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Original Article

Analgesic effect of extracorporeal shock wave therapy versus ultrasound therapy in chronic tennis elbow

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Abstract. [Purpose] This study compared the analgesic effects of extracorporeal shock wave therapy with those of ultrasound therapy in patients with chronic tennis elbow. [Subjects] Fifty patients with tennis elbow were randomized to receive extracorporeal shock wave therapy or ultrasound therapy. [Methods] The extracorporeal shock wave therapy group received 5 treatments once per week. Meanwhile, the ultrasound group received 10 treatments 3 times per week. Pain was assessed using the visual analogue scale during grip strength evaluation, palpation of the lateral epicondyle, Thomsen test, and chair test. Resting pain was also recorded. The scores were recorded and compared within and between groups pre-treatment, immediately post-treatment, and 3 months post-treatment. [Results] Intra- and intergroup comparisons immediately and 3 months post-treatment showed extracorporeal shock wave therapy decreased pain to a significantly greater extent than ultrasound therapy. [Conclusion] Extracorporeal shock wave therapy can significantly reduce pain in patients with chronic tennis elbow.
Key words: Extracorporeal shock wave therapy, Ultrasound, Lateral epicondylitis

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INTRODUCTION

Tennis elbow (TE) is not an inflammation of the outside portion of the elbow but rather is the degeneration of the extensor tendon of the humeral lateral epicondyle (LE) due to microscopic injuries. Common symptoms include pain, tenderness over the LE, pain upon gripping, and dorsiflexion against resistance of the wrist, middle finger, or both[1–5)]. Conservative treatments such as nonsteroidal anti-inflammatory drugs, local steroid injections, strengthening exercises, stretching, taping, ultrasound (US), iontophoresis, laser, acupuncture, and massage are usually used[6–11)]. Meanwhile, surgical intervention is required for cases of TE when conservative management is deemed ineffective[12)].

One non-invasive treatment for TE-associated pain is extracorporeal shock wave therapy (ESWT). Although the underlying mechanism of ESWT is not completely clear, it likely involves hyperstimulation analgesia; it alleviates pain as a result of moderate-to-intense sensory input that is usually applied at the site of greatest discomfort. ESWT stimulates poorly vascularized tissue and cell growth. In TE, only the degenerated fragments of the tendon are treated[13–16)]. However, there is a lack of comparative studies of the analgesic effects of various electrotherapy methods on chronic TE. Therefore, the present study compared the analgesic effects of ESWT and US therapy in patients with chronic TE.

SUBJECTS AND METHODS

From 2012–2014 a total of 65 males with TE were examined. This study was performed in the Department of Physiotherapy Mining in Jaworzno, Poland. The exclusion criteria were local soft-tissue infection, malignant disease, pacemaker, epileptic disorders, rheumatoid arthritis, diabetes mellitus, neurological abnormalities, infectious diseases, cardiovascular disease, lung or endocrine disease, skin ulcerations, reduced range of motion at the elbow, previous surgical intervention of the TE, previous conservative treatment of the TE 6 months before start of the study, and history of local corticosteroid injection 6 months before the study. The inclusion criteria were age >18 years, pain in the lateral epicondyle of the humerus persisting longer than 12 months (Table 1).

After enrollment, 15 patients were excluded from the study. The remaining patients were randomly allocated to receive ESWT or US therapy; randomized was performed by an independent statistician blinded to the baseline characteristics of the participants using a randomization list generated by MedCalc Statistical Software version 15.2.1 (MedCalc Software byba, Ostend, Belgium). Finally, a total of 50 individuals in 2 groups were analyzed (Fig. 1). This study was designed in accordance with the rules for human experimental studies and approved by the Bioethical Committee of the Holycross College in Kielce (resolution 1/12/KB). This

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Table 1. Baseline characteristics

Characteristics	ESWT Group	US Group
Patients (n)	25	25
Occupation: physical worker/white-collar worker (n)	19/7	15/10
Age (yr)	47.9 ± 4.4*	49.0 ± 4.5*
Duration of symptoms (months)	14.9 ± 2.1*	15.1 ± 1.9*
Dominant arm (right/left)	25/0	25/0
Treatment side (right/left)	25/0	25/0
Previous unsuccessful treatment 6 months prioryes† yes/no (n)	25/0	25/0

*Values are mean ± SD
† Including local steroid-injection, cryotherapy, phonophoresis, iontophoresis, laser therapy, kinesiotherapy, taping, massage, or orthoses.

study also conformed to the principles of the Declaration of Helsinki. All participants signed informed consent forms prior to participation.

The ESWT group received 1,000, 1,500, and 2,000 pulses during the first, second, and third through fifth treatments, respectively (pressure, 2.5 bar; frequency, 8 Hz; energy density, 0.4 mJ/mm^2). The patients received 5 ESWT treatments once per week. The treatments were performed using a Rosetta ESWT (CR Technology, Korea). Ultrasound gel was applied between the apparatus head and skin. The procedure was performed in the area with the most intense pain. Treatment was administered at the anterior aspect of the LE and three points around it at a radius of 1.5–2 cm. The treatment time did not exceed 10 minutes. During the treatments, the patients did not receive any drugs.

Meanwhile, the US group received continuous ultrasound waves: intensity, 0.8 W/cm^2; 100% fill; carrier frequency, 1 MHz. The patients received a series of 10 treatments 3 times per week. The treatments were performed using a US 13 EVO Cosmogamma (Emildue, Italy). The active engagement between the apparatus head and skin was ultrasound gel. The applicator head was applied to the LE of the humerus at a right angle in order to maximize energy absorption by the tissue. Each treatment session did not exceed 10 minutes. During the treatment, the patients did not receive any drugs.

The following variables were measured. Pain of the affected upper limb during gripping was measured by a Martin vigorimeter (NexGen Ergonomics Inc., Canada), which is a dynamometer with a rubber balloon that is compressed by hand; the air pressure inside the balloon under the influence of compression in kiloponds per square centimeter (kp/cm^2) was recorded on a manometer. Moreover, resting pain, pain felt during palpation of the LE of the humerus, and pain during the Thomsen test (i.e., wrist extension against resistance) were measured. During the Thomsen test, with the shoulder flexed at 60°, elbow extended, forearm pronated, and wrist extended to approximately 30°, pressure was applied to the dorsum of the second and third metacarpal bones in the direction of flexion and ulnar deviation in order to stress the extensor carpi radialis brevis and longus. Finally, pain during the chair test was evaluated; with the shoulder flexed at 60° and the elbow extended, the subject attempted to lift a chair weighing 3.5 kg.

In addition, patients were asked to assess the level of pain

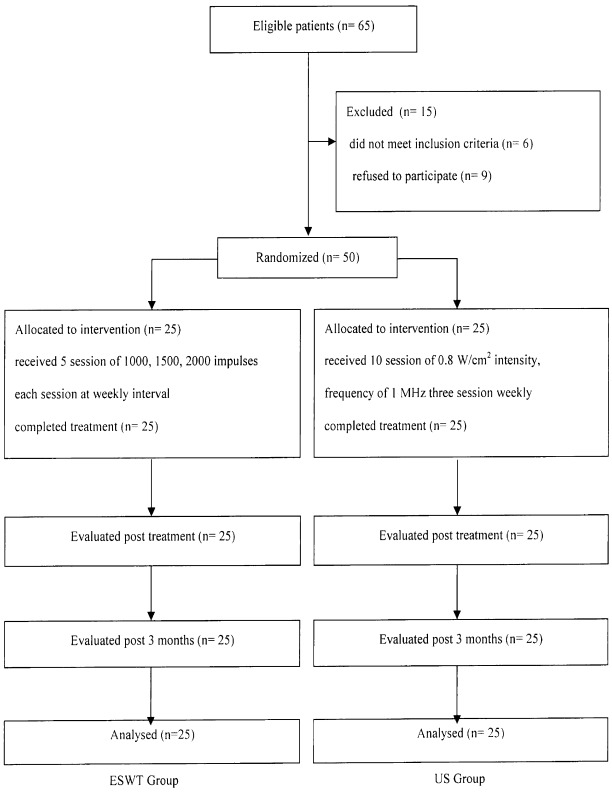

Fig. 1. Study flow diagram

immediately and 3 months post-treatment in comparison to that before treatment according to the following criteria: excellent: pain reduction exceeding 70%, full movement, full activity; good: pain reduction from 50–70%, occasional discomfort, full movement, full activity; acceptable: pain reduction 30–50%, some discomfort after longer activities; poor: pain reduction less than 30%, pain-limiting activity.

Pain was assessed using the visual analog scale (VAS), which is a 10-cm line whose left and right sides correspond to no pain (0) and unbearable pain (10), respectively. The participants marked the scale to indicate their current level of pain. The value (in cm) was recorded for analysis. Pain was evaluated pre-treatment, and immediately and 3 months post-treatment.

MedCalc Statistical Software version 15.2.1 (MedCalc Software byba, Ostend, Belgium) was used for statistical analysis. All data are expressed as mean ± standard deviation (SD) and range. One-way ANOVA was used to compare differences in the measured parameters within a group pre-treatment, post-treatment, and 3 months post-treatment. Meanwhile, the independent samples t-test was for intergroup comparisons pre-treatment, post-treatment, and 3 months post-treatment. The level of significance was set at $p < 0.05$.

RESULTS

Pain in all tests decreased significantly over time within each group, although significantly greater analgesic effects were achieved in the ESWT group (Table 2). In both groups, pain intensity in all tests was similar pre-treatment; meanwhile, post-treatment and 3 months post-treatment, significant greater decreases of pain were observed in the ESWT group than the US group (Table 3). The overall outcomes are shown in Table 4. Three months post-treatment, in the ESWT group, 24 patients had excellent or good results compared to only 7 in the US group. Furthermore, 0 and 8 patients in the ESWT and US groups had poor outcomes at the end of the study, respectively. Therefore, the results indicate ESWT was more effective than US for reducing pain, with long-lasting results.

Table 2. Pain scores within groups at different time points

	ESWT Group mean ± SD (range)	US Group mean ± SD (range)
Pain at grip strength		
Pre treatment	2.8 ± 0.2 (2.7–2.9)	2.8 ± 0.1 (2.7–2.8)
Post treatment	3.9 ± 0.1 (3.9–4.0)	2.8 ± 0.1 (2.8–2.9)
Post 3 months	5.1 ± 0.2 (4.8–5.5)*	2.9 ± 0.1 (2.6–3.1)*
Resting pain		
Pre treatment	4.0 ± 0.7 (3.0–5.0)	4.2 ± 0.6 (3.0–5.0)
Post treatment	1.9 ± 0.9 (0.0–3.0)	4.0 ± 0.6 (3.0–5.0)
Post 3 months	0.2 ± 0.4 (0.0–0.1)*	3.7 ± 0.7 (3.0–5.0)*
Palpation pain		
Pre treatment	6.4 ± 0.6 (5.0–7.0)	6.4 ± 0.5 (6.0–7.0)
Post treatment	3.5 ± 0.6 (2.0–5.0)	6.1 ± 0.6 (5.0–7.0)
Post 3 months	1.5 ± 0.8 (0.0–3.0)*	5.8 ± 0.8 (5.0–7.0)*
Pain at Thomsen Test		
Pre treatment	5.7 ± 0.5 (5.0–7.0)	5.8 ± 0.7 (4.0–7.0)
Post treatment	2.9 ± 0.7 (2.0–4.0)	5.5 ± 0.6 (4.0–6.0)
Post 3 months	1.3 ± 0.4 (0.0–3.0)*	5.1 ± 0.8 (3.0–6.0)*
Pain at Chair Test		
Pre treatment	4.9 ± 0.7 (4.0–6.0)	4.9 ± 0.6 (4.0–6.0)
Post treatment	4.0 ± 0.8 (2.0–5.0)	4.6 ± 0.6 (3.0–6.0)
Post 3 months	3.9 ± 0.6 (3.0–5.0)*	4.4 ± 0.7 (3.0–5.0)*

*Statistically significant ($p < 0.05$)

Table 3. Pain scores between groups at different time points

	Pre treatment		Post treatment		3 months Post treatment	
	ESWT Group	US Group	ESWT Group	US Group	ESWT Group	US Group
Pain upon gripping						
Mean	2.8	2.8	3.9	2.8	5.1	2.9
SD (min-max)	0.2 (2.7–2.9)	0.1 (2.7–2.8)	0.1 (3.9–4.0)	0.1 (2.8–2.9)	0.2 (4.8–5.5)	0.1 (2.6–3.1)
Difference†	0.0		1.1*		2.2*	
Resting pain						
Mean	4.0	4.2	1.9	4.0	0.2	3.7
SD (min-max)	0.7 (3.0–5.0)	0.6 (3.0–5.0)	0.9 (0.0–3.0)	0.6 (3.0–5.0)	0.4 (0.0–0.1)	0.7 (3.0–5.0)
Difference	−0.2		−2.1*		−3.5*	
Palpation pain						
Mean	6.4	6.4	3.5	6.1	1.5	5.8
SD (min-max)	0.6 (5.0–7.0)	0.5 (6.0–7.0)	0.6 (2.0–5.0)	0.6 (5.0–7.0)	0.8 (0.0–3.0)	0.8 (5.0–7.0)
Diffrence	0.0		−2.6*		−4.3*	
Pain at Thomsen Test						
Mean	5.7	5.8	2.9	5.5	1.3	5.1
SD (min-max)	0.5 (5.0–7.0)	0.7 (4.0–7.0)	0.7 (2.0–4.0)	0.6 (4.0–6.0)	0.4 (0.0–3.0)	0.8 (3.0–6.0)
Diffrenc	−0.1		−2.6*		−3.8*	
Pain at Chair Test						
Mean	4.9	4.9	4.0	4.6	3.9	4.4
SD (min-max)	0.7 (4.0–6.0)	0.6 (4.0–6.0)	0.8 (2.0–5.0)	0.6 (3.0–6.0)	0.6 (3.0–5.0)	0.7 (3.0–5.0)
Diffrence	0.0		−0.6 *		−0.5*	

* Statistically significant ($p < 0.05$)
† Difference between means

Table 4. Overall outcome immediately and 3 months post-treatment

	Post treatment				3 months Post treatment			
	ESWT Group		US Group		ESWT Group		US Group	
	n	%	n	%	n	%	n	%
Excellent: VAS reduction > 50–70% no pain, full movement, full activity	10	40	–	–	11	44	–	–
Good: VAS > 50–70% occasional discomfort, full movement, full activity	12	48	7	28	13	52	7	28
Acceptable: VAS reduction > 30–50% some discomfort post longer activities	3	12	13	52	1	4	10	40
Poor: VAS reduction < 30% pain-limiting activity	–	–	5	20	–	–	8	32

DISCUSSION

Although the diagnosis of TE is fairly straightforward, its management is often difficult. Therefore, various treatments have been applied[17–22]. ESWT and US therapy play important roles in the treatment of TE-associated pain; they are used to provoke painful levels of stimulation to relieve pain, which is termed "hyperstimulation analgesia." Meanwhile, some studies have evaluated the influence of Kinesio® taping immediately, 12, 24, and/or 72 after application[23–27].

Lemos et al.[28] evaluated the changes in muscle function in healthy subjects induced by Kinesio tape application with no or moderate tension to the dominant and non-dominant arms. The subjects, aged 18–30 years, received Kinesio taping, Kinesio taping without tension, or no treatment (control); they were assessed before, and 30 minutes, 24 hours, and 48 hours after taping. The results showed the Kinesio group exhibited increased grip strength at all time points after application compared to the controls. Meanwhile, grip strength was significantly greater in the Kinesio groups than the controls after 24 and 48 hours for the right hand and after 48 hours for the left hand. Right grip strength improved in the Kinesio group compared to that in the Kinesio without tension group only 24 hours after application. Thus, the results confirm Kinesio taping is capable of augmenting muscle function.

Spacca et al.[13] compared therapeutic effects of active radial shockwave therapy (RSWT) with sham RSWT. Subjects received 4 RSWT or sham sessions once per week. The RSWT group received 2,000 impulses (1.2 bar at 4 Hz for 500 impulses, and 1 bar at 10 Hz for 1,500 impulses). Meanwhile, the sham RSWT group received 20 impulses (1.2 bar at 4 Hz for 5 impulses, and 1 bar at 10 Hz for 15 impulses). The RSWT group showed a significantly greater decrease of pain and greater increase of pain-free grip strength post-treatment than the sham RSWT group.

The therapeutic effects of ESWT and sham ESWT have also been compared. Both groups received 3 ESWT sessions once per week. The ESWT group received 2,000 pulses (energy flux density, 0.03–0.17 mJ/mm^2), while the sham ESWT group received 2,000 pulses (energy flux density, 0.03 mJ/mm^2). Pain decreased and pain-free grip strength increased post-treatment, but the differences were not significant[14, 15].

Moreover, Rompe et al.[29] compared the long-term therapeutic effects of ESWT with sham ESWT. Both groups received 3 ESWT sessions once per week. The ESWT group received 3,000 impulses (energy flux density, 0.08 mJ/mm^2), while the sham ESWT group received 30 impulses (energy flux density, 0.08 mJ/mm^2). Pain was significantly lower in the ESWT group than the sham ESWT group, which persisted up to 24 months post-treatment.

In the present study, pain decreased to a significantly greater extent in the ESWT group than in the US group. Furthermore, the therapeutic effect persisted for 3 months post-treatment, indicating the effectiveness of the ESWT treatment protocol. These findings may be valuable for physicians, physiotherapists, and patients with TE regarding the selection of the most appropriate treatment on the basis of patients' preference and convenience. In summary, the results of this study provide evidence that patients with TE can obtain significant health benefits with ESWT.

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