REVIEW

Nr 2022;12 (2):247-252

Extracorporeal Shockwave Therapy in the Treatment of Trigger Finger. A Systematic Review

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DOI:
10.32098/mltj.02.2022.20

LEVEL OF EVIDENCE: 1

SUMMARY
Trigger finger is a stenosing tenosynovitis of flexor tendons with consecutive conflict with the A1 pulley. Quinnell defined 4 grades according to the clinical manifestation of the conflict. Studies focused on grade 2 and 3 for conservative treatment. Extracorporeal shockwave therapy (ESWT) is a conservative method to receive extensive attention in the musculoskeletal pathology. Researchers analyzed the effects of ESWT on trigger finge , aiming at defining its effects, dosing and side reactions. We reviewed the only 7 published studies in the literature, one retrospective, three before-after interventional studies and three randomized controlled studies. The most prescribed form was radial ESWT, with variable dosing, with clinical and functional improvement mainly on medium and long term. ESWT and corticosteroid injections led to similar improvement, with more rapid analgesia for corticosteroids and a lower rate of recurrence for ESWT. Focused ESWT with high-energy was more effective than low-energy, counting for a dose-effect relation.

KEY WORDS
ESWT; trigger finger; pain eduction; functional improvement; conservative treatment.

INTRODUCTION

Trigger finger defines a pathologic condition, a stenosing tenosynovitis with a consecutive conflict at the intersection between the flexor tendons of the fingers and the contenting A1 pulley. The gliding of the tendon loses its smoothness and causes triggering, snapping or locking of the fingers at the metacarpophalangeal joint (1). It seems to occur more frequently after 45 years and in women. Its incidence is estimated to 2-3% in the general population; the association of diabetes mellitus increases the incidence at 10%. Other conditions associated with trigger finger are: collagen tiduue disease, rheumatoid arthritis, Dupuytren's disease, amyloidosis, mucopolysaccharide storage disorders, congestive heart failure, genetic predisposition, de Quervain's disease, carpal tunnel syndrome, renal disease.
The severity of the trigger finger is described by Quinnell classification: grade 0 (normal finger movement); grade 1 (uneven movement); grade 2 (trigger finger actively correctable); grade 3 (passively correctable); grade 4 (fixed deformity)
Treatment options include rest or activity modification, splinting, physical agents, drugs (mostly NSAIDs), therapeutic exercise, local injections, surgery. There is no consensus about a certain therapeutic association, as none has been proved absolutely better than the others. Surgery is reserved for grade 4 and for conservative treatment failure, as an effective therapy with some possible complications: hypoesthesia, infection, tendon rupture (2). Extracorporeal shock wave therapy (ESWT) is a relatively new procedure, with extensive studies in the therapy of musculoskeletal disorders. Research on tendinopathies as lateral epicondylitis of the elbow, Achilles tendinopathy, plantar fasciitis brought new insides on its mechanisms. The biological effects of the acoustic impulse reside in cell stimulation, neovascularisation, tissue regeneration, nitric oxide synthase stimulation and suppression of the inflammation (3, 4)
ESWT is an acoustic energy wave applied externally that travels rapidly. It is generated in two forms, focussed and radial, that differ in physical characteristics, energy delivered and method of production. Focussed ESWT affects a small, precisely defined area and travel more deeply, whereas radial ESWT affect a larger, more diffuse and superficial area. Focussed ESWT carries more energy than radial ESWT. Focused ESWT deliver maximum pressure inside the tissue,

while radial ESWT reach the maxmum of pressure right at the source, not at a selected depth in the body. Some authors believe that the radial form is not a true ESWT and should be more accurately be called "radial pressure wave" therapy. Reports on ESWT recommendation for patients with trigger finger are rare. Based on previous experience with musculoskeletal conditions, ESWT may have a place in the armamentarium of stenosing flexor digitorum tenosynovitis. The rationale behind ESWT prescribtion in trigger finge resides in its biological and tissue effects that may be structured as analgesic and as healing reactions. The pain relief effect is due to direct action on nociceptors and to hyperstimulation analgesia through substance P modulation (producing an initial increase followed by a long-term decrease of substance P), with blocking of gate-control mechanism. The tendon healing effects are complex and partially unknown. Research documented neovascularisation and local production of growth factors (transforming growth factor beta, TGFb1 and insulin-like growth factor, IGF-I) with mitogenic and anabolic response. It seems that tenocytes are able to convert the mechanical stimulus into a biochemical response, by increasing gene expression of the growth factors. Anabolic effects consists in colagen type I and type III synthesis (5). Differences between the mode of generation and physical characteristics of the two forms of ESWT are well documented. There are a few studies to compare the two forms; most studies were done with the focused form, as the radial form was more recently introduced in clinical practice. Concerning the biological effects, radial ESWT act more superficially than focused ESWT. On the short-term, it seems that there are no differences between the analgesic effect of the two forms, while, on long-term (24-48 weeks, one year), focused ESWT are significantly superior (6-8)

CLINICAL AND RESEARCH CONSEQUENCES

Search strategy

In August 2021 we performed a scientific literature research on PubMed, Medline, PEDro electronic databases. The articles were selected according to the language (English) and to the different combinations of the following terms: "trigger finger", "extracorporeal shockwave therapy". Two reviewers performed the activity independently. The studies included in the analysis should have been selected by both authors.

Selection criteria

The authors consulted the titles and the abstracts of the selected articles. According to the PICO model, the following parameters were considered eligible:

- P. Participants: patients with trigger finger
- I. Intervention: local application of extracorporeal shockwave therapy as main intervention;
- C. Comparator: none;
- O. Outcome: pain and disability.

Reviewers excluded papers not related with human health. The selected study designs were as follows: prospective cohort trials, retrospective trials, randomized controlled trials (RCTs). The authors excluded letters to the author, editorials, technical notes, case reports, case series, narrative reviews, systematic reviews, meta-analysis.

Data extraction and analysis

The authors independently studied and extracted data from the full-text documents into an Excel document. The following data were extracted: 1) author, publication year; 2) design; 3) number of participants; 4) severity of the trigger finger (Quinell grading); 5) intervention; 6) outcomes; 7) timing of outcomes.

There were 26 records selected from the literature databases, one article was excluded as it was a meta-analysis. After duplication exclusion, 7 studies were considered eligible and screened for title, abstract and full-text.

From the 7 studies, one is retrospective and 6 are interventional, with 3 studies being randomized controlled trials and 3 before-after (pre-post) studies (9) (**table I**).

The reviewed studies on trigger finger and ESWT

In the retrospective study, Malliaropoulus *et al.* included 49 digits grade 2 and 3 according to Quinnell classification, treated with radial ESWT, one weekly session, until symptoms subsided. The number of the sessions varied between 3 and 8, with an average of 6 (± 1.3), the technical parameters were 2000 impulses/session, a pressure between 1 to 3 (depending on the individual pain tolerance) with a mean value of 1.4 bar (± 0.3), a frequency from 5 Hz to 6 Hz and a mean value of 5 ± 0.4 Hz. Outcomes were patient assessment of pain and limitation of activity (Roles and Maudsley score) and pain severity measured with a visual analogue scale (VAS). It is important to observe that both parameters are subjective. Assessments were done at baseline (before treatment), at 1 month, at 3 and 12 months. Results showed significant reduction of pain and functional disability scores at all the moments of the study in 93,1% of cases. They noted a recurrence rate of 6,1% after one year. Over the all, radial ESWT was considered efficient. The parameters of the treatment should be adapted to individual tolerance (10).

Three interventional studies (before-after treatment) were found in the literature. Two of them studied radial ESWT on

Table I. The reviewed studies on trigger finger and ESWT.

Study author	Design	Number of participants	Grade Quinnell	Intervention		Outcome	Timing of outcome
Malliaropoulos *et al.*, 2016 (20)	Retrospective	49 digits (44 patients)	2, 3	**Radial ESWT** 2000 impulses 5-6 Hz 1 – 3 barr One session/week Until pain resolves		Pain (VAS) Functional outcome (Roles and Maudsley score)	One month 3 months 12 months
Yildirim *et al.*, 2016 (14)	RCT (ESWT versus CSi*)	36 patients (19 ESWT 17 CSi)	2	**Radial ESWT** 1000 impulses 15 Hz 2.1 barr One session/week 3 sessions	**CSi** 0.5mL betamethasone dipropionate/ sodium phosphate solution 0.5 mL of 2% lidocaine	Pain (VAS) Frequency of triggering FT Severity of triggering ST Functional impact of triggering FiT QuickDASH	One month 3 months 6 months
Vahdatpour *et al.*, 2020 (13)	Interventional (before-after)	19 patients	> 1	**Radial ESWT + focused ESWT**		Pain (VAS) QuickDASH	Post-treatment 6 weeks 18 weeks
				1000 impulses 15 Hz 2.1 barr	500 impulses 4 Hz 0.1 barr		
				One session/week 3 sessions			
Dogru *et al.*, 2020 (11)	Interventional (before-after)	18 patients	2	**Radial ESWT** 2000 impulses 10 Hz 2 barr 2 sessions/week 10 sessions		Pain (VAS) Grip strength Pinch strength ROM* quickDASH	Post-treatment 3 months
Wah *et al.*, 2020 (15)	RCT (US + paraffin bath + TE versus ESWT + ice massage + TE)	29 patients (19 US 10 ESWT)	1, 2, 3	**US**, 3 MHz, 0.5W/ cm^2, 5 min + Paraffin bath 15 min + T	**Radial ESWT** 1000 impulses 15 Hz 2.1 barr + ice massage 5 min + TE	Pain (VAS) quickDASH	1 week 2 weeks 3 weeks 4 weeks
				2 sessions/week 10 sessions			
Zyluk *et al.*, 2020 (12)	Interventional (before-after)	50 (32 patients)	2, 3	**Radial ESWT** 2000 impulses 8 Hz 2 barr One session/week 4 sessions		Pain (VAS) Grade of triggering (Froimson/ Quinnell scale)	One week 6 months
Chen *et al.*, 2021 (15)	RCT (HS* *versus* LS* *versus* sham)	56 (18 + 19 + 19)	2	Wide-focused ESWT/sham		Pain (VAS) Frequency of triggering Severity of triggering Functional impact of triggering quickDASH	One month 3 months 6 months
				HS 1500 impulses 3 – 5 Hz 5.8 barr (0,01 mJ/mm^2)	**LS** 1500 impulses 3 – 5 Hz 3 barr (0.006 mJ/mm^2)		
				One session/week 4 sessions			

*CSi: corticosteroid injection; *ROM: range of motion; US: ultrasound; TE: therapeutic exercise; *HS: high-energy wide-focused ESWT; *LS: low-energy wide-focused ESWT.

the trigger finge , grade 2 (Dogru *et al.*) and grades 2 and 3 (Zyluk *et al.*) (11, 12). The parameters are in the same range, 2000 impulses/session, pressure 2 bar, frequency 8 or 10 Hz, one or two weekly sessions, 4 to 10 sessions. Outcomes were pain scores (VAS) and different disability scores. Both studies stressed the reduction of pain and disability at mentioned moments (one week, 3 and 6 months). There was a 6% failure at 3 months (Zyluk *et al.*). Another study used a combination between radial and focused ESWT (13). The rationale behind the combined therapy may reside in the area of application: focused ESWT was used directly on the nodule, whereas radial ESWT was used on the peripheral tissues of the nodule. The timing of outcomes was scheduled after treatment, at 6 and 18 weeks. Pain severity improved in the after-treatment evaluation and continued its evolution at 6 and 18 weeks. The severity of triggering and the functional impact of triggering were not significant immediately after treatment; they peaked at 6 weeks and continued this trend at 18 weeks.

Three RCTs from the literature were analysed. One of them compared radial ESWT with corticosteroid injection for grade 2 Quinnell trigger finger (14). Follow-up at 1 month, 3 and 6 months showed that both treatments were equally effective for improving symptom severity and functional status in patients with grade 2 Quinnell trigger finge . There was no statistical significant difference between the two groups and they have a similar rate of failure at 6 months. In conclusion, the study pointed that ESWT is a conservative therapy used as an alternative to corticosteroid injection, with similar results on short and medium term.

In another RCT, ESWT was included in a complex rehabilitation program. In the form of radial ESWT, it was associated with cryotherapy and therapeutic exercise and compared with ultrasound, hot therapy and therapeutic exercise. Pain and functional status (measured as quickDASH scale) were analyzed at 1, 2, 3 and 4 weeks. Results showed that the combination of ESWT plus ice therapy offered no improvement in pain and functional scores, versus the combination of therapeutic ultrasound, hot baths and exercise (15).

Chen *et al.* studied wide-focused ESWT in the treatment of trigger finge , in order to define the most effective dosage. They compared two types of ESWT, high-energy, low-energy with a control group. High-energy wide-focused ESWT had an energy flux density of 0.01 mJ/mm^2 (equivalent to 5.8 bar) and the low-energy wide-focused ESWT, 0.006 mJ/mm^2 (equivalent to 3 bar). Outcomes were pain (VAS), functional (quickDASH) and clinical (frequency of triggering, functional impact of triggering) scores, assessed at 1, 3 and 6 months. There were no differences in all parameters between the three groups at one and three months; at six months the pain and quickDASH score were significantly lower in the high-energy ESWT group. However, clinical parameters did not differ between the three groups at 6 months. One most interesting conclusion was that even the control group had significant improvement within 6 months, counting for the placebo effect and the natural course of the trigger finge . Researchers concluded that wide-focused ESWT, four weekly sessions, are efficient in pain relief and functional improvement in grade II trigger finger at 6 months, with a better result from the high-energy form. There may be a dose-related effectiveness of ESWT (16).

Although the literature mentions the adverse effects of ESWT, as local haemorrhage (ecchimoses, bruises), local hyperesthesia, post-treatment pain, skin redness, all the cited studies found none of them.

CONCLUSIONS

There are few studies on the effect of ESWT on the trigger finge . Most of them focused on the stage 2 and only a small proportion of cases were stage 3. It is worth mentioning that stage 1 trigger finger therapy received little attention in the studies, possibly due to underdiagnose; therapy is conservative, combining rest, splinting, physiotherapy and kinetotherapy. On the other hand, stage 4 is referred immediately to surgery.

The most used ESWT was in the radial form in 5 studies; one study used the focused form and one study a combination between the two forms. Radial ESWT parameters were as follows: 2000 impulses, 5-10 Hz, 1-3 barr, more often, and 1000 Hz, 15 Hz, 2.1 barr in one study. The sessions were weekly or twice a week, with a total number of 3, 4 or 10; one study delivered as many sessions as needed until symptom resolution. Pain improved in the post-treatment follow-up, clinical and functional parameters improved later, in an interval between 6 weeks and 6 months.

Radial ESWT and corticosteroid local injection were equally efficient in pain and functional improvement at 6 months after intervention, with a more rapid effect of corticosteroids. Regarding symptom recurrence at 6 months, studies found a rate of 23-34% for corticosteroid injection and of 6% for radial ESWT (17, 18). Studies comparing corticosteroid versus ESWT in other tendinopathies found similar results in functional and clinical improvement, with a more rapid analgesic effect of corticosteroids (19, 20).

Comparing associations between physical agents, the combination of ESWT and cryotherapy was less efficient than ultrasound and thermotherapy. The place of ESWT and the most useful combination of physical agents has not yet been determined. Ultrasound was found less efficient that corticosteroid injection in reducing pain and dysfunction imme-

diately after treatment, but was associated with a lower rate of recurrence at 3 and 6 months (21).
The focussed ESWT was studied as a high-energy and a low-energy form, with better results for the high-energy form, stressing the dose-effect relation. Focused ESWT is used in the patellar and Achilles tendinopathy, with similar results as platelet-rich plasma injections (22, 23). One study observed that there are no differences between focused and radial ESWT in the treatment of patellar tendinopathy (24). Summarizing, stages 2 and 3 of trigger finger are good candidates for ESWT application, in either radial or focused form. Radial ESWT offers analgesia and functional improvement, with a comparable benefit as corticosteroids. Focused ESWT with high-energy is efficient. Combination between ESWT and physical agents deserves more studies. Due to a small number of studies, there is no consensus on the most efficient form and the mode of application in order to reach pain reduction and functional improvement. It is clearly stated that the therapy is well tolerated, with no side effects.

FUNDINGS
None.

DATA AVAILABILITY
Data are available under reasonable request to the corresponding author.

CONTRIBUTIONS
DP, FO: literature search and studies extraction for the analyses. DC: summary of data for the table. DP: revision for the before-after studies. FO: revision for the retrospective and RCTs studies. DP, FO, DC: conclusions summary.

CONFLICT OF INTERESTS
The authors declare that they have no conflict of interests.

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