15.

Kaplan et al (2023) reported on an investigator-blinded trial that randomized 87 patients with lateral epicondylitis to FSW, RSW, or sham treatment.[45] Both ESWT groups experienced significant reductions in Patient-Rated Tennis Elbow Evaluation (PRTEE) scores from baseline to weeks 5 and 13 (p<.001); the sham group did not demonstrate statistically significant differences from baseline to week 5 or 13 (p>.05). The difference between sham and both focused and RSW groups was significant for all PRTEE score changes (pain, function, and total) (p<.001). Additionally, FSW was superior to RSW for changes in PRTEE pain, function, and total scores from baseline to weeks 5 and 13.

Aldajah et al (2022) compared ESWT (n=20) with conventional physiotherapy (n=20) in patients with lateral epicondylitis.[46] All patients received 5 sessions during the treatment program. Outcome measures included changes in VAS for pain intensity, the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire for upper extremity function, and dynamometer for maximal grip strength. Patients in both groups improved significantly after treatment in terms of VAS, DASH scores, and maximal grip strength from baseline. However, patients in the ESWT arm performed better than those in the physiotherapy arm for all outcomes. This RCT is not included in the summary table because it compares ESWT with a physiotherapy program that includes ultrasound therapy.

Guler et al (2020) compared ESWT (n=20) with kinesiotaping (n=20) as part of a 3-week treatment in patients with newly diagnosed lateral epicondylitis.[47] Outcomes included VAS pain, grip strength, and functional assessment as measured by Roles and Maudsley score. At 8 week follow-up, kinesiotaping revealed a lower VAS score (2.52 vs. 4.0; p=.01), a better hand grip strength score (26.8 vs. 20.6; p=.005), and a lower Roles and Maudsley score (1.7 vs. 2.2; p=.02) compared with ESWT. This RCT is not included in the summary table because it compares ESWT to kinesiotaping as opposed to conservative or nonsteroidal anti-inflammatory therapy.

Yang et al (2017) published results from an RCT (N=30) comparing RSW plus physical therapy with physical therapy alone in patients with lateral epicondylitis.[48] Outcomes included VAS pain and grip strength. Significant differences were seen in grip strength by 12 weeks of follow-up; the MD in grip strength between groups was 7.7 (95% CI, 1.3 to 14.2), favoring RSW. Significant differences in VAS pain (10-point scale) were not detected until 24 weeks of follow-up; the MD between groups was -1.8 (95% CI, -3.0 to -0.5), favoring RSW. This RCT is not included in the summary table because it compares RSW with a physical therapy program that includes ultrasound therapy.

A small RCT by Capan et al (2016) comparing RSW (n=28) with sham RSW (n=28) for lateral epicondylitis did not find significant differences between groups in grip strength or function.[49] However, this trial might have been underpowered to detect a difference.

Lizis (2015) compared ESWT with therapeutic ultrasound among 50 patients who had chronic tennis elbow.[50] For most pain measures assessed, the pain was lower in the ESWT group immediately posttreatment and at 3 months, except pain on gripping, which was higher in the ESWT group. While trial results favored ESWT, it had a high risk of bias, in particular, due to lack of blinding of participants and outcome assessors, which make interpretation of results difficult. This RCT is not included in the summary tables because the comparator is ultrasound as opposed to conservative or nonsteroidal anti-inflammatory therapy.

Gunduz et al (2012) compared ESWT with 2 active comparators.[51] This trial randomized 59 patients with lateral epicondylitis to ESWT, physical therapy, or a single corticosteroid injection. Outcome measures were VAS pain, grip strength, and pinch strength by dynamometer. The authors reported that VAS pain scores improved significantly in all 3 groups at all 3 follow-up time points out to 6 months, but they reported no between-group differences. No consistent changes were reported for grip strength or on ultrasonography. This RCT is not included in the summary table because it compares ESWT with corticosteroid injections, and the physical therapy comparator includes ultrasound therapy.

Staples et al (2008) reported on a double-blind controlled trial of ESWT for epicondylitis in 68 patients.[52] Patients were randomized to 3 ESWT treatments or 3 treatments at a subtherapeutic dose at weekly intervals. There were significant improvements in most of the 7 outcome measures for both groups over 6 months of follow-up but no between-group differences. The authors found little evidence to support the use of ESWT for this indication.

Pettrone and McCall (2005) reported on results from a multicenter, double-blind, randomized trial of 114 patients receiving ESWT in a "focused" manner (2000 impulses at 0.06 mJ/mm[53] without local anesthesia) weekly for 3 weeks or placebo.[54] Patients were followed for 12 weeks, and benefit demonstrated with the following outcomes: VAS pain (0 to 10 points) declined at 12 weeks in the treatment group from 7.4 to 3.8; among placebo patients, from 7.6 to 5.1. A reduction in pain on the Thomsen Provocation Test of at least 50% was demonstrated in 61% of those treated compared with 29% in the placebo group. Mean improvement on a 10-point Upper Extremity Function Scale activity score was 2.4 for ESWT-treated patients compared with 1.4 in the placebo group, a difference at 12 weeks of 0.9 (95% CI, 0.18 to 1.6). Although this trial found a benefit of ESWT for lateral epicondylitis over 12 weeks, the placebo group also improved significantly; whether the natural history of disease was altered with ESWT is unclear.

Table 12. Summary of Key Characteristics of Randomized Controlled Trials Assessing Extracorporeal Shock Wave Therapy for Lateral Epicondylitis

Study; Trial	Countries	Sites	Dates	Participants	Interventions	
					Active	*Comparator*
Kaplan (2023)[45]	Turkey	1	2019-2020	Patients with newly diagnosed (<3 months) LE	RSW: 4 Hz, 1.2 Bar, 500 pulse, 0.144 mJ/mm^2 for 2	Sham ESWT (1 Hz, 1 Bar, 500 pulse for 2 minutes and 5

Study; Trial	Countries	Sites	Dates	Participants	Interventions	
					minutes and 5 seconds + 8 Hz, 1.5 Bar, 1800 pulse, 0.180 mJ/mm^2 for 3 minutes and 45 seconds (n=29) FSW: 4Hz, 1.5 Bar, 500 pulses, 0.02-0.60 mj/mm^2 for 2 minutes and 5 seconds + 8Hz, 1.7 Bar, 1800 pulses, 0.02-0.60 mj/mm^2 for 3 minutes and 45 seconds (n=30)	seconds + 1 Hz, 1 Bar, 1800 pulse for 3 minutes and 45 seconds (n=28)
Capan (2016)[49]	Turkey	1	-	Patients with unilateral LE for >3 months unresponsive to other treatments; (N =56)	RSW with 2000 pulses; 10 Hz frequency; 1.8 bar of air pressure; 3 weekly sessions; (n=28)	3 sham treatments of RSW; same dosage and schedule as active but with no contact between applicator head and skin; (n=28)
Staples (2008)[52]	Australia	1	1998–2001	Adults with lateral elbow pain for ≥6 weeks; normal anteroposterior and lateral elbow radiographs; reproducibility of pain by ≥2 pain tests; (N =68)	ESWT with 2000 pulses; energy level= maximum tolerated by patient; 240 pulses per minute; 3 weekly sessions; (n=36)	ESWT with 100 pulses; maximum energy ≤0.03 mJ/mm^2; 90 pulses per minute; 3 weekly sessions; (n=32)
Pettrone & McCall (2005)[54]	US	3	-	Patients with LE ≥6 months; pain resistant ≥2 of 3 conventional therapies; pain ≥40 mm on VAS with resisted wrist extension; (N =114)	ESWT with 2000 pulses; 0.06 mJ/mm^2; 3 weekly sessions; (n=56)	3 sham treatments of ESWT with same settings as active but with sound-reflecting pad between patient and machine application head; (n=58)

ESWT: extracorporeal shockwave therapy; FSW: focused extracorporeal shockwave therapy; LE: lateral epicondylitis; RSW: radial extracorporeal shockwave therapy; VAS: visual analog scale.

Table 13. Summary of Key Results of Randomized Controlled Trials Assessing Extracorporeal Shock Wave Therapy for Lateral Epicondylitis

Study	Pain Improvement		Grip Strength[1]	
	≤6 wks	3 mos	≤6 wks	3 mos
Kaplan (2023)[45]				
FSW mean change from baseline PRTEE score	18.8±13.9	17.8±13.1	-	-
RSW mean change from baseline PRTEE score	11.8±9.1	11.7±10.5	-	-
Sham mean change from baseline PRTEE score	1.3±7.1	1.0±6.5	-	-

Study	Pain Improvement		Grip Strength[1]	
p-value (FSW and RSW vs. sham)	<.001	<.001	-	-
Capan (2016)[49]				
RSW (SD)	3.4 (2.9)[2]	2.1 (2.2)[2]	15.96 (9.61)	17.30 (10.33)
RSW MD from baseline (SD)	-1.9 (2.2)[2]	-3.2 (2.3)[2]	5.35 (6.82)	1.35 (3.87)
% difference	-36.7[2]	-59.1[2]	76.3	17.8
p-value	<.001	<.001	.002	.074
Control (SD)	3.5 (2.9)[2]	2.6 (2.8)[2]	10.14 (6.42)	12.18 (6.01)
Control MD from baseline (SD)	-2.2 (2.4)[2]	-3.1 (2.7)[2]	3.68 (4.56)	2.05 (3.46)
% difference	-39.6[2]	-54.8[2]	110.0	57.0
p-value	.001	<.001	.001	.017
% difference between groups	0.758	0.882	0.578	0.768
Staples (2008)[52]				
	-	-	-	-
ESWT mean (SE) change	27.7 (5.7)[4]	26.1 (6.5)[4]	0.17 (0.06)	0.35 (0.06)
Control mean (SE) change	26.0 (6.4)[4]	26.7 (6.0)[4]	0.22 (0.07)	0.31 (0.06)
Between-group difference	1.7[4]	-0.6[4]	-0.05	0.04
95% CI	-18.8 to 15.3[4]	-18.4 to 17.3[4]	-0.22 to 0.12	-0.13 to 0.20
p-value	.84	.95	.57	-
Pettrone & McCall (2005)[54]				
ESWT mean (SD)	-	37.6 (28.7)[4]	-	38.2
Change %	-	49[4]	-	23
Control mean (SD)	-	51.3 (29.7)[4]	-	37.4
Change %	-	32[4]	-	12
p-value	-	.02	-	.09
ESWT % pts w/pain reduction	-	61[5]	-	-
Placebo % pts w/pain reduction	-	29[5]	-	-
p-value	-	.0001	-	

CI: confidence interval; ESWT: extracorporeal shockwave therapy; FSW: focused extracorporeal shockwave therapy; MD: mean difference; PRTEE: Patient-Rated Tennis Elbow Evaluation; pts: patients; RSW: radial extracorporeal shockwave therapy; SD: standard deviation; SE: standard error of the mean; VAS: visual analog scale.

[1]Grip strength in kilograms measured with a squeeze dynamometer.

[2] Pain assessed using at-rest VAS (range, 0-10).

[3] Patient-Related Tennis Elbow Evaluation function scores.

[4] VAS pain index (range, 0-100).

[5]Pain reduction of ≥50% on Thomsen test.

[6]Functional improvement assessed using Upper Extremity Functional Scale

[7]Disabilities of the Arm, Shoulder, and Hand questionnaire function scores.

Tables 14 and 15 display notable limitations identified in each study.

Table 14. Study Relevance Limitations of Randomized Controlled Trials Assessing Extracorporeal Shock Wave Therapy for Lateral Epicondylitis

Study	Population[a]	Intervention[b]	Comparator[c]	Outcomes[d]	Follow-Up[e]
Kaplan (2023)[45]				3. CONSORT flow diagram included, but no reporting of harms	
Capan (2016)[49]				3. CONSORT flow diagram included, but no reporting of harms	
Staples (2008)[52]					
Pettrone & McCall (2005)[54]					

The study limitations stated in this table are those notable in the current review; this is not a comprehensive gaps assessment.

[a] Population key: 1. Intended use population unclear; 2. Clinical context is unclear; 3. Study population is unclear; 4. Study population not representative of intended use.

[b] Intervention key: 1. Not clearly defined; 2. Version used unclear; 3. Delivery not similar intensity as comparator;

4. Not the intervention of interest.
c Comparator key: 1. Not clearly defined; 2. Not standard or optimal; 3. Delivery not similar intensity as intervention; 4. Not delivered effectively.
d Outcomes key: 1. Key health outcomes not addressed; 2. Physiologic measures, not validated surrogates; 3. No CONSORT reporting of harms; 4. Not establish and validated measurements; 5. Clinical significant difference not prespecified; 6. Clinical significant difference not supported.
e Follow-Up key: 1. Not sufficient duration for benefit; 2. Not sufficient duration for harms.

Table 15. Study Design and Conduct Limitations of Randomized Controlled Trials Assessing Extracorporeal Shock Wave Therapy for Lateral Epicondylitis

Study	Allocation[a]	Blinding[b]	Selective Reporting[c]	Data Completeness[d]	Power[e]	Statistical[f]
Kaplan (2023)[45]		2. Not blinded outcome assessment	1. Not registered			
Capan (2016)[49]			1. Not registered	6. No intent-to-treat analysis	1. Calculations not reported	
Staples (2008)[52]			1. Not registered		3. Underpowered	
Pettrone & McCall (2005)[54]	3. Unclear how randomized		1. Not registered			

The study limitations stated in this table are those notable in the current review; this is not a comprehensive gaps assessment.
a Allocation key: 1. Participants not randomly allocated; 2. Allocation not concealed; 3. Allocation concealment unclear; 4. Inadequate control for selection bias.
b Blinding key: 1. Not blinded to treatment assignment; 2. Not blinded outcome assessment; 3. Outcome assessed by treating physician.
c Selective Reporting key: 1. Not registered; 2. Evidence of selective reporting; 3. Evidence of selective publication.
d Data Completeness key: 1. High loss to follow-up or missing data; 2. Inadequate handling of missing data; 3. High number of crossovers; 4. Inadequate handling of crossovers; 5. Inappropriate exclusions; 6. Not intent to treat analysis (per protocol for noninferiority trials).
e Power key: 1. Power calculations not reported; 2. Power not calculated for primary outcome; 3. Power not based on clinically important difference.
f Statistical key: 1. Intervention is not appropriate for outcome type: (a) continuous; (b) binary; (c) time to event; 2. Intervention is not appropriate for multiple observations per patient; 3. Confidence intervals and/or p values not reported; 4.Comparative treatment effects not calculated.

Section Summary: Lateral Epicondylitis

The most direct evidence on the use of ESWT to treat lateral epicondylitis comes from multiple small RCTs, which did not consistently show outcome improvements beyond those seen in control groups. The highest quality trials tend to show no benefit, and systematic reviews have generally concluded that the evidence does not support a treatment benefit over placebo or no treatment.

Shoulder Tendinopathy

Clinical Context and Therapy Purpose

The purpose of ESWT is to provide a treatment option that is an alternative to or an improvement on existing therapies, such as conservative therapy (e.g., physical therapy) and nonsteroidal anti-inflammatory therapy, in individuals with shoulder tendinopathy.

The following PICO was used to select literature to inform this review.

Populations

The relevant population of interest is individuals with shoulder tendinopathy.

Interventions

The therapy being considered is ESWT.

Comparators
Comparators of interest include conservative therapy (e.g., physical therapy) and nonsteroidal anti-inflammatory therapy.

Outcomes
The general outcomes of interest are symptoms, functional outcomes, quality of life, medication use, and treatment-related morbidity.

Table 16. Outcomes of Interest for Individuals with Shoulder Tendinopathy

Outcomes	Details	Timing
Symptoms	• Pain reduction via VAS assessment • ASES scale for pain • L'Insalata Shoulder Questionnaire for pain • Reduction in size of deposit as assessed by radiograph or ultrasound[1]	1 week to 1 year
Functional outcomes	• CMS • SPADI • ASES scale for function • Simple Shoulder Test	1 week to 1 year
Quality of life	• Patients' subjective assessment of improvement	1 week to 1 year

ASES: American Shoulder and Elbow Surgeons; CMS: Constant-Murley Score; SPADI: Shoulder Pain And Disability Index; VAS: visual analog scale.
[1] For studies that assessed calcific tendinitis.

Study Selection Criteria
Methodologically credible studies were selected using the following principles:
- To assess efficacy outcomes, comparative controlled prospective trials were sought, with a preference for RCTs;
- In the absence of such trials, comparative observational studies were sought, with a preference for prospective studies;
- To assess longer term outcomes and adverse events, single-arm studies that capture longer periods of follow-up and/or larger populations were sought;
- Studies with duplicative or overlapping populations were excluded.

Review of Evidence
Systematic Reviews
A list of the systematic reviews and their associated studies are presented below in Table 18 with their key characteristics presented in Table 19 and key results in Table 20.

A systematic review and meta-analysis of RCTs by Xue et al (2024) compared ESWT to placebo ESWT on pain intensity and shoulder function in patients with rotator cuff tendinopathy.[55] A literature search through February 2024 identified 17 RCTs (N=1131). Outcomes were pain (VAS), functional assessment (Constant-Murley Score [CMS], University of California Los Angeles score [UCLA], American Shoulder and Elbow Surgeons form [ASES]), angle of motion of the shoulder joint (range of motion [ROM]), and effectiveness of treatment (total effective rate [TER]). When compared to placebo, ESWT demonstrated pain reduction and increased functionality in patients with rotator cuff tendinopathy with improvement in VAS and CMS scores. (Table 20). ESWT recipients reported statistically significant results for UCLA (standardized mean difference [SMD]=2.69, 95% CI 1.64 to 3.74, p<.00001) and ASES (SMD=1.29, 95% CI 0.93 to 1.65, p<.00001) scores indicating improved shoulder functionality. ROM for external rotation was statistically different after ESWT (SMD=1.00, 95% CI 0.29 to 1.72, P=.02) but abduction of the shoulder was not (SMD=0.72, 95% CI -0.22 to 1.66, p=.13). Overall, the TER (OR=3.47, 95% CI: 1.84 to 6.56, p=.0001) indicated that ESWT was an effective intervention for rotator cuff tendinopathy. Despite significant improvement in pain management and shoulder functionality, there are limitations to this review, including but not limited to, heterogeneity in brand and intensity of ESWT used, inappropriate random allocation and concealment methods in some studies.

A systematic review and meta-analysis of RCTs by Kamonseki et al (2023) compared ESWT to sham treatment or other active treatments on pain intensity and shoulder function in patients with non-calcific rotator cuff tendinopathy.[56] A literature search through June 2023 identified 9 RCTs (N=543). The Constant-Murley Score (CMS) was used to assess pain intensity and shoulder function. In the short-term (≤3 months), ESWT was superior to sham treatment for reduction in pain intensity (5 studies; MD, -0.28; 95% CI, -0.55 to -0.01). In the intermediate- (≥3 to 12 months [2 studies]) and long-term (≥12 months [1 study]), the difference between ESWT and sham treatment did not reach statistical significance for reduction in pain intensity. For the function outcomes, the difference between ESWT and sham treatment did not reach statistical significance at ≤3 months (5 studies), ≥3 to 12 months (2 studies), or ≥12 months (1 study). Comparisons between ESWT and other active therapies were limited to analyses of single trials comparing ESWT to exercise, steroid injections, and hyaluronic acid injections; there were no statistically significant differences in the short- or intermediate-term.

A systematic review and meta-analysis of RCTs by Angileri et al (2023) compared the efficacy of nonoperative and operative treatments for chronic calcific tendonitis.[57] A literature review through February 2022 identified 27 RCTs (N=2352). Outcomes were pain (VAS; minimal clinically important difference, 2.4), functional assessment (CMS; minimal clinically important difference, 10.4), and calcific deposit resolution. The pooled MD in VAS was -3.83 for ESWT versus -4.83 for ultrasound-guided needling and -4.65 for operative interventions. The pooled MD in CMS score was 18.30 for ESWT versus 22.01 for ultrasound-guided needling and 38.35 for operative interventions. Complete resolution of calcific deposits occurred in a mean of 27.3% of patients who received ESWT, 66.7% of patients who received ultrasound-guided needling, and 85% for individuals who had surgery. The authors concluded that surgical treatment was more effective than nonoperative interventions, but that all modalities are likely to lead to clinically significant improvements.

A systematic review and network meta-analysis of RCTs by Wu et al (2017) compared the effectiveness of nonoperative treatments for chronic calcific tendinitis.[58] The literature review, conducted through April 2016, identified 14 RCTs (N=1105) for inclusion. Treatments included in the network meta-analysis were ultrasound-guided needling (UGN), RSW, H-FSW , L-FSW , ultrasound therapy, and transcutaneous electrical nerve stimulation. Trials either compared the treatments with each other or with sham/placebo. Outcomes were pain (VAS range, 0 [no pain] to 10 [worst pain]), functional assessment (CMS, up to 100 [asymptomatic]), and calcific deposit change ("no change," "partial resolution," or "complete resolution," assessed by radiograph or ultrasound). Treatments most effective in reducing pain and resolving calcific deposits were UGN, RSW, and H-FSW. The only treatment significantly improving function was H-FSW. Table 17 lists the treatments, from most effective to the least effective, by outcome, as determined by network meta-analysis.

Table 17. Ranking of Nonoperative Treatments for Chronic Calcific Tendinitis, by Outcome

Pain Reduction (8 Trials)		Functional Assessment (7 Trials)		Calcific Deposit Change (14 Trials)	
Treatment	Difference From Control (95% CrI)	Treatment	Difference From Control (95% CrI)	Treatment	Difference From Control (95% CrI)
UGN	8.0 (4.9 to 11.1)	H-FSW	25.1 (10.3 to 40.0)	UGN	6.8 (3.8 to 9.9)
RSW	6.1 (3.9 to 8.3)	TENS	8.7 (-13.5 to 30.9)	RSW	6.2 (3.2 to 9.1)
H-FSW	4.2 (2.0 to 6.4)	L-FSW	7.6 (-7.2 to 22.5)	H-FSW	2.4 (1.5 to 3.4)
TENS	3.2 (-0.1 to 6.5)	Ultrasound	3.3 (-15.0 to 21.6)	Ultrasound	2.1 (0.4 to 3.8)
L-FSW	1.9 (-0.4 to 4.3)			TENS	1.9 (-0.8 to 4.6)
Ultrasound	1.1 (-1.7 to 3.9)			L-FSW	1.2 (0.1 to 2.2)

Adapted from Wu et al (2017).[58]
CrI: credible interval; H-FSW: high-energy focused extracorporeal shockwave; L-FSW: low-energy focused extracorporeal shockwave; RSW: radial extracorporeal shockwave; TENS: transcutaneous electrical nerve stimulation; UGN: ultrasound-guided needling.

A systematic review and network meta-analysis of RCTs by Arirachakaran et al (2017) evaluated ESWT, ultrasound-guided percutaneous lavage (UGPL), subacromial corticosteroid injection (SAI), and combined treatments for rotator cuff calcific tendinopathy.[59] The literature search, conducted through September 2015, identified 7 RCTs for inclusion. Six of the trials had ESWT as 1 treatment arm, with the following comparators: placebo (4 trials), UGPL plus ESWT (1 trial), and UGPL plus SAI (1 trial). One trial compared UGPL plus SAI with SAI alone. Outcomes were CMS (5 trials), VAS pain (5 trials), and size of calcium deposit (4 trials). Network meta-analysis results are summarized below:

- VAS pain:
  - ESWT, UGPL plus SAI, and SAI alone were more effective in reducing pain than placebo
  - Compared with each other, ESWT, UGPL plus SAI, and SAI alone did not differ statistically
- CMS:
  - ESWT was statistically more effective than placebo
  - No other treatment comparisons differed statistically
- Size of calcium deposit:
  - UGPL plus SAI was statistically more effective than placebo and SAI alone
  - ESWT was statistically better than SAI alone, but not more effective than placebo.

In a systematic review and meta-analysis, Loppolo et al (2013) identified 6 RCTs that compared ESWT with sham treatment or placebo for calcific shoulder tendinopathy.[60] Greater shoulder function and pain improvements were reported at 6 months with ESWT than placebo. Most studies were considered low quality.

Table 18. Comparison of Systematic Reviews with Meta-Analyses Assessing Extracorporeal Shock Wave Therapy for Shoulder Tendinopathy

Study	Arirachakaran (2017)[59]	Ioppolo (2013)[60]	Wu (2017)[58]	Angileri (2023)[57]	Kamonseki (2023)[56]	Xue (2024)[55]
Ainsworth (2007)	●					
Albert (2007)			●	●		
Battaglia (2017)				●		
Cacchio (2006)	●	●	●	●		●
Clement (2015)				●		
Cosentino (2003)	●	●	●	●		
Cosentino (2004)			●			
del Castillo-Gonzalez (2016)			●	●		
de Witte (2013)	●			●		
de Witte (2017)				●		
Ebenbichler (1999)			●			
Efe (2014)					●	
Frassanito (2018)				●		
Frizziero (2017)					●	
Galasso (2012)					●	●
Gerdesmeyer (2003)	●	●	●			
Hearnden (2009)		●	●			
Hsu (2008)	●	●	●			
Ioppolo (2012)			●	●		
Kim (2014)	●		●	●		
Kolk (2013)					●	
Krasny (2005)	●			●		
Kvalva (2017)					●	

Study	Arirachakaran (2017)[59]	Ioppolo (2013)[60]	Wu (2017)[58]	Angileri (2023)[57]	Kamonseki (2023)[56]	Xue (2024)[55]
Lee (2022)					●	
Li (2017)					●	
Loew (1999)			●			
Louwerens (2020)				●		
Orlandi (2017)				●		
Pan (2003)			●	●		
Papadopoulos (2019)				●		
Perlick (2003)				●		
Perron (1997)				●		
Peters (2004)		●				
Pieber (2018)				●		
Pleiner (2004)			●	●		
Rompe (1998)			●			
Rubenthalier (2003)				●		
Sabeti-Aschraf (2005)				●		
Sabeti (2014)				●		
Sconfienza (2012)				●		
Schmitt (2021)					●	
Speed (2022)					●	
Tornese (2011)				●		
Zhu (2008)				●		

Table 19. Characteristics of Systematic Reviews with Meta-Analyses Assessing Extracorporeal Shock Wave Therapy for Shoulder Tendinopathy

Study	Dates	Trials	Participants	N (Range)	Design	Duration
Xue (2024)[55]	2006 to 2023	17	Adults with rotator cuff tendinopathy	1131 (20 to 160)	RCTs	3 weeks to 8 weeks
Kamonseki (2023)[56]	Through June 2023	9	Patients with non-calcific rotator cuff tendinopathy	543 (20 to 143)	RCTs	≤3 months to ≥12 months
Angileri (2023)[57]	1997- 2020	27	Patients with chronic calcific tendinitis	2352 (20 to 462)	RCTs	0.75 to 120 months
Arirachakaran (2017)[59]	2003–2008	4	Patients with rotator cuff calcific tendinopathy	882 (136 to 302)	RCTs	6 to 12 months
Ioppolo (2013)[60]	2003–2009	6	Adults with shoulder pain or tenderness from calcific tendinitis with type I or II calcification	460 (20 to 144)	RCTs	1 week to 1 year
Wu (2017)[58]	1998–2016	5	Adults with clinical symptoms related to calcific tendinitis of the shoulder	370 (20 to 144)	RCTs	1 month to 1 year

RCT: randomized controlled trial.

Table 20. Results of Systematic Reviews with Meta-Analyses Assessing Different Forms of Extracorporeal Shock Wave Therapy for Shoulder Tendinopathy

Study	VAS/NRS/CMS Score Improvement/Pain Reduction	CMS/SPADI/Functional Improvement	Decrease in Calcium Deposit Size
ESWT			
Xue (2024)[55]			
I^2 %	91	91	-
SMD	-1.94	1.30	-
95% CI	-2.47 to -1.41	0.67 to 1.92	-
p-value	<.00001	<.0001	-
Kamonseki (2023)[56]			

Study	VAS/NRS/CMS Score Improvement/Pain Reduction	CMS/SPADI/Functional Improvement	Decrease in Calcium Deposit Size
MD from pretreatment (≤3 months) (95% CI vs. sham treatment); p-value	-0.28 (-0.55 to -0.01); p=.04	-0.15 (-0.48 to 0.18); p=.36	-
MD from pretreatment (≥3 to 12 months) (95% CI vs. sham treatment)	-0.25 (-0.57 to 0.07); p=.13	-0.15 (-0.59 to 0.30); p=.51	-
MD from pretreatment (≥12 months) (95% CI vs. sham treatment)	0.18 (-0.55 to 0.91); p=.63	-0.21 (-0.94 to 0.52); p=.57	-
Angileri (2023)[57]			
I^2 %	94	82	-
MD from pretreatment	-3.83	18.30	-
95% CI	-5.38 to -2.27	10.95 to 25.66	-
p-value	<.00001	<.00001	-
Arirachakaran (2017)[59]			
I^2 %	95.8	92.4	97.4
UMD	-4.4	23.3	-11.3 mm
95% CI	-6.3 to -2.3	9.8 to 17.6	-24.7 to 2.2
p-value	<.05	<.05	>.05
Ioppolo (2013)[60]			
Pooled total resorption ratio	-	-	27.19
95% CI	-	-	7.20 to 102.67
p-value			.552
Pooled partial resorption ratio	-	-	16.22
95% CI	-	-	3.33 to 79.01
p-value			.845
H-FSW			
Wu (2017)[58]			
WMD	4.18	-	-
95% CrI	1.99 to 6.37	-	-
L-FSW			
WMD	1.94	-	-
95% CrI	-0.42 to 4.30	-	-
RSW			
WMD	6.12	-	-
95% CrI	3.91 to 8.34	-	-

CI: confidence interval; CMS: Constant-Murley Score; CrI: credible interval; ESWT: extracorporeal shockwave therapy; H-FSW: high-energy focused extracorporeal shockwave therapy; L-FSW: low-energy focused extracorporeal shockwave therapy; MD: mean difference; NRS: numerical rating scale; RSW: radial extracorporeal shockwave therapy; SPADI: Shoulder Pain And Disability Index; UMD: unstandardized mean difference; VAS: visual analog scale; WMD: weighted mean difference.

The following systematic reviews are mostly qualitative in nature and are not included in the summary tables.

Brindisino et al (2024) conducted a systematic review with meta-analysis of 21 RCTs comparing the use of ESWT with other conservative, minimally invasive and sham interventions on their ability to reduce pain and disability, improve function, quality of life, and complete resorption rate of calcification in patients with rotator cuff calcific tendinopathy.[61] Ultrasound guided needling procedures proved to be statistically superior to ESWT in reducing pain at < 24- and 48-weeks. ESWT was clinically better at reducing pain and improving function at 24-weeks compared to sham ESWT, while high energy ESWT was more effective than low energy ESWT at reducing pain, improving function < 24-weeks, and resolving calcific deposits at 12-weeks. The authors concluded that the certainty of evidence was rated as very low due to heterogeneity of the studies, high-risk of bias, and incomplete or partial outcomes data.

Majidi et al (2024) performed a systematic review and meta-analysis of 45 studies on the use of ESWT to reduce pain in patients with various tendinopathies.[14] The review included 13 studies focused on the outcome for plantar fasciitis (PF), 3 studies evaluating outcomes of chronic Achilles tendinopathy (CAT), 22 studies examining outcomes of lateral epicondylitis (LE), 3 studies focused on outcomes for rotator cuff tendinopathy (RC), and 5 studies exploring outcomes in patellar tendinopathy (PT). The analysis of studies regarding mean pain scores in patients with RC incorporated findings from 3 studies with 15 different effect sizes and indicated that the mean pain score decreased by an average of 2.37 units when ESWT was used to treat the tendinopathy (SMD: -2.37, 95% CI: -3.58 to -1.15; I2: 98.46%; P heterogeneity:.0001). Publication bias was assessed using the Egger's test and demonstrated no evidence of bias.

In a systematic review by Yu et al (2015) of RCTs of various passive physical modalities for shoulder pain, which included 11 studies considered at low risk of bias, 5 studies reported on ESWT.[62] Three, published from 2003 to 2011, assessed calcific shoulder tendinopathy, including 1 RCT comparing high-energy ESWT with low-energy ESWT (N=80), 1 RCT comparing RSW with sham ESWT (N=90), and 1 RCT comparing high-energy ESWT with low-energy ESWT and sham ESWT (N=144). All 3 trials reported statistically significant differences between groups for change in VAS score for shoulder pain.

In another meta-analysis of RCTs comparing high-energy with low-energy ESWT, Verstraelen et al (2014) evaluated 5 studies (N=359 patients) on calcific shoulder tendinitis.[63,] Three were considered high quality. High-energy ESWT was associated with significant improvements in functional outcomes, with a MD at 3 months of 9.88 (95% CI, 0.04 to 10.72; p<.001). High-energy ESWT was more likely to lead to resolution of calcium deposits at 3 months (pooled odds ratio, 3.4; 95% CI, 1.35 to 8.58; p=.009). The pooled analysis could not be performed for 6-month follow-up data.

Bannuru et al (2014) published a systematic review of RCTs comparing high-energy ESWT with placebo or low-energy ESWT for the treatment of calcific or noncalcific shoulder tendinitis.[64] All 7 studies comparing ESWT with placebo for calcific tendinitis reported significant improvements in pain or functional outcomes associated with ESWT. Only high-energy ESWT was consistently associated with significant improvements in both pain and functional outcomes. Eight studies comparing high- with low-energy ESWT for calcific tendinitis did not demonstrate significant improvements in pain outcomes, although shoulder function improved. Trials were reported to be of low quality with a high risk of bias.

Huisstede et al (2011) published a systematic review of RCTs that included 17 RCTs on calcific (n=11) and noncalcific (n=6) tendinopathy of the rotator cuff.[65] Moderate-quality evidence was found for the efficacy of ESWT versus placebo for calcific tendinopathy, but not for noncalcific tendinopathy. High-frequency ESWT was found to be more efficacious than low-frequency ESWT for calcific tendinopathy.

Randomized Controlled Trials

ElGendy et al (2022) conducted a single-blind RCT in patients with shoulder impingement syndrome.[66] Patients were randomized to 4 weeks of conventional physical therapy plus local corticosteroid injection (n=20), physical therapy alone (n=20), or physical therapy plus ESWT (n=20). Outcomes were assessed at 4 and 12 weeks. There were no differences between groups at 4 weeks. At week 12, ESWT was numerically more effective than corticosteroid injection in improving shoulder internal rotation and abduction, Shoulder Pain and Disability Index, and distance of the subacromial space; statistical differences were not reported.

Lee et al (2022) conducted a small (n=26) RCT in patients with supraspinatus tendinitis that compared ESWT and ultrasound-guided steroid injection to the shoulder.[67] At 1 month, VAS (p=.015), American Shoulder and Elbow Society score (p=.005), and constant score (a measure of range of motion, muscular strength, subjective pain, patient satisfaction, and physical testing; p=.044) were better in the steroid injection group; however, at 3 months of follow-up outcomes were similar between treatments (all p>.05).

An RCT by Kvalvaag et al (2017) randomized patients with subacromial shoulder pain o RSW plus supervised exercise (n=74) or to sham treatment plus supervised exercise (n=69).[68,69] Patients received 4 treatments of RSW or sham at 1-week intervals. After 24 weeks of follow-up, both groups improved from baseline, with no significant differences between groups. Within a prespecified subgroup of patients with calcification in the rotator cuff, there was a statistically significant improvement in the group receiving ESWT compared with sham treatment (p=.18). After 1 year, there was no statistically significant difference in improvements between RSW and sham when groups were analyzed together and separately.

An RCT by Kim et al (2016) evaluated the use of ESWT in patients with calcific tendinitis.[70] All patients received nonsteroidal anti-inflammatory drugs, transcutaneous electrical nerve stimulation, and ultrasound therapy (N=34). A subset (n=18) also received ESWT, 3 times a week for 6 weeks. CMS was measured at 2-, 6-, and 12-weeks. Both groups improved significantly from baseline. The group receiving ESWT improved significantly more than the control group; however, the lack of a sham control limits interpretability of results.

The following are select trials included in the systematic reviews described above.

Kim et al (2014) compared UGPL plus SAI with ESWT in patients who had unilateral calcific shoulder tendinopathy and ultrasound-documented calcifications of the supraspinatus tendon.[71] Sixty-two patients were randomized. Fifty-four patients were included in the data analysis (8 subjects were lost to follow-up). ESWT was performed for 3 sessions once weekly. The radiologic evaluation was blinded, although it was not specified whether evaluators for pain and functional outcomes were blinded. After an average follow-up of 23.0 months (range, 12.1 to 28.5 months), functional outcomes improved in both groups: for the UGPL plus SAI group, scores on the American Shoulder and Elbow Surgeons scale improved from 41.5 to 91.1 (p=.001) and on the Simple Shoulder Test from 38.2% to 91.7% (p=.03). In the ESWT group, scores on the American Shoulder and Elbow Surgeons scale improved from 49.9 to 78.3 (p=.026) and on the Simple Shoulder Test from 34.0% to 78.6% (p=.017). Similarly, VAS pain scores improved from baseline to the last follow-up in both groups. At the last follow-up visit, calcium deposit size was smaller in the UGPL plus SAI group (0.5 mm) than in the ESWT group (5.6 mm; p=.001).

An example of a high-energy versus low-energy trial is that by Schofer et al (2009), which assessed 40 patients with rotator cuff tendinopathy.[72] An increase in function and reduction of pain were found in both groups (p<.001). Although improvement in the Constant score was greater in the high-energy group, there were no statistically significant differences in any outcomes studied (Constant score, pain, subjective improvement) at 12 weeks, or at 1 year posttreatment.

At least 1 RCT has evaluated patients with bicipital tendinitis of the shoulder.[73] This trial by Liu et al (2012) randomized 79 patients with tenosynovitis to ESWT or to sham treatment. ESWT was given for 4 sessions over 4 weeks. Outcomes were measured at up to 12 months using a VAS for pain and the L'Insalata Shoulder Questionnaire. The mean decrease in the VAS score at 12 months was greater for the ESWT group (4.24 units) than for the sham group (0.47 units; p<.001). There were similar improvements in the L'Insalata Shoulder Questionnaire, with scores in the ESWT group improving by 22.8 points.

Section Summary: Shoulder Tendinopathy

A number of small RCTs, summarized in several systematic reviews and meta-analyses, have evaluated the use of ESWT to treat shoulder tendinopathy. Network meta-analyses focused on 3 outcomes: pain reduction, functional assessment, and change in calcific deposits. One network meta-analysis separated trials using H-FSW, L-FSW, and RSW. It reported that the most effective treatment for pain reduction was UGN, followed by RSW and H-FSW. The only treatment showing a benefit in functional outcomes was H-FSW. For the largest change in calcific deposits, the most effective treatment was UGN, followed by RSW and H-FSW. Although some trials have reported a benefit for pain and functional outcomes, particularly for high-energy ESWT for calcific tendinopathy, many available trials have been considered poor quality. For non-calcific tendinopathy, 1 meta-analysis found that ESWT exhibited a small improvement in shoulder pain compared to sham ESWT at short-term follow-up (≤3 months). However, ESWT was not superior to sham ESWT in improving function at short- or long-term follow up (≥12 months), and ESWT was not superior to other treatments. More high-quality trials are needed to determine whether ESWT improves outcomes for shoulder tendinopathy.

Achilles Tendinopathy

Clinical Context and Therapy Purpose

The purpose of ESWT is to provide a treatment option that is an alternative to or an improvement on existing therapies, such as conservative therapy (e.g., physical therapy) and nonsteroidal anti-inflammatory therapy, in individuals with Achilles tendinopathy.

The following PICO was used to select literature to inform this review.

Populations

The relevant population of interest is individuals with Achilles tendinopathy.

Interventions

The therapy being considered is ESWT.

Comparators

Comparators of interest include conservative therapy (e.g., physical therapy) and nonsteroidal anti-inflammatory therapy.

Outcomes

The general outcomes of interest are symptoms, functional outcomes, quality of life, medication use, and treatment-related morbidity (Table 21).

Table 21. Outcomes of Interest for Individuals with Achilles Tendinopathy

Outcomes	Details	Timing
Symptoms	• Pain improvement via VAS assessment • VISA-Achilles (measures redness, warmth, swelling, tenderness, edema) • AOFAS for pain[1] • Roles and Maudsley pain scores of "good" or "excellent"	4 weeks to >1 year
Functional outcome	• AOFAS for function • Roles and Maudsley function scores of "good" or "excellent"	4 weeks to >1 year

AOFAS: American Orthopedic Foot and Ankle Score; VAS: visual analog scale; VISA: Victorian Institute of Sports Assessment.

[1] Researchers concluded that AOFAS might not be appropriate to evaluate treatment of Achilles tendinopathy.

Study Selection Criteria

Methodologically credible studies were selected using the following principles:

- To assess efficacy outcomes, comparative controlled prospective trials were sought, with a preference for RCTs;
- In the absence of such trials, comparative observational studies were sought, with a preference for prospective studies;

- To assess longer term outcomes and adverse events, single-arm studies that capture longer periods of follow-up and/or larger populations were sought;
- Studies with duplicative or overlapping populations were excluded.

Review of Evidence

Systematic Reviews

Majidi et al (2024) performed a systematic review and meta-analysis of 45 studies on the use of ESWT to reduce pain in patients with various tendinopathies.[14] The review included 13 studies focused on the outcome for plantar fasciitis (PF), 3 studies evaluating outcomes of chronic Achillies tendinopathy (CAT), 22 studies examining outcomes of lateral epicondylitis (LE), 3 studies focused on outcomes for rotator cuff tendinopathy (RC), and 5 studies exploring outcomes in patellar tendinopathy (PT). The analysis of studies regarding mean pain scores in patients with CAT incorporated findings from 2 studies with 6 different effect sizes and indicated that the mean pain score decreased by an average of 1.38 units when ESWT was used to treat the tendinopathy (standardized mean difference [SMD]: -1.38, 95% CI: -1.66 to -1.10; I2: 96.44%; P heterogeneity:.0001). Publication bias was assessed using the Egger's test and demonstrated no evidence of bias.

Mani-Babu et al (2015) reported on results of a systematic review of studies evaluating ESWT for lower-limb tendinopathies.[74] Reviewers included 20 studies, 11 of which evaluated ESWT for Achilles tendinopathy (5 RCTs, 4 cohort studies, 2 case-control studies). In the pooled analysis, reviewers reported that evidence was limited, but showed that ESWT was associated with greater short-term (<12 months) and long-term (>12 months) improvements in pain and function compared with nonoperative treatments, including rest, footwear modifications, anti-inflammatory medication, and gastrocnemius-soleus stretching and strengthening. Reviewers noted that findings from RCTs of ESWT for Achilles tendinopathy were contradictory, but that some evidence supported short-term improvements in function with ESWT. Reviewers warned that results be interpreted cautiously due to heterogeneity in patient populations (age, insertional versus mid-portion Achilles tendinopathy) and treatment protocols.

Al-Abbad and Simon (2013) conducted a systematic review of 6 studies on ESWT for Achilles tendinopathy.[75] Selected for the review were 4 small RCTs and 2 cohort studies. Satisfactory evidence was found in 4 studies demonstrating the effectiveness of ESWT in the treatment of Achilles tendinopathy at 3 months. However, 2 RCTs found no significant difference between ESWT and placebo in the treatment of Achilles tendinopathy. These trials are described next.[76,77]

Randomized Controlled Trials

Alsulaimani et al (2025) conducted a randomized trial that compared radial extracorporeal shockwave therapy (rESWT; n=38) with sham control (n=38) in individuals with unilateral or bilateral insertional Achilles tendinopathy.[78] The primary objective of the trial was to evaluate the efficacy of rESWT in combination with recommended exercise and education for pain and function with follow-up on outcomes at 6- and 12-weeks. There was no evidence of a difference between-group differences in Victorian Institute of Sports Assessment- Achilles questionnaire or on overall pain at 6- or 12-weeks. No serious adverse events were reported.

Stania et al (2023) performed a randomized trial that compared ESWT, ultrasound therapy, and placebo ultrasound for pain control in 39 patients with Achilles tendinopathy.[79] Outcomes were measured at 1 and 6 weeks after the completion of therapy. Activity-related pain was lower with ESWT compared to ultrasound therapy at 6 weeks ($p<.05$). Intensity of pain at rest was similar between groups at both time points.

Abdelkader et al (2021) performed a double-blind, randomized trial that compared ESWT (n=25) with sham control (n=25) in patients with unilateral noninsertional Achilles tendinopathy.[80] Scores were improved in both ESWT and control groups at 1 month on the Victorian Institute of Sports Assessment-Achilles (VISA-A) questionnaire (85 and 53.4, respectively) and the VAS (1 and 7, respectively), as well as at 16 months on the VISA-A (80 and 67, respectively) and the VAS (3 and 5.6, respectively). At both time points, scores were statistically and clinically superior with ESWT than with sham control (both p=.0001).

Pinitkwamdee et al (2020) conducted a double-blind, randomized trial to compare the effectiveness of low-energy ESWT (n=16) with sham controls (n=15) in patients with chronic insertional Achilles tendinopathy.[81] The primary outcomes consisted of changes in VAS pain scores and VAS foot and ankle pain scores at time points ranging from 2 to 24 weeks. At 24 weeks, low-energy ESWT and sham controls revealed similar changes in VAS and VAS foot and ankle pain scores. But ESWT had a significant improvement in VAS scores compared with sham controls at weeks 4 to 12, based on which, authors concluded that ESWT may provide a short period of therapeutic effect.

Lynen et al (2017) published results from an RCT comparing 2 peri-tendinous hyaluronan injections (n=29) with 3 ESWT applications (n=30) for the treatment of Achilles tendinopathy.[82] The primary outcome was percent change in VAS pain score at the 3-month follow-up. Other measurements included the VISA-A, clinical parameters (redness, warmth, swelling, tenderness, edema), and patients' and investigators' impression of treatment outcome. Follow-up was conducted at 4 weeks, 3 months, and 6 months. Pain decreased in both groups from baseline, though percent decrease in pain was statistically larger in the hyaluronan injections group than in the ESWT group at all follow-up time points. Secondary outcomes also showed larger improvements in the hyaluronan injection group.

The 2 trials described next were included in the systematic reviews.

Rasmussen et al (2008) reported on a single-center, double-blind controlled trial with 48 patients, half randomized after 4 weeks of conservative treatment to 4 sessions of active RSW and half to sham ESWT.[77] The primary end point was AOFAS score measuring function, pain, and alignment and VAS pain score. AOFAS score after treatment increased from 70 to 88 in the ESWT group and from 74 to 81 in the control (p=.05). The pain was reduced in both groups, with no statistically significant difference between groups. The authors suggested that the AOFAS might not be appropriate to evaluate treatment of Achilles tendinopathy.

Costa et al (2005) reported on a randomized, double-blind, placebo-controlled trial of ESWT for chronic Achilles tendon pain treated monthly for 3 months.[76] The trial randomized 49 participants and was powered to detect a 50% reduction in VAS pain scores. No differences in pain relief at rest or during sports participation were found at 1 year. Two older ESWT-treated participants experienced tendon ruptures.

Section Summary: Achilles Tendinopathy

Three systematic reviews of RCTs and 5 RCTs published after the systematic reviews have evaluated the use of ESWT for Achilles tendinopathy. In a recent systematic review, a pooled analysis found that ESWT reduced both short- and long-term pain compared with nonoperative treatments, although these reviewers warned that results were inconsistent across the RCTs and that there was heterogeneity across patient populations and treatment protocols. An RCT published after the systematic review compared ESWT with hyaluronan injections and reported improvements in both treatment groups, although significantly higher in the injection group. Another RCT found no difference in pain scores between low-energy ESWT and sham controls at week 24, but ESWT may provide short therapeutic effects at weeks 4 to 12. Another RCT found scores were statistically and clinically improved with ESWT compared with sham control at 1 month and 16 months on measures of pain and function. Another RCT found that activity-related pain was lower with ESWT at 6 weeks compared to ultrasound therapy, but there was no difference in pain at rest. The most recent RCT found no significant difference in pain outcomes for rESWT vs sham control at 6 and 12 weeks.

Patellar Tendinopathy

Clinical Context and Therapy Purpose

The purpose of ESWT is to provide a treatment option that is an alternative to or an improvement on existing therapies, such as conservative therapy (e.g., physical therapy) and nonsteroidal anti-inflammatory therapy, in individuals with patellar tendinopathy.

The following PICO was used to select literature to inform this review.

Populations

The relevant population of interest is individuals with patellar tendinopathy.

Interventions

The therapy being considered is ESWT.

Comparators

Comparators of interest include conservative therapy (e.g., physical therapy) and nonsteroidal anti-inflammatory therapy.

Outcomes

The general outcomes of interest are symptoms, functional outcomes, quality of life, medication use, and treatment-related morbidity (Table 22).

Table 22. Outcomes of Interest for Individuals with Patellar Tendinopathy

Outcomes	Details	Timing
Symptoms	• Pain reduction via VAS assessment • Patellar tendon thickness • VISA-Patellar Tendon • McGill Pain Questionnaire • Roles and Maudsley score for pain • Likert scale/numerical rating scale for pain • Swelling	<1 month to 1 year
Functional Outcomes	• Range of motion • Knee Outcome Survey Activities of Daily Living • Vertical jump test • Roles and Maudsley score for function • International Knee Documentation Committee scale	<1 month to 1 year

VAS: visual analog scale; VISA: Victorian Institute of Sports Assessment.

Study Selection Criteria

Methodologically credible studies were selected using the following principles:

- To assess efficacy outcomes, comparative controlled prospective trials were sought, with a preference for RCTs;
- In the absence of such trials, comparative observational studies were sought, with a preference for prospective studies;
- To assess longer term outcomes and adverse events, single-arm studies that capture longer periods of follow-up and/or larger populations were sought;
- Studies with duplicative or overlapping populations were excluded.

Review of Evidence

Systematic Reviews

Majidi et al (2024) performed a systematic review and meta-analysis of 45 studies on the use of ESWT to reduce pain in patients with various tendinopathies.[14] The review included 13 studies focused on the outcome for plantar fasciitis (PF), 3 studies evaluating outcomes of chronic Achillies tendinopathy (CAT), 22 studies examining outcomes of lateral epicondylitis (LE), 3 studies focused on outcomes for rotator cuff tendinopathy (RC), and 5 studies exploring outcomes in patellar tendinopathy (PT). The analysis of studies regarding mean pain scores in patients with PT incorporated findings from 3 studies with 5 different effect sizes and indicated that the mean pain score increased by an average of 1.36 units when ESWT was used to treat the tendinopathy (SMD: 1.36, 95% CI: 0.99 to 1.73; I2: 97.73%; P heterogeneity:.0001) thus, ESWT had a significant impact on pain reduction for PT. Publication bias was assessed using the Egger's test and demonstrated no evidence of bias.

Stania et al (2022) conducted a systematic review and meta-analysis of 7 RCTs of ESWT in patients with patellar tendinitis.[83] Compared to control groups at 6 months or more after therapy completion, VAS scores and VISA for Patella scores were similar between groups. The analyses were limited by heterogeneity (I^2=98% and 99%, respectively) and the authors stated that generalized conclusions could not be drawn.

Liao et al (2018) examined RCTs to determine the clinical efficacy of ESWT of different shockwave types, energy levels, and durations to treat knee tendinopathies and other knee soft tissue disorders.[84] Their review included 19 RCTs, encompassing 1189 participants. Of the participants, 562 underwent ESWT and 627 received a placebo or other conservative treatment. Analysis revealed that ESWT results in significant improvements in pain levels, with a pooled standard MD of -1.49 (95% CI, -2.11 to -0.87; p<.0001; I^2=95%) compared with the control groups. This effect resulted regardless of follow-up duration, type of shockwave, application level, or control intervention type. Four trials reported range of motion (ROM) recovery, specifically from FSW and RSW, with significant pooled standard MD of 2.61 (95% CI, 2.11 to 3.12; p<.0001; I^2=0%). In general, low-energy FSW was more effective in increasing treatment success rate than high-energy FSW; however, high-energy RSW was more effective than low-energy RSW. No severe adverse effects were reported with ESWT. Meta-analysis limitations include, but are not limited to, heterogeneity across trials; no consideration for other application parameters (rate of shocks, number of treatments, and treatment intervals); and high risk of selection, blinding, performance, and other biases.

Van Leeuwen et al (2009) conducted a literature review to study the effectiveness of ESWT for patellar tendinopathy and to draft a treatment protocol.[85] Reviewers found that most of the 7 selected studies had methodologic deficiencies, small numbers and/or short follow-up periods, and variation in treatment parameters. Reviewers concluded ESWT appears to be a safe and promising treatment but could not recommend a treatment protocol.

In the systematic review of ESWT for lower-extremity tendinopathies (previously described), Mani-Babu et al (2015) identified 7 studies of ESWT for patellar tendinopathy (2 RCTs, 1 quasi-RCT, 1 retrospective cross-sectional study, 2 prospective cohort studies, 1 case-control study).[74] The 2 RCTs came to different conclusions: 1 found no difference in outcomes between ESWT and placebo at 1, 12, or 22 weeks, whereas the other found improved outcomes on vertical jump test and VISA-Patellar scores at 12 weeks with ESWT compared with placebo. Two studies that evaluated outcomes beyond 24 months found ESWT comparable to patellar tenotomy surgery and better than nonoperative treatments.

Randomized Controlled Trials

An RCT by Thijs et al (2017) compared the use of ESWT plus eccentric training (n=22) with sham shock wave therapy plus eccentric training (n=30) for the treatment of patellar tendinopathy.[86] Patients were physically active with a mean age of 28.6 years (range, 18 to 45 years). ESWT and sham shock wave were administered in 3 sessions, once weekly. Patients were instructed to perform eccentric exercises, 3 sets of 15 repetitions twice daily for 3 months on a decline board at home. Primary outcomes were VISA-Patellar score and pain score during functional knee loading tests (10 decline squats, 3 single leg jumps, 3 vertical jumps). Measurements were taken at baseline, 6, 12, and 24 weeks. There were no statistically significant differences between the ESWT and sham shock wave groups for any of the primary outcome measurements at any follow-up except for the vertical jump test at week 6.

In an RCT of patients with chronic patellar tendinopathy (N=46), despite at least 12 weeks of nonsurgical management, Smith and Sellon (2014) reported that improvements in pain and functional outcomes were significantly greater (p<.05) with plasma-rich protein injections than with ESWT at 6 and 12 months, respectively.[87]

Section Summary: Patellar Tendinopathy

The trials on the use of ESWT for patellar tendinopathy have reported inconsistent results and were heterogeneous in treatment protocols and lengths of follow-up.

Medial Tibial Stress Syndrome

Clinical Context and Therapy Purpose

The purpose of ESWT is to provide a treatment option that is an alternative to or an improvement on existing therapies, such as icing or support, in individuals with medial tibial stress syndrome.

The following PICO was used to select literature to inform this review.

Populations

The relevant population of interest is individuals with medial tibial stress syndrome.

Interventions

The therapy being considered is ESWT.

Comparators

The comparator of interest is conservative therapy (e.g., icing, support).

Outcomes

The general outcomes of interest are symptoms, functional outcomes, quality of life, medication use, and treatment-related morbidity (Table 23).

Table 23. Outcomes of Interest for Individuals with Medial Tibial Stress Syndrome

Outcomes	Details	Timing
Symptoms	• 6-point Likert scale for pain • Self-reported pain during bone pressure, muscle pressure, or while running	1 to 15 months from baseline

Study Selection Criteria

Methodologically credible studies were selected using the following principles:

- To assess efficacy outcomes, comparative controlled prospective trials were sought, with a preference for RCTs;
- In the absence of such trials, comparative observational studies were sought, with a preference for prospective studies;
- To assess longer term outcomes and adverse events, single-arm studies that capture longer periods of follow-up and/or larger populations were sought;
- Studies with duplicative or overlapping populations were excluded.

Review of Evidence

Randomized and Nonrandomized Studies

Newman et al (2017) published a double-blind, sham-controlled randomized trial on the use of ESWT for the treatment of 28 patients with medial tibial stress syndrome (commonly called shin splints).[88] Enrolled patients had running-related pain for at least 21 days confined to the posteromedial tibia, lasting for hours or days after running. Patients received treatments (ESWT or sham) at weeks 1, 2, 3, 5, and 9 and were instructed to keep activity levels as consistent as possible. At week 10 measurements, there was no difference between the treatment and control groups in self-reported pain during bone pressure, muscle pressure, or during running. There was no difference in pain-limited running distances between groups.

Rompe et al (2010) published a report on the use of ESWT in medial tibial stress syndrome.[89] In this nonrandomized cohort study, 47 patients with medial tibial stress syndrome for at least 6 months received 3 weekly sessions of RSW and were compared with 47 age-matched controls at 4 months. Mild adverse events were noted in 10 patients: skin reddening in 2 patients and pain during the procedure in 8 patients. Patients rated their condition on a 6-point Likert scale. Successful treatment was defined as self-rating "completely recovered" or "much improved." The authors reported a success rate of 64% (30/47) in the treatment group compared with 30% (14/47) in the control group. In a comment, Barnes (2010) raised several limitations of this nonrandomized study, including the possibility of selection bias.[90]

Section Summary: Medial Tibial Stress Syndrome

Evidence for the use of ESWT for medial tibial stress syndrome includes a small RCT and a small nonrandomized study. The RCT showed no differences in self-reported pain measurements between study groups. The nonrandomized trial reported improvements with ESWT, but selection bias limited the strength of the conclusions.

Osteonecrosis of the Femoral Head

Clinical Context and Therapy Purpose

The purpose of ESWT is to provide a treatment option that is an alternative to or an improvement on existing therapies, such as medication (e.g., alendronate) or hip arthroplasty, in individuals with osteonecrosis of the femoral head.

The following PICO was used to select literature to inform this review.

Populations

The relevant population of interest is individuals with osteonecrosis of the femoral head.

Interventions

The therapy being considered is ESWT.

Comparators

Comparators of interest include medication and hip arthroplasty.

Outcomes

The general outcomes of interest are symptoms, functional outcomes, quality of life, medication use, and treatment-related morbidity (Table 24).

Table 24. Outcomes of Interest for Individuals with Osteonecrosis of the Femoral Head

Outcomes	Details	Timing
Symptoms	• Pain reduction via VAS assessment • Harris Hip Scores for pain • Radiographic reduction of bone marrow edema on magnetic resonance imaging	3 months to >24 months

Outcomes	Details	Timing
Functional outcomes	• HHS for function	3 months to >24 months

HHS: Harris Hip Score; VAS: visual analog scale.

Study Selection Criteria

Methodologically credible studies were selected using the following principles:

- To assess efficacy outcomes, comparative controlled prospective trials were sought, with a preference for RCTs;
- In the absence of such trials, comparative observational studies were sought, with a preference for prospective studies;
- To assess longer term outcomes and adverse events, single-arm studies that capture longer periods of follow-up and/or larger populations were sought;
- Studies with duplicative or overlapping populations were excluded.

Review of Evidence

Systematic Reviews

Tan et al (2024) conducted a systematic review of 9 studies of ESWT in patients (N=716) with osteonecrosis of the femoral head (ONFH) and performed a meta-analysis comparing pretreatment and post-treatment outcomes.[91] Using a random effects model, 5 studies demonstrated statistically significant improvements in Harris Hip Scores (HHS) for patients who underwent ESWT (mean difference [MD] = − 33.38; 95% CI: − 46.31 to − 20.45; p<.00001, I2= 96%). Visual analogue scores (VAS) used to assess pain were significantly lower post-treatment with ESWT (MD = 4.64; 95% CI: 3.63–5.64; p<.00001, I2= 86%), but no significant differences were seen in the size of lesions via imaging. The mean patient follow-up time across studies was 15.19 months with 4 studies having a follow-up period longer than 24 months. No obvious publication bias was found, however, there was some heterogeneity between studies. Other limitations included, but not limited to, small sample sizes for some of the studies, the inclusion of RCTs and case series, limited duration of follow-up and the exclusion of comparators.

In their meta-analysis, Hao et al (2018) compared the effectiveness of ESWT with other treatment strategies in improving pain scores and Harris Hip Score (HHS) for patients with osteonecrosis of the femoral head.[92] Their search for interventional studies published in Chinese or English yielded 4 articles with a total of 230 patients, most of whom were in stages I through III of osteonecrosis of the femoral head. Before treatment, no significant differences in pain scores (p=.1328) and HHS (p=.287) were found between the ESWT group (n=130) and control group (n=110). Post-treatment, the ESWT group reported significantly higher improvement in pain scores than the control group (standard MD, -2.1148; 95% CI, -3.2332 to -0.9965; Z=3.7063; p=.0002), as well as higher HHSs (standard MD, 2.1377; 95% CI, 1.2875 to 2.9880; Z=4.9281; p<.001). However, the analysis revealed no significant improvements in pain scores before and after treatment (p=.005), but it did reveal significant improvements in the HHS (p<.001). Patient follow-up time across studies ranged from 3 to 25 months. This analysis had several limitations including: only 1 RCT was included out of 4 studies; small sample size resulted in more pronounced heterogeneity between studies; the studies were of poor quality; publication bias was detected for the HHS after treatment; and only 2 studies reported pain scores.

A systematic review by Zhang et al (2016) evaluated evidence on the use of ESWT for osteonecrosis of the femoral head.[93] The literature search, conducted through July 2016, identified 17 studies for inclusion (9 open-label studies, 4 RCTs, 2 cohort studies, 2 case reports). Study quality was assessed using the Oxford Centre of Evidence-Based Medicine Levels of Evidence (I = highest quality and V = lowest quality, and each level can be subdivided a through c). Four studies were Ib, 2 studies were IIb, and 11 studies were IV. Most studies included patients with Association Research Circulation Osseous categories I through III (out of 5 stages of osteonecrosis). Outcomes in most studies were VAS pain score and HHS, a composite measure of pain and hip function. Reviewers concluded that ESWT can be a safe and effective method to improve motor function and relieve pain, particularly in patients with early-stage osteonecrosis. Studies that included imaging results showed that bone marrow edema could be relieved, but that necrotic bone was not reversed. Evidence limitations included the heterogeneity of treatment protocol (numbers of sessions, energy intensities, focus sizes differed among studies) and most studies were of low quality.

A systematic review of ESWT for osteonecrosis (avascular necrosis) of the femoral head was conducted by Alves et al (2009).[94] The literature search conducted through 2009 identified 5 articles, all from non-U.S. sites (2 RCTs, 1 comparative study, 1 open-label study, 1 case report; N=133 patients). Of the 2 RCTs, 1 randomized 48 patients to the use of concomitant alendronate; both arms received ESWT treatments and therefore ESWT was not a comparator. The other RCT compared ESWT with a standard surgical procedure. All results noted a reduction in pain during the trial, which the authors attributed to ESWT. However, reviewers, when discussing the limitations of the available evidence, noted a lack of double-blind design, small numbers of patients enrolled, short follow-up times, and nonstandard interventions (e.g., energy level, the number of treatments).

Section Summary: Osteonecrosis of the Femoral Head
The body of evidence on the use of ESWT for osteonecrosis of the femoral head consists of systematic reviews of small, mostly nonrandomized studies. Many of the studies were low quality and lacked comparators. While most studies reported favorable outcomes with ESWT, limitations such as heterogeneity in the treatment protocols, patient populations, and lengths of follow-up make conclusions on the efficacy of ESWT for osteonecrosis uncertain.

Nonunion or Delayed Union of Acute Fracture
Clinical Context and Therapy Purpose
The purpose of ESWT is to provide a treatment option that is an alternative to or an improvement on surgical therapy for individuals with acute fracture nonunion or delayed union.

The following PICO was used to select literature to inform this review.

Populations
The relevant population of interest is individuals with acute fracture nonunion or delayed union.

Interventions
The therapy being considered is ESWT.

Comparators
The comparator of interest is surgical therapy.

Outcomes
The general outcomes of interest are symptoms, functional outcomes, quality of life, medication use, and treatment-related morbidity (Table 25).

Table 25. Outcomes of Interest for Individuals with Acute Fracture Nonunion or Delayed Union

Outcomes	Details	Timing
Symptoms	• Pain reduction via VAS assessment • Radiographic evidence of healing	6 to 12 months
Functional outcomes	• Weight-bearing status	6 to 12 months

VAS: visual analog scale.

Study Selection Criteria
Methodologically credible studies were selected using the following principles:

- To assess efficacy outcomes, comparative controlled prospective trials were sought, with a preference for RCTs;

- In the absence of such trials, comparative observational studies were sought, with a preference for prospective studies;
- To assess longer term outcomes and adverse events, single-arm studies that capture longer periods of follow-up and/or larger populations were sought;
- Studies with duplicative or overlapping populations were excluded.

Review of Evidence
Systematic Reviews
Sansone et al (2022) published a systematic review and meta-analysis involving 23 studies that evaluated the effectiveness of ESWT in the treatment of nonunion fracture in long bones.[95] The review included 2 RCTs, a single non-randomized controlled trial, and 20 observational studies (14 retrospective; 6 prospective), with a total of 1838 cases of delayed union or nonunion. Only data for 1200 of the 1838 cases were included in the meta-analysis since several studies did not separate results from long bones from those of other bones. Healing occurred in 876 (73%) of the 1200 total long bones after ESWT. Hypertrophic cases were associated with a 3-fold higher healing rate as compared to oligotrophic or atrophic cases (p=.003). Bones in the metatarsal region were the most receptive to ESWT with a healing rate of 90%, followed by the tibiae (75.5%), femurs (66.9%), and humeri (63.9%). Increased healing rates were observed among patients who had shorter periods between the injury and ESWT (p<.02). Six months of follow-up was generally too brief to fully evaluate the healing potential of ESWT with several studies demonstrating increasing healing rates at follow-ups beyond 6 months after the last ESWT. Limitations included that the authors in 7 included studies did not distinguish between delayed union and nonunion when describing the patient population. In several other studies, the patient population was described clearly; however, data from delayed unions and nonunions were reported together. Incomplete data reporting also contributed to a lack of identifying and differentiating treatment protocols for ESWT.

Zelle et al (2010) published a review of the English and German medical literature on ESWT for the treatment of fractures and delayed union/nonunion.[96] Limiting the review to studies with more than 10 patients, reviewers identified 10 case series and 1 RCT. The number of treatment sessions, energy levels, and definitions of nonunion varied across studies; union rates after the intervention were likewise defined heterogeneously, ranging from 40.7% to 87.5%. Reviewers concluded that the overall quality of evidence was conflicting and of poor quality.

Randomized Controlled Trials
Wang et al (2007), which was the single RCT included in the Zelle et al (2010) review, randomized 56 trauma patients with femur or tibia fractures to a single ESWT treatment following surgical fixation while still under anesthesia.[97] Patients in the control group underwent surgical fixation but did not receive the ESWT. Patients were evaluated for pain and percent weight-bearing capability by an independent, blinded evaluator at 3, 6, and 12 months. Radiographs taken at these same intervals were evaluated by a radiologist blinded to study group assignment. Both groups showed significant improvements in pain scores and weight-bearing status. Between-group comparisons of VAS pain and weight bearing favored ESWT patients at each interval. At 6 months, patients who had received ESWT had VAS scores of 1.2 compared with 2.5 in the control group (p<.001); mean percentage of weight bearing at 6 months was 87% and 78%, respectively (p=.01). Radiographic evidence of union at each interval also favored the ESWT group. At 6 months, 63% (17/27) of the treatment group achieved fracture union compared with 20% (6/30) in the control group (p<.001). The authors noted some limitations of the trial: the small number of patients enrolled, surgeries performed by multiple surgeons, and questions about the adequacy of randomization.

Cacchio et al (2009) published a multicenter RCT after the Zelle et al (2010) review, which randomized 126 patients into 3 groups: low-energy ESWT, high-energy ESWT therapy, or surgery.[98] Nonunion fractures were defined as at least 6 months without evidence of radiographic healing. The primary end point was radiographic evidence of healing. Secondary end points were pain and functional status, collected by blinded evaluators. Neither patients nor treating physicians were blinded. At 6 months, healing rates in the low-energy ESWT, high-energy ESWT, and surgical arms were similar (70%, 71%, and 73%, respectively). All groups' healing rates improved at 12- and 24-month follow-ups, without significant between-group differences. Secondary endpoints of pain and disability were also similar. Lack of blinding might have led to differing levels of participation in other aspects of the treatment protocol.

A study by Zhai et al (2016), included in the Sansone et al (2022) review, evaluated the use of human autologous bone mesenchymal stem cells combined with ESWT for the treatment of nonunion long bones.[99] Nonunion was defined as 6 or more months post fracture with no evidence of additional healing in the past 3 months. Patients were randomized to high-energy ESWT (n=31) or human autologous mesenchymal stem cells plus ESWT (n=32). ESWT was administered every 3 days: 4 times for upper-limb nonunion and 5 times for lower-limb nonunion. Outcome measures were no pain, no abnormal mobility, an x-ray showing a blurred fracture line, and upper-limb holding 1 kg for 1 minute or lower-limb walking for 3 minutes. Success was defined as meeting all 4 criteria at 12 months. The human autologous stem cells plus ESWT group experienced an 84% healing rate. The ESWT alone group experienced a 68% healing rate (p<.05).

Section Summary: Nonunion or Delayed Union of Acute Fracture
The evidence on the use of ESWT for the treatment of fractures or for fracture nonunion or delayed union includes systematic reviews, relatively small RCTs with methodologic limitations (e.g., heterogeneous outcomes and treatment protocols), and case series. The available evidence does not permit conclusions on the efficacy of ESWT in fracture nonunion, delayed union, or acute long bone fractures.

Spasticity
Clinical Context and Therapy Purpose
The purpose of ESWT is to provide a treatment option that is an alternative to or an improvement on existing therapies, such as medication and intrathecal medication therapy, in individuals with spasticity.

The following PICO was used to select literature to inform this review.

Populations
The relevant population of interest is individuals with spasticity.

Interventions
The therapy being considered is ESWT.

Comparators
Comparators of interest are medication and intrathecal medication therapy.

Outcomes
The general outcomes of interest are symptoms, functional outcomes, quality of life, medication use, and treatment-related morbidity (Table 26).

Table 26. Outcomes of Interest for Individuals with Spasticity

Outcomes	Details	Timing
Symptoms	• Modified Ashworth Scale for assessing resistance during soft-tissue stretching • Passive range of motion with goniometer	4 weeks to 3 months
Function outcomes	• Brunnstrom Recovery Stage tool to assess motor recovery	Up to 5 weeks post-therapy

Study Selection Criteria

Methodologically credible studies were selected using the following principles:

- To assess efficacy outcomes, comparative controlled prospective trials were sought, with a preference for RCTs;
- In the absence of such trials, comparative observational studies were sought, with a preference for prospective studies;
- To assess longer term outcomes and adverse events, single-arm studies that capture longer periods of follow-up and/or larger populations were sought;
- Studies with duplicative or overlapping populations were excluded.

Review of Evidence

Systematic Reviews

Liu and Zhang (2025) performed a systematic review and meta-analysis of 9 RCTs examining ESWT with routine rehabilitation training for limb dysfunction and spasticity after stroke using Modified Ashworth Scale (MAS) which is a 6-point scale used to assess muscle tone, specifically spasticity, by measuring resistance to passive movement and passive range of motion (PROM).[100] Compared with control (routine rehabilitation training with/without sham-ESWT), ESWT significantly reduced spasticity in the upper (MD: 0.28, 95% CI: 0.06 to 0.50; $p<.05$) and lower limbs (MD: 0.33, 95% CI: 0.06 to 0.60; $p<.05$). Six studies included range of motion outcomes (PROM) for treatment of spasticity using ESWT, with 2 articles on upper limbs and 4 articles on lower, and reported that ESWT improved the range of motion of lower extremity joints (MD: 4.33, 95% CI: 2.18 to 6.48; $p<.05$), but had little effect on upper limbs. Limitations of this meta-analysis include, the small number of available studies and sample sizes, unclear monitoring and follow-up procedures for interventions, heterogeneity among the included studies, and heterogeneity of treatment protocols (numbers of sessions, energy intensities, radial or focus waves, and focus sizes differed among studies). Results should be interpreted cautiously as the Modified Ashworth Scale does not account for certain clinically important factors related to spasticity, including pain and functional impairment.

Afzal et al (2024) conducted a meta-analysis of 7 RCTs and 8 nonrandomized observational studies evaluating ESWT (focused and radial) on lower limb post-stroke spasticity using MAS, QOL (Barthel Index), and other physical function based outcomes (mobility, gait, ankle range of motion [ROM], lower limb motor function, time up and go, 10-meter walk test, and 6-min walk test) at 3- (short-term) and 12-weeks (long-term) after ESWT intervention.[101] Compared with control, ESWT did significantly improve Modified Ashworth Scale scores in the short-term (standardized MD [SMD]=1.04, 95% CI, 0.722 to 1.353; $p=.0001$) and long-term (SMD=1.58, 95% CI, 1.059 to 2.091; $p=.0001$). The addition of ESWT to conventional physiotherapy also provided improvement in the Modified Ashworth Scale scores compared with conventional physiotherapy in the short-term (SMD=0.260, (95% CI, −0.058 to 0.578; $p=.01$). After receiving ESWT patients' ROM in lower limbs significantly improved when compared to baseline and conventional physiotherapy at 3- (SMD=0.604, 95% CI, −0.234 to 0.973; $p=.001$) and 12-weeks (SMD=0.573, 95% CI, 0.074 to 1.072; $p=.02$). Limitations of this meta-analysis include, but are not limited to, the small number of available studies and sample size, inclusion of nonrandomized and low-quality studies, unclear monitoring and follow-up procedures for interventions, heterogeneity among the included studies, and heterogeneity of treatment protocol (numbers of sessions, energy intensities, radial or focus waves, and focus sizes differed among studies). Results should be interpreted cautiously as the Modified Ashworth Scale does not account for certain clinically important factors related to spasticity, including pain and functional impairment.

Otero-Luis et al (2024) performed a meta-analysis of 14 RCTs and 2 crossover trials evaluating the effect of ESWT on spasticity secondary to various etiologies, including stroke, cerebral palsy, and multiple sclerosis.[102] The control group treatments were not specified. Results demonstrated that ESWT showed significant reductions in spasticity levels as indicated by Modified Ashworth Scale scores, both in upper limbs (MD, -1.05; 95% CI, -1.39 to -0.71) and lower limbs (MD, -0.40; 95% CI, -0.77

to -0.03). However, at 12 weeks post-intervention, the efficacy of ESWT did not reach statistical significance compared to control (MD, -0.47; 95% CI, -1.30 to 0.35). Limitations of this meta-analysis include small sample sizes and heterogeneity due to differences between populations (i.e., age, etiology) and ESWT protocols.

Mihai et al (2021) performed a meta-analysis of 7 RCTs to estimate the effect of ESWT on lower limb post-stroke spasticity at long-term follow-up (≥3 weeks after treatment).[103] Compared with control, ESWT did not significantly improve Modified Ashworth Scale score at up to 12 weeks (7 studies; N=146; SMD, 0.32; 95% CI, -0.01 to 0.65; I^2=0%) or VAS score at up to 12 weeks (2 studies; N=50; SMD, 0.35; 95% CI, -0.21 to 0.91; I^2=0%), but did significantly improve passive range of motion at up to 12 weeks (3 studies; N=69; standardized MD, 0.69; 95% CI, 0.20 to 1.19; I^2=0%). Limitations of this meta-analysis include the small number of available studies, as well as small sample sizes.

Cabanas-Valdes et al (2020) performed a meta-analysis of 16 RCTs evaluating the effectiveness of ESWT on spasticity of the upper limb in 764 patients who survived stroke.[104] Compared with sham therapy, ESWT significantly improved the Modified Ashworth Scale scores (MD, -0.28; 95% CI, -0.54 to -0.03). The addition of ESWT to conventional physiotherapy also provided improvement in the Modified Ashworth Scale scores compared with conventional physiotherapy only (MD, -1.78; 95% CI, -2.02 to -1.53). Some limitations of this meta-analysis consist of studies with small sample sizes, unclear monitoring and follow-up procedures for interventions, and heterogeneity among the included studies.

Jia et al (2020) conducted a meta-analysis of 8 RCTs evaluating the effectiveness of ESWT on post-stroke spasticity in 301 patients.[105] At long-term follow-up, ESWT significantly reduced Modified Ashworth Scale scores (weighted MD, -0.36; 95% CI, -0.53 to -0.19; p<.001; I^2=15%) compared with controls. Controls varied among included studies and comprised rehabilitation therapy, oral anti-spastic medications, sham therapy, botulinum toxin type A, stretching exercises, and/or physical therapy.

Kim et al (2019) performed a meta-analysis of 5 RCTs evaluating the effectiveness of ESWT on reducing spasticity in patients with cerebral palsy.[106] Compared with controls, ESWT significantly improved Modified Ashworth Scale scores (MD, -0.62; 95% CI, -1.05 to -0.18; p<.00001; I^2=86%). Controls included placebo or no therapy.

Lee et al (2014) conducted a meta-analysis of studies evaluating ESWT for patients with spasticity secondary to a brain injury.[107] Studies included evaluated ESWT as sole therapy and reported pre- and post-intervention Modified Ashworth Scale scores. Five studies were selected, 4 examining spasticity in the ankle plantar flexor and 1 examining spasticity in the wrist and finger flexors; 3 studies evaluated poststroke spasticity and 2 evaluated spasticity associated with cerebral palsy. Immediately post-ESWT, Modified Ashworth Scale scores improved significantly compared with baseline (standardized MD, -0.792; 95% CI, -1.001 to -0.583; p<.001). Four weeks post-ESWT, Modified Ashworth Scale scores continued to demonstrate significant improvements compared with baseline (standardized MD, -0.735; 95% CI, -0.951 to -0.519; p<.001). A strength of this meta-analysis was its use of a consistent and well-definable outcome measure. However, the Modified Ashworth Scale does not account for certain clinically important factors related to spasticity, including pain and functional impairment.

Randomized Controlled Trials

Yang et al (2024) conducted a double-blind clinical trial (N=39) that randomized patients with poststroke spasticity of ankle plantar flexor muscles to double-dose focused ESWT (n=19) or control ESWT (single-dose) group (n=20) to assess spasticity using MAS scores and function by measuring change in PROM at baseline, 1-, 4-, 12-, and 24-weeks.[48] In addition to focused ESWT, all patients received traditional rehabilitation which involves range of motion exercises, muscle stretching and strengthening, stance and balance training, core stability exercises, gait training, functional training, the use of physical modalities, and orthoses. A total of 11 patients were lost to follow-up, with 5 lost in ESWT (double-dose) group and 6 in the control ESWT (single-dose) group at week 12 and 24. Using the Friedman test, a within-group analysis demonstrated significant improvements in MAS scores (p=.043) and PROM (p=.007) for patients receiving a double-dose of ESWT throughout the 24-week follow-up period, while the control group (single-dose of ESWT) showed no significant change (p=.128 and p=.181, respectively). Limitations of this RCT include, but are not limited to, the small sample size, heterogeneity among stroke patients, and the use of traditional rehabilitation may have confounded the results. Results should be interpreted cautiously as the Modified Ashworth Scale does not account for certain clinically important factors related to spasticity, including pain and functional impairment.

Two randomized controlled trials comparing radial extracorporeal shock wave therapy (rESWT) with sham-control on improvement of spasticity symptoms via MAS scores.[108,109] Fan et al (2024) assessed the efficacy of rESWT (n=47) in treating upper limb spasticity after a stroke vs sham (n=48). Greater improvements in the MAS scores were observed in patients treated with rESWT versus sham (difference: -0.45; 95% CI, -0.69 to -0.22; p<.001). Nada et al (2024) published results from a RCT evaluating the effectiveness of rESWT (n= 50) on poststroke spasticity and range of motion (n= 50) at 1 and 2 months. Improved MAS scores and passive ankle dorsiflexion motion improved significantly at 1- and 2-month follow-ups for patients who received rESWT compared to sham-rESWT.

Brunelli et al (2022) conducted a pilot RCT in 40 patients with poststroke spasticity.[110] Patients were randomized to RSW or conventional physiotherapy and assessed for change in Modified Ashworth Scale scores of the shoulder, elbow, and wrist. Follow-up occurred at 1 month after the last RSW session. Significant differences in Modified Ashworth Scale elbow scores were noted after the second RSW session and remained until the end of follow-up. Scores at the shoulder were only significantly better in the RSW group at the 1-month follow-up.

Vidal et al (2020) performed a randomized, controlled, crossover trial that compared RSW with botulinum toxin type A in reducing plantar flexor muscle spasticity in 68 patients with cerebral palsy.[111] After 6 months, patients crossed over to the alternative treatment. Spasticity was evaluated using the Tardieu scale, which measures resistance to passive movement at slow and fast velocities with a goniometer. Treatment success was defined as improvement in dorsiflexion by ≥10° of the gastrocnemius muscle or the soleus muscle at 2 months after each intervention. In the first phase, success rates were similar between RSW and botulinum toxin type A (45.7% and 36.4%, respectively; p=.469). Following crossover, significantly more patients achieved response with RSW (39.4% vs. 11.4%; p=.011), which the authors attributed to a carry-over effect of RSW from the first phase of treatment.

Li et al (2020) assessed the effects of RSW on agonist muscles (n=27) and antagonist muscles (n=30) compared with control (n=25) in patients with stroke.[112] All patients received conventional physical therapy for 3 weeks. Radial ESWT was administered at 4-day intervals for 5 consecutive treatments on either agonist or antagonist muscles. After treatment and 4 weeks of follow-up, the changes in the Modified Ashworth Scale scores were 24% for the control group, 74.1% for the agonist muscle group receiving RSW, and 66.7% for the antagonist muscle group receiving RSW, with statistical significance at p<.01 among the 3 groups. The authors concluded that RSW is effective for spasticity after stroke and may have lasting effects up to 4 weeks after the treatment.

Wu et al (2018) evaluated whether ESWT is noninferior to botulinum toxin type A for poststroke upper limb spasticity among 42 patients with chronic stroke.[113] At week 4, the change from baseline of the Modified Ashworth Scale score of the wrist flexors was -0.80 with ESWT and -0.9 with botulinum toxin type A; the difference between the 2 groups was within the prespecified margin of 0.5, meeting the noninferiority of ESWT to botulinum toxin type A.

The efficacy and safety of RSW in the treatment of spasticity in patients with cerebral palsy were examined in a small European RCT.[114] As reported by Vidal et al (2011), the 15 patients in this trial were divided into 3 groups (ESWT in a spastic muscle, ESWT in both spastic and antagonistic muscle, placebo ESWT) and treated in 3 weekly sessions. Spasticity was evaluated in the lower limbs by passive range of motion with a goniometer and in the upper limbs with the Ashworth Scale (0 [not spasticity] to 4 [severe spasticity]) at 1, 2, and 3 months posttreatment. The blinded evaluation showed significant differences between the ESWT and placebo groups for range of motion and Ashworth Scale score. For the group in which only the spastic muscle was treated, there was a 1-point improvement on the Ashworth Scale (reported significant vs. placebo); for the group with both spastic agonist and antagonist muscles treated, there was a 0.5-point improvement (p=not significant vs. placebo); and for the placebo group, there was no change. The significant improvements were maintained at 2 months posttreatment, but not at 3 months.

Section Summary: Spasticity

RCT and systematic review evidence are available on the use of ESWT for spasticity, primarily in patients with stroke and cerebral palsy. Several studies have demonstrated improvements in spasticity measures after ESWT, but most studies have small sample sizes and a single center design. More well-designed controlled trials in larger populations are needed to determine whether ESWT leads to clinically meaningful improvements in pain and/or functional outcomes for spasticity.

Extracorporeal Shock Wave Treatment for Other Conditions

ESWT has been investigated in small studies for other conditions, including coccydynia in a case series of 2 patients[115] and an RCT involving 34 patients,[116] painful neuromas at amputation sites in an RCT assessing 30 subjects,[117] and chronic distal biceps tendinopathy in a case-control study of 48 patients.[118]

The systematic review of ESWT for lower-extremity tendinopathies (previously described) by Mani-Babu et al (2015) reviewed 2 studies of ESWT for greater trochanteric pain syndrome, including 1 quasi-RCT comparing ESWT with home therapy or corticosteroid injection and 1 case-control study comparing ESWT with placebo.[74] ESWT was associated with some benefits compared with placebo or home therapy.

Supplemental Information

The purpose of the following information is to provide reference material. Inclusion does not imply endorsement or alignment with the evidence review conclusions.

Practice Guidelines and Position Statements

Guidelines or position statements will be considered for inclusion in 'Supplemental Information' if they were issued by, or jointly by, a U.S. professional society, an international society with U.S. representation, or National Institute for Health and Care Excellence (NICE). Priority will be given to guidelines that are informed by a systematic review, include strength of evidence ratings, and include a description of management of conflict of interest.

American College of Foot and Ankle Surgeons

In 2010, Thomas et al revised guidelines on the treatment of heel pain on behalf of the American College of Foot and Ankle Surgeons.[119] The guidelines identified extracorporeal shock wave therapy (ESWT) as a third tier treatment modality in patients who have failed other interventions, including steroid injection. The guidelines recommended ESWT as a reasonable alternative to surgery. In an update to the American College of Foot and Ankle Surgeons clinical consensus statement, Schneider et al stated that ESWT is a safe and effective treatment for plantar fasciitis.[120]

National Institute for Health and Care Excellence

The NICE has published guidance on ESWT for a number of applications.

- The 2 guidance documents issued in 2009 stated that current evidence on the efficacy of ESWT for refractory tennis elbow and plantar fasciitis "is inconsistent".[121,122]

- A guidance issued in 2011 stated that evidence on the efficacy and safety of ESWT for refractory greater trochanteric pain syndrome "is limited in quality and quantity".[123]
- A guidance issued in 2016 stated that current evidence on the efficacy of ESWT for Achilles tendinopathy "is inconsistent and limited in quality and quantity".[124]
- A guidance issued in 2022 stated that evidence on the efficacy of ESWT for calcific tendinopathy of the shoulder is inadequate. Despite a lack of safety concerns, the ESWT should only be used in the context of research.[125]

U.S. Preventive Services Task Force Recommendations

Not applicable.

Medicare National Coverage

There is no national coverage determination. In the absence of a national coverage determination, coverage decisions are left to the discretion of local Medicare carriers.

Ongoing and Unpublished Clinical Trials

Some currently ongoing and unpublished trials that might influence this review are listed in Table 27.

Table 27. Summary of Key Trials

NCT No.	Trial Name	Planned Enrollment	Completion Date
Ongoing			
NCT06815328	Efficacy of Shock Wave Therapy in Patients with Muscle Spasticity After a Stroke	50	Apr 2025
NCT06909838	Radial Shockwave Therapy With ShockMaster 300® to Reduce Spasticity in Children With CP or Acquired Brain Injury: a Pilot Stud	24	Jun 2025
NCT06674785	Effects of Extracorporeal Shock Wave Therapy on Shoulder Internal Rotator Spasticity in Post-Stroke Patients: A Randomized Controlled Trial	40	Dec 2027
NCT06705881	Efficacy of the Extracorporeal Shock Wave Therapy in Athletes With Patellar Tendinopathy	32	Sept 2025
NCT06372600	Effect of Extracorporeal Shock Wave Combined With Autologous Platelet-rich Plasma Injection on Rotator Cuff Calcific Tendinitis: A Randomized Controlled Trial	60	Feb 2026
NCT06603181	Effect of Extracorporeal Shock Wave Therapy (ESWT) and Phonophoresis Treatment on Pain, Function, Grip Strength and Tendon Thickness in Ultrasonography in Patients With Lateral Epicondylitis.	60	Apr 2025
NCT06890806	Comparison of the Effects of Foot Core Stabilization Exercises Versus Extracorporeal Shock Wave Therapy (ESWT) on Pain, Muscle Strength and Functionality in Individuals with Plantar Fasciitis	40	Jun 2025
NCT06846931	Comparison of the Efficacy of Low Intensity ESWT and Low Intensity LASER Therapy in the Treatment of Chronic Plantar Fasciitis; Randomized Controlled Trial	90	Dec 2025
NCT06128616	Efficacy of Extracorporeal Shock Wave Therapy in Children With Cerebral Palsy (Last Update Posted 2023-11-18)	40	Sept 2024 (not yet recruiting)
NCT06329154	Clinical Study On Extracorporeal Shock Wave Therapy For Rotator Cuff Injuries (Last Update Posted 2024-03-25)	58	Feb 2025 (recruiting)
NCT04316026	Effectiveness of Shock Wave Therapy to Treat Upper Limb Spasticity in Hemiparetic Patients (Last Update Posted 2023-04-13)	48	Jun 2024 (unknown status)
NCT02546128	LEICSTES=LEICeSter Tendon Extracorporeal Shock Wave Studies Assessing the Benefits of the Addition of Extracorporeal Shock Wave Treatment to a Home-Rehabilitation Programme for Patients with Tendinopathy (Last Update Posted 2024-05-01)	720	Dec 2024 (recruiting)

NCT No.	Trial Name	Planned Enrollment	Completion Date
NCT04332471	Treatment of Plantar Fasciitis With Radial Shockwave Therapy vs. Focused Shockwave Therapy: a Randomized Controlled Trial	114	Mar 2026
Unpublished			
NCT03472989	The Effectiveness of Radial Extracorporeal Shockwave Therapy (rESWT), Sham- rESWT, Standardized Exercise Program or Usual Care for Patients With Plantar Fasciopathy. Study Protocol for a Double-blind, Randomized Sham-Controlled Trial	200	Feb 2023
NCT05423366	Comparative Effects of Large Focused and Controlled Unfocused (Radial) Extracorporeal Shock Wave Therapies in the Treatment of Patellar Tendinopathy	75	Dec 2022
NCT05702606	Radial Extracorporeal Shock Wave Therapy for Management of Spasticity in Patients With Cerebral Palsy	73	Oct 2022
NCT05360316	The Effect of Extracorporeal Shock Wave Therapy Applied to the Plantar Region in Individuals With Hemiplegia on Mobility, Plantar Pressure Distribution and Sensory	60	May 2021
NCT03779919	The Therapeutic Effect of the Extracorporeal Shock Wave Therapy on Shoulder Calcific Tendinitis	90	May 2020
NCT03399968	Extracorporeal Shockwave Therapy (ESWT) in Patients Suffering From Complete Paraplegia at the Thoracic Level	25	May 2020
NCT02424084	Effects of Extracorporeal Shock Wave Therapy in Bone Microcirculation	80	Feb 2023
NCT05883020	Effect of Radial Shockwave on Calf Muscle Spasticity in Patients With Cerebral Palsy	50	March 2024
NCT06076239	Effect of Extracorporeal Shock Wave Therapy in Impingement Syndrome (ESWT)	32	June 2022
NCT05689593	Comparison of the Efficiency of Low Intensity Extracorporeal Shock Wave Therapy and Low Intensity Laser Therapy in Adhesive Capsulitis Treatment: a Randomized Controlled Study	60	Aug 2023
NCT05405140	Multiphasic Neuroplasticity Based Training Protocol With Shock Wave Therapy For Post Stroke Spasticity	32	Oct 2023
NCT05771220	The Effect of Extracorporeal Shockwave Therapy on Adhesive Capsulitis Shoulder: A Randomized Controlled Trial	40	Jul 2023

NCT: national clinical trial.

References

1. Dizon JN, Gonzalez-Suarez C, Zamora MT, et al. Effectiveness of extracorporeal shock wave therapy in chronic plantar fasciitis: a meta-analysis. Am J Phys Med Rehabil. Jul 2013; 92(7): 606-20. PMID 23552334
2. Aqil A, Siddiqui MR, Solan M, et al. Extracorporeal shock wave therapy is effective in treating chronic plantar fasciitis: a meta-analysis of RCTs. Clin Orthop Relat Res. Nov 2013; 471(11): 3645-52. PMID 23813184
3. Zhiyun L, Tao J, Zengwu S. Meta-analysis of high-energy extracorporeal shock wave therapy in recalcitrant plantar fasciitis. Swiss Med Wkly. 2013; 143: w13825. PMID 23832373
4. Yin MC, Ye J, Yao M, et al. Is extracorporeal shock wave therapy clinical efficacy for relief of chronic, recalcitrant plantar fasciitis? A systematic review and meta-analysis of randomized placebo or active-treatment controlled trials. Arch Phys Med Rehabil. Aug 2014; 95(8): 1585-93. PMID 24662810
5. Lou J, Wang S, Liu S, et al. Effectiveness of Extracorporeal Shock Wave Therapy Without Local Anesthesia in Patients With Recalcitrant Plantar Fasciitis: A Meta-Analysis of Randomized Controlled Trials. Am J Phys Med Rehabil. Aug 2017; 96(8): 529-534. PMID 27977431
6. Sun J, Gao F, Wang Y, et al. Extracorporeal shock wave therapy is effective in treating chronic plantar fasciitis: A meta-analysis of RCTs. Medicine (Baltimore). Apr 2017; 96(15): e6621. PMID 28403111

7. Li S, Wang K, Sun H, et al. Clinical effects of extracorporeal shock-wave therapy and ultrasound-guided local corticosteroid injections for plantar fasciitis in adults: A meta-analysis of randomized controlled trials. Medicine (Baltimore). Dec 2018; 97(50): e13687. PMID 30558080
8. Xiong Y, Wu Q, Mi B, et al. Comparison of efficacy of shock-wave therapy versus corticosteroids in plantar fasciitis: a meta-analysis of randomized controlled trials. Arch Orthop Trauma Surg. Apr 2019; 139(4): 529-536. PMID 30426211
9. Cortés-Pérez I, Moreno-Montilla L, Ibáñez-Vera AJ, et al. Efficacy of extracorporeal shockwave therapy, compared to corticosteroid injections, on pain, plantar fascia thickness and foot function in patients with plantar fasciitis: A systematic review and meta-analysis. Clin Rehabil. Aug 2024; 38(8): 1023-1043. PMID 38738305
10. Daher M, Covarrubias O, Herber A, et al. Platelet-Rich Plasma vs Extracorporeal Shock Wave Therapy in the Treatment of Plantar Fasciitis at 3-6 Months: A Systematic Review and Meta-analysis of Randomized Controlled Trials. Foot Ankle Int. Jul 2024; 45(7): 796-803. PMID 38419209
11. Lippi L, Folli A, Moalli S, et al. Efficacy and tolerability of extracorporeal shock wave therapy in patients with plantar fasciopathy: a systematic review with meta-analysis and meta-regression. Eur J Phys Rehabil Med. Oct 2024; 60(5): 832-846. PMID 39257331
12. Simental-Mendía M, Simental-Mendía LE, Sánchez-García A, et al. Effect of extracorporeal shockwave therapy on plantar fascia thickness in plantar fasciitis: a systematic review and meta-analysis of randomized controlled trials. Arch Orthop Trauma Surg. Aug 2024; 144(8): 3503-3516. PMID 39023569
13. Tung WS, Daher M, Covarrubias O, et al. Extracorporeal shock wave therapy shows comparative results with other modalities for the management of plantar fasciitis: A systematic review and meta-analysis. Foot Ankle Surg. Jun 2025; 31(4): 283-290. PMID 39572278
14. Majidi L, Khateri S, Nikbakht N, et al. The effect of extracorporeal shock-wave therapy on pain in patients with various tendinopathies: a systematic review and meta-analysis of randomized control trials. BMC Sports Sci Med Rehabil. Apr 24 2024; 16(1): 93. PMID 38659004
15. Heide M, Røe C, Mørk M, et al. Is radial extracorporeal shock wave therapy (rESWT), sham-rESWT or a standardised exercise programme in combination with advice plus customised foot orthoses more effective than advice plus customised foot orthoses alone in the treatment of plantar fasciopathy? A double-blind, randomised, sham-controlled trial. Br J Sports Med. Jul 31 2024; 58(16): 910-918. PMID 38904119
16. Gollwitzer H, Saxena A, DiDomenico LA, et al. Clinically relevant effectiveness of focused extracorporeal shock wave therapy in the treatment of chronic plantar fasciitis: a randomized, controlled multicenter study. J Bone Joint Surg Am. May 06 2015; 97(9): 701-8. PMID 25948515
17. Gerdesmeyer L, Frey C, Vester J, et al. Radial extracorporeal shock wave therapy is safe and effective in the treatment of chronic recalcitrant plantar fasciitis: results of a confirmatory randomized placebo-controlled multicenter study. Am J Sports Med. Nov 2008; 36(11): 2100-9. PMID 18832341
18. Food and Drug Administration. Summary of safety and effectiveness data: OrthospecTM Orthopedic ESWT. 2005; https://www.accessdata.fda.gov/cdrh_docs/pdf4/P040026b.pdf. Accessed April 22, 2025.
19. Food and Drug Administration. Summary of safety and effectiveness: Orbasone Pain Relief System. 2005; https://www.accessdata.fda.gov/cdrh_docs/pdf4/P040039b.pdf. Accessed April 24, 2025.
20. Radwan YA, Mansour AM, Badawy WS. Resistant plantar fasciopathy: shock wave versus endoscopic plantar fascial release. Int Orthop. Oct 2012; 36(10): 2147-56. PMID 22782376
21. Eslamian F, Shakouri SK, Jahanjoo F, et al. Extra Corporeal Shock Wave Therapy Versus Local Corticosteroid Injection in the Treatment of Chronic Plantar Fasciitis, a Single Blinded Randomized Clinical Trial. Pain Med. Sep 2016; 17(9): 1722-31. PMID 27282594

22. Lai TW, Ma HL, Lee MS, et al. Ultrasonography and clinical outcome comparison of extracorporeal shock wave therapy and corticosteroid injections for chronic plantar fasciitis: A randomized controlled trial. J Musculoskelet Neuronal Interact. Mar 01 2018; 18(1): 47-54. PMID 29504578
23. Xu D, Jiang W, Huang D, et al. Comparison Between Extracorporeal Shock Wave Therapy and Local Corticosteroid Injection for Plantar Fasciitis. Foot Ankle Int. Feb 2020; 41(2): 200-205. PMID 31744313
24. Rai S, Rajauria S, Khandelwal N, et al. Intralesional Steroid Injection Versus Extracorporeal Shockwave Therapy in the Treatment of Plantar Fasciitis: A Comparative, Prospective, Case Series Study. Cureus. Jan 2023; 15(1): e33593. PMID 36779116
25. Cinar E, Saxena S, Uygur F. Combination Therapy Versus Exercise and Orthotic Support in the Management of Pain in Plantar Fasciitis: A Randomized Controlled Trial. Foot Ankle Int. Apr 2018; 39(4): 406-414. PMID 29327602
26. Pisirici P, Cil ET, Coskunsu DK, et al. Extracorporeal Shockwave Therapy Versus Graston Instrument-Assisted Soft-Tissue Mobilization in Chronic Plantar Heel Pain: A Randomized Controlled Trial. J Am Podiatr Med Assoc. 2022; 112(6). PMID 36125974
27. Bahar-Ozdemir Y, Atan T. Effects of adjuvant low-dye Kinesio taping, adjuvant sham taping, or extracorporeal shockwave therapy alone in plantar fasciitis: A randomised double-blind controlled trial. Int J Clin Pract. May 2021; 75(5): e13993. PMID 33410228
28. Akdere E, Karpuz S, Yılmaz R, et al. Comparison of effectiveness of extracorporeal shock wave therapy and peloidotherapy in patients with plantar fasciitis: a prospective, randomized, controlled study. Int J Biometeorol. Jan 2025; 69(1): 17-28. PMID 39311965
29. Dede BT, Ada A, Oğuz M, et al. Comparing Myofascial Pain Syndrome Treatment with Dry Needling Versus Extracorporeal Shock Wave Therapy for Plantar Fasciitis on Pain and Function of the Heel. J Foot Ankle Surg. 2024; 63(4): 477-481. PMID 38484790
30. Timurtaş E, Çinar E, Selçuk H, et al. Extracorporeal Shockwave Therapy versus Low-Level Laser Therapy in the Treatment of Plantar Fasciitis: A Randomized Controlled Trial. J Am Podiatr Med Assoc. 2024; 114(4). PMID 36279266
31. Buchbinder R, Green SE, Youd JM, et al. Shock wave therapy for lateral elbow pain. Cochrane Database Syst Rev. Oct 19 2005; 2005(4): CD003524. PMID 16235324
32. Dingemanse R, Randsdorp M, Koes BW, et al. Evidence for the effectiveness of electrophysical modalities for treatment of medial and lateral epicondylitis: a systematic review. Br J Sports Med. Jun 2014; 48(12): 957-65. PMID 23335238
33. Zheng C, Zeng D, Chen J, et al. Effectiveness of extracorporeal shock wave therapy in patients with tennis elbow: A meta-analysis of randomized controlled trials. Medicine (Baltimore). Jul 24 2020; 99(30): e21189. PMID 32791694
34. Yoon SY, Kim YW, Shin IS, et al. Does the Type of Extracorporeal Shock Therapy Influence Treatment Effectiveness in Lateral Epicondylitis? A Systematic Review and Meta-analysis. Clin Orthop Relat Res. Oct 2020; 478(10): 2324-2339. PMID 32332245
35. Karanasios S, Tsamasiotis GK, Michopoulos K, et al. Clinical effectiveness of shockwave therapy in lateral elbow tendinopathy: systematic review and meta-analysis. Clin Rehabil. Oct 2021; 35(10): 1383-1398. PMID 33813913
36. Liu WC, Chen CT, Lu CC, et al. Extracorporeal Shock Wave Therapy Shows Superiority Over Injections for Pain Relief and Grip Strength Recovery in Lateral Epicondylitis: A Systematic Review and Network Meta-analysis. Arthroscopy. Jun 2022; 38(6): 2018-2034.e12. PMID 35093494
37. Yao G, Chen J, Duan Y, et al. Efficacy of Extracorporeal Shock Wave Therapy for Lateral Epicondylitis: A Systematic Review and Meta-Analysis. Biomed Res Int. 2020; 2020: 2064781. PMID 32309425
38. Yan C, Xiong Y, Chen L, et al. 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. J Orthop Surg Res. Aug 06 2019; 14(1): 248. PMID 31387611

39. Xiong Y, Xue H, Zhou W, et al. Shock-wave therapy versus corticosteroid injection on lateral epicondylitis: a meta-analysis of randomized controlled trials. Phys Sportsmed. Sep 2019; 47(3): 284-289. PMID 30951399
40. Zhang L, Zhang X, Pang L, et al. Extracorporeal Shock Wave Therapy Versus Local Corticosteroid Injection for Chronic Lateral Epicondylitis: A Systematic Review with Meta-Analysis of Randomized Controlled Trials. Orthop Surg. Nov 2024; 16(11): 2598-2607. PMID 39198038
41. Bilir EE, Atalay SG, Tezen Ö, et al. Comparison of high intensity laser therapy and extracorporeal shock wave in treatment of lateral epicondylitis: a randomized controlled study. Lasers Med Sci. Nov 08 2024; 39(1): 270. PMID 39511042
42. Perveen W, Anwar S, Hashmi R, et al. Effects of extracorporeal shockwave therapy versus ultrasonic therapy and deep friction massage in the management of lateral epicondylitis: a randomized clinical trial. Sci Rep. Jul 17 2024; 14(1): 16535. PMID 39019948
43. Król P, Łojewski B, Król T, et al. Focused shock wave and ultrasound therapies in the treatment of lateral epicondylitis - a randomized control trial. Sci Rep. Oct 30 2024; 14(1): 26053. PMID 39472446
44. Çetin BV, Sepetçi Ö, Yazar İ, et al. Comparison of local massage, steroid injection, and extracorporeal shock wave therapy efficacy in the treatment of lateral epicondylitis. Jt Dis Relat Surg. Apr 26 2024; 35(2): 386-395. PMID 38727119
45. Kaplan S, Sah V, Ozkan S, et al. Comparative Effects of Focused and Radial Extracorporeal Shock Wave Therapies on Lateral Epicondylitis: A Randomised Sham-controlled Trial. J Coll Physicians Surg Pak. May 2023; 33(5): 554-559. PMID 37190692
46. Aldajah S, Alashram AR, Annino G, et al. Analgesic Effect of Extracorporeal Shock-Wave Therapy in Individuals with Lateral Epicondylitis: A Randomized Controlled Trial. J Funct Morphol Kinesiol. Mar 18 2022; 7(1). PMID 35323612
47. Guler T, Yildirim P. Comparison of the efficacy of kinesiotaping and extracorporeal shock wave therapy in patients with newly diagnosed lateral epicondylitis: A prospective randomized trial. Niger J Clin Pract. May 2020; 23(5): 704-710. PMID 32367880
48. Yang TH, Huang YC, Lau YC, et al. Efficacy of Radial Extracorporeal Shock Wave Therapy on Lateral Epicondylosis, and Changes in the Common Extensor Tendon Stiffness with Pretherapy and Posttherapy in Real-Time Sonoelastography: A Randomized Controlled Study. Am J Phys Med Rehabil. Feb 2017; 96(2): 93-100. PMID 27323324
49. Capan N, Esmaeilzadeh S, Oral A, et al. Radial Extracorporeal Shock Wave Therapy Is Not More Effective Than Placebo in the Management of Lateral Epicondylitis: A Double-Blind, Randomized, Placebo-Controlled Trial. Am J Phys Med Rehabil. Jul 2016; 95(7): 495-506. PMID 26544854
50. Lizis P. Analgesic effect of extracorporeal shock wave therapy versus ultrasound therapy in chronic tennis elbow. J Phys Ther Sci. Aug 2015; 27(8): 2563-7. PMID 26357440
51. Gündüz R, Malas FÜ, Borman P, et al. Physical therapy, corticosteroid injection, and extracorporeal shock wave treatment in lateral epicondylitis. Clinical and ultrasonographical comparison. Clin Rheumatol. May 2012; 31(5): 807-12. PMID 22278162
52. Staples MP, Forbes A, Ptasznik R, et al. A randomized controlled trial of extracorporeal shock wave therapy for lateral epicondylitis (tennis elbow). J Rheumatol. Oct 2008; 35(10): 2038-46. PMID 18792997
53. Blue Cross and Blue Shield Association Technology Evaluation Center (TEC). Extracorporeal shock wave treatment for musculoskeletal indications TEC Assessments. 2003;Volume 18:Tab 5.
54. Pettrone FA, McCall BR. Extracorporeal shock wave therapy without local anesthesia for chronic lateral epicondylitis. J Bone Joint Surg Am. Jun 2005; 87(6): 1297-304. PMID 15930540
55. Xue X, Song Q, Yang X, et al. Effect of extracorporeal shockwave therapy for rotator cuff tendinopathy: a systematic review and meta-analysis. BMC Musculoskelet Disord. May 04 2024; 25(1): 357. PMID 38704572

56. Kamonseki DH, da Rocha GM, Ferreira VMLM, et al. Extracorporeal Shockwave Therapy for the Treatment of Noncalcific Rotator Cuff Tendinopathy: A Systematic Review and Meta-analysis. Am J Phys Med Rehabil. Jun 01 2024; 103(6): 471-479. PMID 37903597
57. Angileri HS, Gohal C, Comeau-Gauthier M, et al. Chronic calcific tendonitis of the rotator cuff: a systematic review and meta-analysis of randomized controlled trials comparing operative and nonoperative interventions. J Shoulder Elbow Surg. Aug 2023; 32(8): 1746-1760. PMID 37080421
58. Wu YC, Tsai WC, Tu YK, et al. Comparative Effectiveness of Nonoperative Treatments for Chronic Calcific Tendinitis of the Shoulder: A Systematic Review and Network Meta-Analysis of Randomized Controlled Trials. Arch Phys Med Rehabil. Aug 2017; 98(8): 1678-1692.e6. PMID 28400182
59. Arirachakaran A, Boonard M, Yamaphai S, et al. Extracorporeal shock wave therapy, ultrasound-guided percutaneous lavage, corticosteroid injection and combined treatment for the treatment of rotator cuff calcific tendinopathy: a network meta-analysis of RCTs. Eur J Orthop Surg Traumatol. Apr 2017; 27(3): 381-390. PMID 27554465
60. Ioppolo F, Tattoli M, Di Sante L, et al. Clinical improvement and resorption of calcifications in calcific tendinitis of the shoulder after shock wave therapy at 6 months' follow-up: a systematic review and meta-analysis. Arch Phys Med Rehabil. Sep 2013; 94(9): 1699-706. PMID 23499780
61. Brindisino F, Marruganti S, Lorusso D, et al. The effectiveness of extracorporeal shock wave therapy for rotator cuff calcific tendinopathy. A systematic review with meta-analysis. Physiother Res Int. Jul 2024; 29(3): e2106. PMID 38878302
62. Yu H, Côté P, Shearer HM, et al. Effectiveness of passive physical modalities for shoulder pain: systematic review by the Ontario protocol for traffic injury management collaboration. Phys Ther. Mar 2015; 95(3): 306-18. PMID 25394425
63. Verstraelen FU, In den Kleef NJ, Jansen L, et al. High-energy versus low-energy extracorporeal shock wave therapy for calcifying tendinitis of the shoulder: which is superior? A meta-analysis. Clin Orthop Relat Res. Sep 2014; 472(9): 2816-25. PMID 24872197
64. Bannuru RR, Flavin NE, Vaysbrot E, et al. High-energy extracorporeal shock-wave therapy for treating chronic calcific tendinitis of the shoulder: a systematic review. Ann Intern Med. Apr 15 2014; 160(8): 542-9. PMID 24733195
65. Huisstede BM, Gebremariam L, van der Sande R, et al. Evidence for effectiveness of Extracorporal Shock-Wave Therapy (ESWT) to treat calcific and non-calcific rotator cuff tendinosis--a systematic review. Man Ther. Oct 2011; 16(5): 419-33. PMID 21396877
66. ElGendy MH, Mazen MM, Saied AM, et al. Extracorporeal Shock Wave Therapy vs. Corticosteroid Local Injection in Shoulder Impingement Syndrome : A Three-Arm Randomized Controlled Trial. Am J Phys Med Rehabil. Jun 01 2023; 102(6): 533-540. PMID 36730000
67. Lee HW, Kim JY, Park CW, et al. Comparison of Extracorporeal Shock Wave Therapy and Ultrasound-Guided Shoulder Injection Therapy in Patients with Supraspinatus Tendinitis. Clin Orthop Surg. Dec 2022; 14(4): 585-592. PMID 36518938
68. Kvalvaag E, Roe C, Engebretsen KB, et al. One year results of a randomized controlled trial on radial Extracorporeal Shock Wave Treatment, with predictors of pain, disability and return to work in patients with subacromial pain syndrome. Eur J Phys Rehabil Med. Jun 2018; 54(3): 341-350. PMID 28655271
69. Kvalvaag E, Brox JI, Engebretsen KB, et al. Effectiveness of Radial Extracorporeal Shock Wave Therapy (rESWT) When Combined With Supervised Exercises in Patients With Subacromial Shoulder Pain: A Double-Masked, Randomized, Sham-Controlled Trial. Am J Sports Med. Sep 2017; 45(11): 2547-2554. PMID 28586628
70. Kim EK, Kwak KI. Effect of extracorporeal shock wave therapy on the shoulder joint functional status of patients with calcific tendinitis. J Phys Ther Sci. Sep 2016; 28(9): 2522-2524. PMID 27799684
71. Kim YS, Lee HJ, Kim YV, et al. Which method is more effective in treatment of calcific tendinitis in the shoulder? Prospective randomized comparison between ultrasound-guided

needling and extracorporeal shock wave therapy. J Shoulder Elbow Surg. Nov 2014; 23(11): 1640-6. PMID 25219475

72. Schofer MD, Hinrichs F, Peterlein CD, et al. High- versus low-energy extracorporeal shock wave therapy of rotator cuff tendinopathy: a prospective, randomised, controlled study. Acta Orthop Belg. Aug 2009; 75(4): 452-8. PMID 19774810
73. Liu S, Zhai L, Shi Z, et al. Radial extracorporeal pressure pulse therapy for the primary long bicipital tenosynovitis a prospective randomized controlled study. Ultrasound Med Biol. May 2012; 38(5): 727-35. PMID 22425375
74. Mani-Babu S, Morrissey D, Waugh C, et al. The effectiveness of extracorporeal shock wave therapy in lower limb tendinopathy: a systematic review. Am J Sports Med. Mar 2015; 43(3): 752-61. PMID 24817008
75. Al-Abbad H, Simon JV. The effectiveness of extracorporeal shock wave therapy on chronic achilles tendinopathy: a systematic review. Foot Ankle Int. Jan 2013; 34(1): 33-41. PMID 23386759
76. Costa ML, Shepstone L, Donell ST, et al. Shock wave therapy for chronic Achilles tendon pain: a randomized placebo-controlled trial. Clin Orthop Relat Res. Nov 2005; 440: 199-204. PMID 16239807
77. Rasmussen S, Christensen M, Mathiesen I, et al. Shockwave therapy for chronic Achilles tendinopathy: a double-blind, randomized clinical trial of efficacy. Acta Orthop. Apr 2008; 79(2): 249-56. PMID 18484252
78. Alsulaimani B, Perraton L, Vallance P, et al. Does shockwave therapy lead to better pain and function than sham over 12 weeks in people with insertional Achilles tendinopathy? A randomised controlled trial. Clin Rehabil. Feb 2025; 39(2): 174-186. PMID 39704142
79. Stania M, Juras G, Marszałek W, et al. Analysis of pain intensity and postural control for assessing the efficacy of shock wave therapy and sonotherapy in Achilles tendinopathy - A randomized controlled trial. Clin Biomech (Bristol). Jan 2023; 101: 105830. PMID 36469960
80. Abdelkader NA, Helmy MNK, Fayaz NA, et al. Short- and Intermediate-Term Results of Extracorporeal Shockwave Therapy for Noninsertional Achilles Tendinopathy. Foot Ankle Int. Jun 2021; 42(6): 788-797. PMID 33451253
81. Pinitkwamdee S, Laohajaroensombat S, Orapin J, et al. Effectiveness of Extracorporeal Shockwave Therapy in the Treatment of Chronic Insertional Achilles Tendinopathy. Foot Ankle Int. Apr 2020; 41(4): 403-410. PMID 31924120
82. Lynen N, De Vroey T, Spiegel I, et al. Comparison of Peritendinous Hyaluronan Injections Versus Extracorporeal Shock Wave Therapy in the Treatment of Painful Achilles' Tendinopathy: A Randomized Clinical Efficacy and Safety Study. Arch Phys Med Rehabil. Jan 2017; 98(1): 64-71. PMID 27639439
83. Stania M, Król T, Marszałek W, et al. Treatment of Jumper's Knee with Extracorporeal Shockwave Therapy: A Systematic Review and Meta-Analysis. J Hum Kinet. Oct 2022; 84: 124-134. PMID 36457482
84. Liao CD, Xie GM, Tsauo JY, et al. Efficacy of extracorporeal shock wave therapy for knee tendinopathies and other soft tissue disorders: a meta-analysis of randomized controlled trials. BMC Musculoskelet Disord. Aug 02 2018; 19(1): 278. PMID 30068324
85. van Leeuwen MT, Zwerver J, van den Akker-Scheek I. Extracorporeal shockwave therapy for patellar tendinopathy: a review of the literature. Br J Sports Med. Mar 2009; 43(3): 163-8. PMID 18718975
86. Thijs KM, Zwerver J, Backx FJ, et al. Effectiveness of Shockwave Treatment Combined With Eccentric Training for Patellar Tendinopathy: A Double-Blinded Randomized Study. Clin J Sport Med. Mar 2017; 27(2): 89-96. PMID 27347857
87. Smith J, Sellon JL. Comparing PRP injections with ESWT for athletes with chronic patellar tendinopathy. Clin J Sport Med. Jan 2014; 24(1): 88-9. PMID 24366015
88. Newman P, Waddington G, Adams R. Shockwave treatment for medial tibial stress syndrome: A randomized double blind sham-controlled pilot trial. J Sci Med Sport. Mar 2017; 20(3): 220-224. PMID 27640922

89. Rompe JD, Cacchio A, Furia JP, et al. Low-energy extracorporeal shock wave therapy as a treatment for medial tibial stress syndrome. Am J Sports Med. Jan 2010; 38(1): 125-32. PMID 19776340
90. Barnes M. Letter to the editor. "Low-energy extracorporeal shock wave therapy as a treatment for medial tibial stress syndrome". Am J Sports Med. Nov 2010; 38(11): NP1; author reply NP1-2. PMID 20971968
91. Tan H, Tang P, Chai H, et al. Extracorporeal shock wave therapy with imaging examination for early osteonecrosis of the femoral head: a systematic review. Int J Surg. Jan 01 2025; 111(1): 1144-1153. PMID 38896858
92. Hao Y, Guo H, Xu Z, et al. Meta-analysis of the potential role of extracorporeal shockwave therapy in osteonecrosis of the femoral head. J Orthop Surg Res. Jul 03 2018; 13(1): 166. PMID 29970103
93. Zhang Q, Liu L, Sun W, et al. Extracorporeal shockwave therapy in osteonecrosis of femoral head: A systematic review of now available clinical evidences. Medicine (Baltimore). Jan 2017; 96(4): e5897. PMID 28121934
94. Alves EM, Angrisani AT, Santiago MB. The use of extracorporeal shock waves in the treatment of osteonecrosis of the femoral head: a systematic review. Clin Rheumatol. Nov 2009; 28(11): 1247-51. PMID 19609482
95. Sansone V, Ravier D, Pascale V, et al. Extracorporeal Shockwave Therapy in the Treatment of Nonunion in Long Bones: A Systematic Review and Meta-Analysis. J Clin Med. Apr 01 2022; 11(7). PMID 35407583
96. Zelle BA, Gollwitzer H, Zlowodzki M, et al. Extracorporeal shock wave therapy: current evidence. J Orthop Trauma. Mar 2010; 24 Suppl 1: S66-70. PMID 20182240
97. Wang CJ, Liu HC, Fu TH. The effects of extracorporeal shockwave on acute high-energy long bone fractures of the lower extremity. Arch Orthop Trauma Surg. Feb 2007; 127(2): 137-42. PMID 17053946
98. Cacchio A, Giordano L, Colafarina O, et al. Extracorporeal shock-wave therapy compared with surgery for hypertrophic long-bone nonunions. J Bone Joint Surg Am. Nov 2009; 91(11): 2589-97. PMID 19884432
99. Zhai L, Ma XL, Jiang C, et al. Human autologous mesenchymal stem cells with extracorporeal shock wave therapy for nonunion of long bones. Indian J Orthop. Sep 2016; 50(5): 543-550. PMID 27746499
100. Liu WF, Zhang SM. Extracorporeal Shock Wave Therapy for Limb Dysfunction after Stroke: A Systematic Review and Meta-analysis. Am J Phys Med Rehabil. Jan 03 2025. PMID 39750027
101. Afzal B, Noor R, Mumtaz N, et al. Effects of extracorporeal shock wave therapy on spasticity, walking and quality of life in poststroke lower limb spasticity: a systematic review and meta-analysis. Int J Neurosci. Dec 2024; 134(12): 1503-1517. PMID 37824712
102. Otero-Luis I, Cavero-Redondo I, Álvarez-Bueno C, et al. Effectiveness of Extracorporeal Shock Wave Therapy in Treatment of Spasticity of Different Aetiologies: A Systematic Review and Meta-Analysis. J Clin Med. Feb 26 2024; 13(5). PMID 38592705
103. Mihai EE, Dumitru L, Mihai IV, et al. Long-Term Efficacy of Extracorporeal Shock Wave Therapy on Lower Limb Post-Stroke Spasticity: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. J Clin Med. Dec 29 2020; 10(1). PMID 33383655
104. Cabanas-Valdés R, Serra-Llobet P, Rodriguez-Rubio PR, et al. The effectiveness of extracorporeal shock wave therapy for improving upper limb spasticity and functionality in stroke patients: a systematic review and meta-analysis. Clin Rehabil. Sep 2020; 34(9): 1141-1156. PMID 32513019
105. Jia G, Ma J, Wang S, et al. Long-term Effects of Extracorporeal Shock Wave Therapy on Poststroke Spasticity: A Meta-analysis of Randomized Controlled Trials. J Stroke Cerebrovasc Dis. Mar 2020; 29(3): 104591. PMID 31899073
106. Kim HJ, Park JW, Nam K. Effect of extracorporeal shockwave therapy on muscle spasticity in patients with cerebral palsy: meta-analysis and systematic review. Eur J Phys Rehabil Med. Dec 2019; 55(6): 761-771. PMID 31615195

107. Lee JY, Kim SN, Lee IS, et al. Effects of Extracorporeal Shock Wave Therapy on Spasticity in Patients after Brain Injury: A Meta-analysis. J Phys Ther Sci. Oct 2014; 26(10): 1641-7. PMID 25364134
108. Fan T, Chen R, Wei M, et al. Effects of radial extracorporeal shock wave therapy on flexor spasticity of the upper limb in post-stroke patients: A randomized controlled trial. Clin Rehabil. Sep 2024; 38(9): 1200-1213. PMID 38863234
109. Nada DW, El Sharkawy AM, Elbarky EM, et al. Radial extracorporeal shock wave therapy as an additional treatment modality for spastic equinus deformity in chronic hemiplegic patients. A randomized controlled study. Disabil Rehabil. Sep 2024; 46(19): 4486-4494. PMID 37926696
110. Brunelli S, Gentileschi N, Spanò B, et al. Effect of Early Radial Shock Wave Treatment on Spasticity in Subacute Stroke Patients: A Pilot Study. Biomed Res Int. 2022; 2022: 8064548. PMID 35909493
111. Vidal X, Martí-Fàbregas J, Canet O, et al. Efficacy of radial extracorporeal shock wave therapy compared with botulinum toxin type A injection in treatment of lower extremity spasticity in subjects with cerebral palsy: A randomized, controlled, cross-over study. J Rehabil Med. Jun 30 2020; 52(6): jrm00076. PMID 32556354
112. Li G, Yuan W, Liu G, et al. Effects of radial extracorporeal shockwave therapy on spasticity of upper-limb agonist/antagonist muscles in patients affected by stroke: a randomized, single-blind clinical trial. Age Ageing. Feb 27 2020; 49(2): 246-252. PMID 31846499
113. Wu YT, Yu HK, Chen LR, et al. Extracorporeal Shock Waves Versus Botulinum Toxin Type A in the Treatment of Poststroke Upper Limb Spasticity: A Randomized Noninferiority Trial. Arch Phys Med Rehabil. Nov 2018; 99(11): 2143-2150. PMID 30392753
114. Vidal X, Morral A, Costa L, et al. Radial extracorporeal shock wave therapy (rESWT) in the treatment of spasticity in cerebral palsy: a randomized, placebo-controlled clinical trial. NeuroRehabilitation. 2011; 29(4): 413-9. PMID 22207070
115. Marwan Y, Husain W, Alhajii W, et al. Extracorporeal shock wave therapy relieved pain in patients with coccydynia: a report of two cases. Spine J. Jan 2014; 14(1): e1-4. PMID 24094989
116. Ahadi T, Hosseinverdi S, Raissi G, et al. Comparison of Extracorporeal Shockwave Therapy and Blind Steroid Injection in Patients With Coccydynia: A Randomized Clinical Trial. Am J Phys Med Rehabil. May 01 2022; 101(5): 417-422. PMID 34091468
117. Jung YJ, Park WY, Jeon JH, et al. Outcomes of ultrasound-guided extracorporeal shock wave therapy for painful stump neuroma. Ann Rehabil Med. Aug 2014; 38(4): 523-33. PMID 25229031
118. Furia JP, Rompe JD, Maffulli N, et al. Radial Extracorporeal Shock Wave Therapy Is Effective and Safe in Chronic Distal Biceps Tendinopathy. Clin J Sport Med. Sep 2017; 27(5): 430-437. PMID 27893487
119. Thomas JL, Christensen JC, Kravitz SR, et al. The diagnosis and treatment of heel pain: a clinical practice guideline-revision 2010. J Foot Ankle Surg. 2010; 49(3 Suppl): S1-19. PMID 20439021
120. Schneider HP, Baca JM, Carpenter BB, et al. American College of Foot and Ankle Surgeons Clinical Consensus Statement: Diagnosis and Treatment of Adult Acquired Infracalcaneal Heel Pain. J Foot Ankle Surg. 2018; 57(2): 370-381. PMID 29284574
121. National Institute for Health and Care Excellence (NICE). Extracorporeal shockwave therapy for refractory tennis elbow [IPG313]. 2009; https://www.nice.org.uk/guidance/ipg313. Accessed April 23, 2025.
122. National Institute for Health and Care Excellence (NICE). Extracorporeal shockwave therapy for refractory plantar fasciitis: guidance [IPG311]. 2009; https://www.nice.org.uk/guidance/ipg311. Accessed April 23, 2025.
123. National Institute for Health and Care Excellence (NICE). Extracorporeal shockwave therapy for refractory greater trochanteric pain syndrome [IPG376]. 2011; https://www.nice.org.uk/guidance/ipg376. Accessed April 23, 2025.

124. National Institute for Health and Care Excellence (NICE). Extracorporeal shockwave therapy for Achilles tendinopathy [IPG571]. 2016; https://www.nice.org.uk/guidance/ipg571. Accessed April 23, 2025.
125. National Institute for Health and Care Excellence. Extracorporeal shockwave therapy for calcific tendinopathy in the shoulder. Published November 2022. https://www.nice.org.uk/guidance/ipg742. Accessed April 23, 2025.

Documentation for Clinical Review

Please provide the following documentation:

- History and physical and/or consultation notes including:
  - Clinical findings (i.e., pertinent symptoms and duration)
  - Comorbidities
  - Activity and functional limitations
  - Family history, if applicable
  - Reason for procedure/test/device, when applicable
  - Pertinent past procedural and surgical history
  - Past and present diagnostic testing and results
  - Prior conservative treatments, duration, and response
  - Treatment plan (i.e., surgical intervention)
- Consultation and medical clearance report(s), when applicable
- Radiology report(s) and interpretation (i.e., MRI, CT, discogram)
- Laboratory results
- Other pertinent multidisciplinary notes/reports: (i.e., psychological or psychiatric evaluation, physical therapy, multidisciplinary pain management), when applicable

Post Service (in addition to the above, please include the following):

- Results/reports of tests performed
- Procedure report(s)

Coding

The list of codes in this Medical Policy is intended as a general reference and may not cover all codes. Inclusion or exclusion of a code(s) does not constitute or imply member coverage or provider reimbursement policy.

Type	Code	Description
CPT®	0101T	Extracorporeal shock wave involving musculoskeletal system, not otherwise specified
	0102T	Extracorporeal shock wave performed by a physician, requiring anesthesia other than local, and involving the lateral humeral epicondyle
	20999	Unlisted procedure, musculoskeletal system, general
	28890	Extracorporeal shock wave, high energy, performed by a physician or other qualified health care professional, requiring anesthesia other than local, including ultrasound guidance, involving the plantar fascia
HCPCS	None	

Policy History

This section provides a chronological history of the activities, updates and changes that have occurred with this Medical Policy.

Effective Date	Action
12/01/2025	New policy.

Definitions of Decision Determinations

Healthcare Services: For the purpose of this Medical Policy, Healthcare Services means procedures, treatments, supplies, devices, and equipment.

Medically Necessary or **Medical Necessity** means reasonable and necessary services to protect life, to prevent significant illness or significant disability, or alleviate severe pain through the diagnosis or treatment of disease, illness, or injury, as required under W&I section 14059.5(a) and 22 CCR section 51303(a). Medically Necessary services must include services necessary to achieve age-appropriate growth and development, and attain, maintain, or regain functional capacity.

For Members less than 21 years of age, a service is Medically Necessary if it meets the Early and Periodic Screening, Diagnostic, and Treatment (EPSDT) standard of Medical Necessity set forth in 42 USC section 1396d(r)(5), as required by W&I sections 14059.5(b) and 14132(v). Without limitation, Medically Necessary services for Members less than 21 years of age include all services necessary to achieve or maintain age-appropriate growth and development, attain, regain or maintain functional capacity, or improve, support, or maintain the Member's current health condition. Contractor must determine Medical Necessity on a case-by-case basis, taking into account the individual needs of the Child.

Criteria Determining Experimental/Investigational Status
In making a determination that any procedure, treatment, therapy, drug, biological product, facility, equipment, device, or supply is "experimental or investigational" by the Plan, the Plan shall refer to evidence from the national medical community, which may include one or more of the following sources:

1. Evidence from national medical organizations, such as the National Centers of Health Service Research.
2. Peer-reviewed medical and scientific literature.
3. Publications from organizations, such as the American Medical Association (AMA).
4. Professionals, specialists, and experts.
5. Written protocols and consent forms used by the proposed treating facility or other facility administering substantially the same drug, device, or medical treatment.
6. An expert physician panel selected by one of two organizations, the Managed Care Ombudsman Program of the Medical Care Management Corporation or the Department of Managed Health Care.

Feedback

Blue Shield of California Promise Health Plan is interested in receiving feedback relative to developing, adopting, and reviewing criteria for medical policy. Any licensed practitioner who is contracted with Blue Shield of California Promise Health Plan is welcome to provide comments, suggestions, or concerns. Our internal policy committees will receive and take your comments into consideration. Our medical policies are available to view or download at www.blueshieldca.com/en/bsp/providers.

For medical policy feedback, please send comments to: MedPolicy@blueshieldca.com

Questions regarding the applicability of this policy should be directed to the Blue Shield of California Promise Health Plan Prior Authorization Department at (800) 468-9935, or the Complex Case Management Department at (855) 699-5557 (TTY 711) for San Diego County and (800) 605-2556 (TTY 711) for Los Angeles County or visit the provider portal at www.blueshieldca.com/en/bsp/providers.

Disclaimer: Blue Shield of California Promise Health Plan may consider published peer-reviewed scientific literature, national guidelines, and local standards of practice in developing its medical policy. Federal and state law, as well as member health services contract language, including definitions and specific contract provisions/exclusions, take precedence over medical policy and must be considered first in determining covered services. Member health services contracts may differ in their benefits. Blue Shield of California Promise Health Plan reserves the right to review and update policies as appropriate.