

# Application of ESWT in post-operative treatment in Carpal Tunnel Syndrome – a review

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**ABSTRACT:** The aim of this study is to evaluate the potential use of extracorporeal shockwave therapy (ESWT) in the post-operative treatment of patients with carpal tunnel syndrome. A body of evidence validates the use of ESWT in various medical areas, mostly in nephrolithiasis, but also in a number of musculoskeletal conditions and in wound healing. Our knowledge about the use of ESWT in carpal tunnel syndrome seems sparse, which combined with a lack of reference values, forms a major limitation of the use of ESWT in this condition.

**KEYWORDS:** carpal tunnel syndrome, ESWT, post-operative treatment, rehabilitation

## ABBREVIATIONS

**BCTQ** – Boston Carpal Tunnel Questionnaire  
**BDI** – Beck depression index  
**CPT** – conservative physical therapy  
**ESWT** – extracorporeal shockwave therapy  
**FSWT** – focused shockwave therapy  
**GTPS** – greater trochanteric pain syndrome  
**LCsI** – local corticosteroid injections  
**MNCV** – motor nerve muscular conduction  
**moVSS** – modified Vancouver Scar Scale  
**NO** – nitric oxide  
**NOS** – nitric oxide synthase  
**ODI** – Oswestry Disability Index  
**ONFH** – osteonecrosis of the femoral head  
**ROM** – range of motion score  
**RSWT** – radial shockwave therapy  
**SMD** – standardized mean difference  
**SNCV** – sensory nerve conduction velocity  
**VAS** – visual analogue scale

## WHAT IS ESWT?

ESWT (Extracorporeal Shockwave Therapy) is a therapy which uses acoustic pulse, in a wide range of medical applications. Most commonly, it is used for lithotripsy in patients suffering from kidney stones [1], but there are numerous other applications of ESWT, such as treatment of ‘tennis elbow’ [2], Achilles tendinitis [3], promotion of bone healing [4] or wound healing [5].

Introduced in 1982 for urinary stones lithotripsy [6], ESWT redefined the approach to nephrolithiasis and became the primary strategy for its treatment [7]. Later, the method has been transferred to orthopaedics, where it is not only still in use, but also new applications are being innovated [8].

Sound waves are oscillating, mechanical waves which travel through all states of matter. Shockwave is a certain kind of sound wave, which is non-linear and has a short rise time. Its total duration time is around 10  $\mu$ s. Shockwaves consist of a positive and a negative phase. Firstly, the positive phase of a shockwave causes high pressure to hit

an interface, resulting in either reflection, or passing and gradual absorption of energy. Secondly, the negative phase causes cavitation on tissue interfaces. As a consequence, air bubbles are formed which burst with high energy, causing the second shockwave [9].

ESWT includes two types of therapy: focused shockwave therapy (FSWT) and radial shockwave therapy (RSWT). In FSWT, the waves are formed in water inside the applicator. This decreases reflection and promotes better transfer of waves inside the body, as the acoustic impedance of water and body tissues are analogous. The pressure field converges at desired depth in the tissues, where it reaches its maximal pressure. In RSWT, the shockwaves are generated by accelerating the projectile by air pressure inside the applicator. In this case, the pressure field diverges, which means that the maximal pressure is generated at the point of application [10].

The purpose of this study is to analyse available data on the use of ESWT in carpal tunnel syndrome and evaluate its application in this condition.

## HOW DOES ESWT AFFECT TISSUES?

The exact mechanism of ESWT remains unknown. Nevertheless, many proofs of its efficacy can be easily found in the literature. Considering the vast body of already existing academic research, the fact that ESWT is an efficient and versatile treatment seems undeniable.

### Tendinopathies

In a study [11] by Vahdatpour et al., the authors analysed the effectiveness of ESWT in chronic Achilles tendinopathy. Pain was measured by visual analogue scale (VAS). Among 43 patients, the mean VAS score decreased in the ESWT-treated group from 7.55 to 3. Although the overall decrease in that group was visible, due to the small sample size, the difference was statistically insignificant and the authors proposed a more valuable, prospective study with a larger sample size to be carried out. Moreover, in a meta-analysis studying various non-surgical treatments of patellar tendinopathy [12], involving 70 studies and 2530 patients, ESWT showed a positive outcome in the general qualitative data synthesis. In another

meta-analysis, 29 randomized controlled trials were analysed to understand the influence of ESWT on lower extremity tendinopathy. Data was collected during an immediate follow-up appointment, as well as 3, 6 and more than 12 months afterwards. Patients treated with ESWT showed standardized mean difference (SMD) in pain score equal to -1.41 and improvement of function of lower extremity (LE) (SMD = 2.59). The authors claim that 'ESWT exerted a positive overall effect on pain and function in LE tendinopathy' [13].

### Low back pain

In a randomised study ESWT was assessed in the treatment of patients with low back pain. In a group of thirty patients, ESWT showed 'significant improvement in terms of values of amplitude of the sensory nerve conduction velocity (SNCV) of the plantar medialis nerve [...], the motor nerve muscular conduction (MNCV) of the deep peroneal nerve [...] and recruitment of motor units of finger brevis extensor' [14] as compared to the control group – patients treated with exercise program – where the improvement was statistically insignificant. In a different study, Korean authors showed advantage of exercise program combined with ESWT over conservative physical therapy (CPT) in patients with chronic low back pain [15]. The same was analysed in a different study, where ESWT was assessed with VAS, Oswestry Disability Index (ODI) and Beck depression index (BDI), revealing significant decreases in these parameters and, therefore, inclining the authors to consider ESWT 'an effective intervention for the treatment of pain, disability, and depression in chronic low back pain patients' [16].

### Osteonecrosis

Application of ESWT can be found in the treatment of bone necrosis. In another study, 14 patients with hip necrosis were tested, half of whom received ESWT treatment. It was observed that patients treated with ESWT 'showed significantly more viable bone and less necrotic bone, higher cell concentration and more cell activities including phagocytosis than the control group' [17]. In a systematic review, Chinese authors, basing on 17 articles, concluded a positive effect of ESWT in patients with osteonecrosis of the femoral head (ONFH) in terms of pain relief and improvement of motor functions, suggesting that ESWT 'could slow or even block the progression of ONFH and therefore reduce the demand for surgery' [18]. In a meta-analysis, the authors aimed to evaluate the influence of ESWT on ONFH, in comparison to other treatment strategies. Although there was no statistically significant difference in pain score before and after the treatment between ESWT and other methods, Harris hip score, which qualifies hip disability, showed a great improvement in ESWT-treated patients (SMD = 1.2969). The authors concluded that 'For patients at an early stage, ESWT may be safe and effective for relief of pain and improvement of motor function' [19]. These results are confirmed in long-term outcomes found in another study with a 10-year follow-up [20].

### Other musculoskeletal conditions

ESWT is found useful in the treatment of plantar heel pain, a condition associated with inflammation of plantar fascia. In one meta-analysis, where altogether 2450 patients with plantar heel pain were evaluated, the shockwave therapy, similarly to corticosteroid injections, were 'ranked most likely to be effective

in the management of short-term, medium-term and long-term pain or function' [21]. In a retrospective, cohort study, published by Furia et al., 36 patients with greater trochanteric pain syndrome (GTPS) were treated with ESWT. The results were measured by the use of VAS scores, Harris Hip Scores and Roles-Maudsley scores, in all of which the treatment led to 'a statistically significant improvement' [22]. Additionally, Rompe et al. compared ESWT to corticosteroid injections and home training program in patients with GTPS, concluding that the shockwave therapy presents better long-term outcomes [23].

## APPLICATION OF ESWT IN WOUND HEALING AND SCAR TISSUE

In a meta-analysis, the efficacy and safety of ESWT in the therapy for acute and chronic soft tissue wounds were studied. The treatment was compared to conventional wound therapy (CWT). In total, 473 patients were included. The results showed that 'ESWT statistically significantly increased the healing rate of acute and chronic soft tissue wounds 2.73-fold [...] and improved wound-healing area percentage by 30.45%' [24]. Additionally, 'ESWT reduced wound-healing time by 3 days [...] for acute soft tissue wounds and 19 days [...] for chronic soft tissue wounds and the risk of wound infection by 53% [...] when compared with CWT alone' [25]. As there have been no serious adverse effects, it can be summarized that ESWT shows better therapeutic effects on acute and chronic soft tissue wounds as compared to CWT [26]. In a systematic review, published by Dymarek et al., a total number of 919 patients was analysed to evaluate the use of ESWT as a complementary wound treatment. The results suggest that 'ESWT can be used as an adjunct therapy for healing chronic and acute soft tissue wounds' [27]. Another meta-analysis, published by Zhang et al., confirmed positive influence of ESWT on chronic wound healing, markedly increasing the wound healing rate 1.86 times and the percentage of wound healing area to 30.46%. The authors also suggest ESWT to be an adjunct to wound treatment [28].

As it comes to scar management, the use of ESWT also seems to be reasonable. In a study involving patients with post-burn scars, the authors claim the treatment to be justified, simultaneously being cost-effective. The authors affirmed that 'Already after the first session, scars appeared more pliable, and color mismatch was less evident. At the end of the study period, all treated scars obtained a more acceptable appearance' [29]. In a different study investigating the use of ESWT for retracting scars on hands, 70 patients with a history of hand surgery with painful, retracting scarring at least 1 month old were tested. Statistically significant improvement in the groups treated with ESWT was shown with the use of modified Vancouver Scar Scale (moVSS), VAS and range of motion score (ROM) [30]. Moreover, the therapy not only helped with the scar, but also with accompanying symptoms like pruritus [31] and scar pain [32].

## APPLICATION OF ESWT IN THE TREATMENT OF CARPAL TUNNEL SYNDROME

Not many publications looked into the application of ESWT in carpal tunnel syndrome. In a study published by Atthakomol et al., 25 patients were tested in order to compare the use of single-dose

radial ESWT and local corticosteroid injections (LCsI) in the treatment of carpal tunnel syndrome. ESWT-treated patients received shockwaves of the following specifications: 4 Bar, 15 Hz frequency, 5000 shocks, BTL-6000 system, radial shockwave mode, duration from 3 to 7 minutes, with the probe placed perpendicularly to the centre of the palm and ultrasound gel as a conductive medium. After the procedure, each patient obtained a cold pack for 15 minutes. The outcome was evaluated using Boston Carpal Tunnel Questionnaire (BCTQ), VAS and electrodiagnostic parameters. In all of these variables, ESWT-treated patients showed significantly greater improvement, compared to LCsI-treated patients, with 'no statistically significant differences' [33]. Similar results were obtained in studies comparing the use of ESWT in contrast to sham ESWT treatment [34] (4 Bar, 5 Hz frequency, 2000 shocks, Physio Shock Wave Therapy system, with the probe placed perpendicularly to the palm and the treated area ranging from pisiform level to 2 cm proximal to the median nerve) or conservative treatment, including wrist splint at night [35].

As it was mentioned before, the exact mechanism of ESWT remains unknown. In an experimental study, the authors tried to analyse the foundation of the anti-inflammatory effect of ESWT. Their focus was the role of nitric oxide (NO) and its synthase (NOS) in the inflammatory processes. The results proved that the anti-inflammatory action of ESWT 'should include tyrosine-dephosphorylation of eNOS, a successive increase in NO production and suppression of NF- $\kappa$ B activation' [36]. Various reports have also described the positive influence of ESWT on axonal regeneration, for instance in the study measuring the regeneration after axotomy [37]. The method was suggested to cause 'faster Wallerian degeneration, improved removal of degenerated axons and a greater capacity of the injured axons to regenerate' [38].

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## APPLICATION OF ESWT IN THE HEALING AFTER CARPAL TUNNEL RELEASE

There are several types of pain commonly occurring after the carpal tunnel release. Pillar pain, located in the thenar and in the hypothenar eminence, is a side effect which arises with a vast frequency in the postoperative, initial phase [39]. The scar pain occurs due to the incision crossing through one of the nerve branches of the palm: palmar branch of the median nerve, palmar branch of the ulnar nerve, nerve of Henle or palmar transverse branches of the ulnar nerve [40]. In the literature, the frequency of scar discomfort after carpal tunnel surgery ranges from 11% [41] to 30% [42]. Researchers from Instituto Ortopedico Galeazzi tested ESWT in the treatment for pillar pain after carpal tunnel release. Forty patients at least 6 months after carpal tunnel release surgery were analysed. The results showed that 'in all of the treated patients, there was a marked improvement: the mean VAS score decreased from 6.18 ( $\pm 1.02$ ) to 0.44 ( $\pm 0.63$ ) 120 days after treatment, and redness and swelling of the surgical scar had also decreased significantly' [43].

## CONCLUSION

To sum up, it can be seen that ESWT is an effective treatment not only in the most common medical applications, like lithotripsy, the treatment of 'tennis elbow' or bone healing, but it also aspires to become a standard method for both treatment of carpal tunnel syndrome and healing after the carpal tunnel release. A standard therapy, consisting of 5 repeated sessions, in the private medical sector in Poland costs around 250 PLN, which classifies ESWT as moderately inexpensive treatment, guaranteeing permanent improvement of symptoms [44]. At last, the use of ESWT seems sensible in the healing after carpal tunnel release and, as there are very few reports on this matter, it should be recommended for further research.

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