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Research article

Extra corporeal shock wave therapy is superior to ultrasound in the treatment of lateral epicondylitis: An experimental study

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Abstract

Background: Tennis elbow or lateral epicondylitis is a pathological condition of wrist extensor muscles at the lateral humeral epicondyle. It is a challenging condition, its treatment is difficult. The purpose of this study was to compare the effect of extracorporeal shock wave therapy and ultrasound on lateral epicondylitis. **Materials and Methods:** Forty patients (22 females and 18 males) with mean age 37±96 years participated in the study. Participants were randomly assigned into two equal groups each of 20 patients. Group A received ESWT 2000 shock, 700 / session, 3 sessions, one week a part, 0.32 mj /mm2 in addition to a programme of stretching exercises for wrist flexors and extensors followed by strengthening exercises twice daily for 4 weeks. Group B received ultrasound 1 MHz, continuous mode, 1.5 w/cm2 3 sessions/week, for 4 weeks, in addition to the same programme of exercise. Patients were assessed for pain and hand grip strength, pre-treatment, post treatment and six month after. **Results:** Statistical analysis of the results revealed a significant difference in all variables between groups post treatment and after 6 months follow-up in favour of Group A; p≤0.001. Differences in pain scores between groups after treatment were: tennis elbow test p=0.0004, Cozen test p=0.00009, chair test p=0.0003, pressure pain test p=0.0004, pain at work p = 0.0003 and pain at rest p=0.0005 respectively; pain-free grip strength p=0.0001. Differences in pain scores between groups 6 months follow-up were tennis elbow test p=0.08, Cozen test p=0.004, chair test p=0.03, pressure pain test p=0.029, pain at work p=0.015, and pain at rest p=0.001 respectively; pain-free grip strength p=0.000. **Conclusion**: ESWT was more effective in treating patients with lateral epicondylitis compared to ultrasound despite being a newer and costly modality.

Key words: Shock wave therapy; ultrasound therapy, lateral epicondylitis

Introduction

Lateral epicondylitis or tennis elbow is one of the most common lesions of the arm which affects the wrist extensor muscles at their origin on the lateral humeral epicondyle[1]. It is by far the commonest cause of elbow pain in patients attending the orthopaedic clinics[2]. This injury is a major challenge, as it is difficult to treat, prone to recurrence, and may last for several weeks or months[1]. The most common complaints of subjects with tennis elbow are pain and decreased hand grip, both of which may affect daily living, job or sports activities[3]. Activities involving prolonged or repeated gripping, wrist extension, forearm supination, and pronation cause eventual failure of the affected portion of the tendon. The mechanical failure of the tendon results in an ensuring tendinitis and symptoms of lateral epicondylitis such as radiating humeral lateral epicondyle pain[4].

Extracorporeal shock wave therapy (ESWT) has been object of previous studies that have shown its effectiveness in the short term for treatment of epicondylitis of elbow[5-9]. Ultrasound (US) is also as effective as ESWT[10-12,8], it is one of a multiplicity of treatment used in lateral epicondylitis by physiotherapists[13].

Shock waves are high-amplitude sound waves with a sudden pressure increase at the wave front[14]. It is a newer non-surgical method of treating orthopedic and musculoskeletal disorders. It is theorized that when given in low doses the shock waves disrupt the scar tissue, reduce inflammation, reduce pain signal transmission and stimulate healing[15-16].

This study was conducted to compare the effectiveness of ESWT and US in the treatment of tennis elbow and to investigate if ESWT is superior to US in the treatment of the common musculoskeletal disorder tennis elbow.

Materials & methods

Participants: Of 52 patients, 6 did not meet the inclusion criteria, 4 had met the exclusion criteria, and 2 refused to participate, thus only 40 patients (22 females and 18 males) with mean age of 37±1.56 years, ranged from 30 to 45 years participated in the study. Participants were recruited from the out clinic of faculty of physical therapy Cairo University. In 32 patients, the right elbow was affected, and the left elbow in the remaining 8. The average duration of the condition was 12 months.

This study was conducted in outpatient clinic at the faculty of physical Therapy and the out clinic at National institute of neuro-locomotor system, Cairo, Egypt in the period from June to September 2012.

Inclusion criteria:

*Clinical diagnosis of lateral epicondylitis of the elbow by diagnostic imaging .
*Duration of symptoms for at least 10 months.
*Pain with a visual analogue scale (VAS score ≥3cm).
*Failed previous conservative treatments including non-steroidal anti-inflammatory drugs, elbow bracing physical therapy, exercise programs

Exclusion criteria:

*Inflammatory or neoplastic disorders.
* Pregnancy.
*Other musculoskeletal disorders that needed treatment with corticosteroid injection in the last 4 weeks.
*Cardiac pacemaker.

The study was approved by an Ethical Committee of the Cairo University. Patients were provided with a Volunteer Information Sheet and written consent informing them about the purpose of the study, its benefits and inherent risks and their comittement with regard to time and money.

Patients who met inclusion criteria were randomly assigned, by the use of computer based 1:1 randomization scheme into 2 study groups. Group A consisted of 20 subjects with average age 38.4±3.67, received 3 sessions of ESWT and a program of stretching and strengthening exercises twice daily for 4 weeks. Group B consisted of 20 patients with average age 38.25±4.19. Received ultrasound and the same programme of exercises for 4 weeks.

Instrumentations:

1. For treatment

A. ESWT for patients in group A was applied by using the Orthospec (Medispec LTD, Germantown, MD) portable ESWT device that is approved for distribution and is used in the United States by the FDA. It is connected to electrical main supply 115/230V, single phase 60/50Hz and 10/5A. The orthospec ESWT device used in this study uses an electrohydraulic, or "spark-gap", method of creating therapeutic shockwaves. The portable shockwave generator targets the shockwaves to a 35-mm diameter therapy zone that enables shockwaves of sufficient energy to be delivered to the tissues in a single therapeutic session.

B. Ultrasound device Phyaction 190 serial number 2745, 230V, 300 mA / 50 - 60Hz, Pus: 8w. Continuous mode 1.5 w/cm , frequency 1 MHz, session duration 5 minutes, with transducer head circumference of 5 cm .

2. For evaluation

The examination consisted of

A. Pain elicited on tennis elbow test

Tennis-elbow test was performed by the patient attempts to extend the wrist against moderate resistance from the examiner. At the same time, the examiner puts pressure on the common extensor tendons at the musculotendinous junction. Pain and discomfort is reproduced at the lateral epicondyle[17].

B. Cozen test

Cozen's test was performed by the patient's elbow is stabilized by the examiner's thumb, which rests on the patient's lateral epicondyle. The patient is then asked to make a fist, pronate the forearm and radially deviate and extend the wrist while the examiner resists the motion. Sudden severe pain is felt in the area of lateral epicondyle of the humerus[18]. pressure pain test,

C.Chair pain test.

Chair test pain was performed by lifting a 3.5 kg stool or same weight with the patient in sitting position, elbow extended and forearm in midposition[19].

D.Pain at rest and pain at work were also detected.
E.Pain free grip strength test was used to measure strength .

On the basis of the studies of **Stratford et al.,** showing on subjects with lateral epicondylitis, maximum hand grip strength test less reliable, less valid, and less sensitive to change than pain-free grip strength test[20]. Pain-free grip strength was defined as the amount of grip force generated with an isometric contraction prior to the onset of pain. It was measured using a Jamar dynamometer (Preston Healthcare, Jackson, USA) with the subject in a supine lying position; the palm of the hand was flat on the treatment couch and adjacent to the subject's side. That is, internal rotation of the shoulder, pronation of the forearm, and slight shoulder abduction to allow for the dynamometer handles to fit between the hand and body. The elbow in full extension, as this is the most efficient position of the elbow for optimizing grip strength[21]. Participants were instructed to smoothly increase their grip force, and cease squeezing at the onset of lateral epicondylar pain while maintaining the upper limb in the standardized test position.
6.VAS range from 0 (no pain) to 10 (maximum pain). Each patient was asked to detect the intensity of pain in the affected elbow on the VAS. Each patient was instructed to make a single mark across the line corresponding to the severity of pain. The scale was scored by measuring the distance by using a ruler.

Procedures:

1. **GA received** 2000 shock of ESWT were given to the patient, 700 / session, 3 sessions, one week apart, 0.32 mj /mm2. Patients were treated sitting in a chair with their affected arm supported by an arm rest. On palpation, the most painful point over the lateral epicondyle was identified by therapist and marked with a pen. Prior to the treatment; coupling gel was applied to the treatment area[16]. In addition to:-

a. Stretching the wrist extensor muscles by Straighten the arm out fully and push the palm of the hand down so patient feel a stretch across the top of the forearm.

b. Strengthening exercises. With the patient sitting in a chair with the elbow supported on the edge of a table or on the arm of the chair the wrist hanging over the edge. Using a light weight such as a hammer or soup can for resistance. Exercises repeated for 30 times, but not beyond the point of pain. Exercises are performed twice a day following the stretching exercises.

2. **GB received** 12 sessions 3 sessions per week for 4 weeks. The patient was relaxed in sitting position and elbow was slightly flexed. In addition to the same programme of exercises as group A.
3. All patients were evaluated 3 times: before starting treatment, after completing treatment sessions, and to 6 months later (follow up). The decision to set the follow up at 6 months is based on the hypothesis of Haake et al. about the possibility of spontaneous improvement of painful symptoms in a longer period[13].

Statistical analyses:

Statistical analyses were performed using the computer program SPSS 16. All analysis of the outcomes was performed. Paired t-tests were used to analyze within group difference to test the effect of ESWT and US on pain scores and pain-free hand grip strength after treatment and 6 months follow up, and independent student tests were used to analyze between group difference of the same measured variables after treatment and 6 months follow-up. The p value of less than 0.01 was taken as significant.

Results

There was no device related problems, and no systemic or local complications. The baseline characteristics that were similar and without statistical significance for both groups are shown in table 1. All patients were re-assessed after treatment period and at 6 months follow-up. There has been no withdrawal, so the total 40 recruited patients have completed the study.

Table 1. Baseline characteristics of both groups

Characteristics	Group A	Group B
Patients (n)	20	20
Age	38.4±3.67	38.25±4.19
Duration (mo)	12±0.495	13±5.03
Mae/Female	12/8	12/8
Pain-free grip strength test (kg)	18.25	18.35

Paired t-test of all pain scores analyzed **tennis elbow test** has shown a significant effect of treatment in group A, pre treatment value was 5.95±0.94 and after treatment value was 2.5±0.82, (*p*=0.0002) and group B pre treatment value was 5.5±1.05 and after treatment value was 3.65±1.03, (*p*=0.0006), comparing after treatment and 6 months follow up (3.20±1.01, 3.80±1.11) for group A and group B respectively) within each group have shown a statistical significant increase (improvement) is shown (Table 2, Figure.1, 2) (*p*=0.0001) of both groups. Unpaired t-test comparison demonstrated significant difference between groups after treatment (*p*=0.0004) in favour to group A, and a non-significant difference 6 months follow up (*p*=0.082).

Paired t-test of all pain scores analyzed **Cozen test** has shown a significant effect of treatment in group A, pre treatment value was 4.7±1.22 and after treatment value was 1.95±1.1 , (*p*=0.0001) and group B pre treatment value was 5.1±1.52 and after treatment value was 3.1±0.91, (*p*=0.0001), comparing after treatment and follow up (2.5±0.75, 3.35±0.99 for shock wave and ultrasound respectively) within each group have shown a statistical significant increase (improvement) is shown (Table 2, Figure.1, 2) (*p*=0.0001) of both groups. Unpaired t-test comparison demonstrated significant difference between groups after treatment (*p*=0.0009), and 6 months follow up (*p*=0.0042) in favour of group A.

Paired t-test of all pain scores analyzed **Chair test pain** has shown a significant effect of treatment in group A, pre treatment value was 5.25±1.07 and after treatment value was 1.75±1.2, (*p*=0.0003) and group B pre treatment value was 5.25±0.91 and after treatment value was 3.8±1.19, (*p*=0.001), comparing after treatment and follow up (2.70±0.98), 3.4±0.99 for group A and B respectively) within each group have shown a statistical significant increase (improvement) as shown (Table 2, Figure.1, 2) (*p*=0.0001) of both groups. Unpaired t-test comparison demonstrated significant difference between groups after treatment (*p*=0.0003), and 6 months follow up (*p*=0.03) in favour of group A.

Paired t-test of all pain scores analyzed **Pressure pain test** has shown a significant effect of treatment in group A, pre treatment value was 5.55±1.53 and after treatment value was 1.95±1.09, (*p*=0.0008) and group B pre treatment value was 5.15±1.38and after treatment value was 3.95±1.43, (*p*=0.0006), comparing after treatment and follow up (3.00±1.08, 3.8±1.15 for group A and group B respectively) within each group have shown a statistical significant increase (improvement) as shown (Table 2, Figure1,. 2) (*p*=0.0001) for group A and (*p*=0.0085) for group B. Unpaired t-test comparison demonstrated significant difference between groups after treatment (*p*=0.0004), and 6 months follow up (*p*=0.029) in favour of group A.

Paired t-test of all pain scores analyzed **Pain at work** has shown a significant effect of treatment in group A, pre treatment value was 6.7±1.17and after treatment value was 2.95±0.94, (*p*=0.0004) and group B pre treatment value was 6.25±0.78and after treatment value was 4.55±1.23, (*p*=0.0006), comparing after treatment and follow up (3.95±1.05, 4.8±1.15for shock wave and ultrasound respectively) within each group have shown a statistical significant increase (improvement) is shown (Table 2, Figure1,. 2) (*p*=0.0001) of both groups. Unpaired t-test comparison demonstrated significant difference between groups after treatment (*p*=0.0003), and 6 months follow up (*p*=0.015) in favour of group A.

Paired t-test of all pain scores analyzed **Pain at rest** has shown a significant effect of treatment in group A, pre treatment value was 4.0±1.21 and after treatment value was 0.85±0.87, (*p*=0.0001) and group B pre treatment value was 4.3±1.19 and after treatment value was 2.1±1.17, (*p*=0.0001), comparing after treatment and follow up (2.05±0.94, 3.2±1.11 for group A and group B respectively) within each group have shown a statistical significant increase (improvement) as shown in (Table 2, Figure1,. 2) (*p*=0.0001) for group A and (*p*=0.0051) for group B. Unpaired t-test comparison demonstrated significant difference between groups after treatment (*p*=0.0005), and 6 months follow up (*p*=0.0011) in favour of group A.

Table 2. Pain scores before and after treatment and 6 month follow up in groups A, B

Score	Group A	Group B	P value
Tennis elbow test			
Before treatment	5.95±0.94	5.5±1.05	0.16*
After treatment	2.5±0.82	3.65±1.03	0.0004*
P value	0.0002**	0.0006**	
Follow up	3.20±1.01	3.80±1.11	0.082*
P value	0.0001***	0.0001***	
Cozen test			
Before treatment	4.7±1.22	5.1±1.52	0.4271*

After treatment P value Follow up *P value*	1.95±1.1 0.0001** 2.5±0.75 0.0001***	3.1±0.91 0.0001** 3.35±0.99 0.0001***	0.0009* 0.0042*
Chair test pain Before treatment A.1fter treatment P value Follow up *P value*	 5.25±1.07 1.75±1.2 0.0003** 2.70±0.98 0.0001***	 5.25±0.91 3.8±1.19 0.001** 3.4±0.99 0.0001***	 0.43* 0.0003* 0.03*
Pressure pain test Before treatment After treatment P value Follow up *P value*	 5.55±1.53 1.95±1.09 0.0008** 3.00±1.08 0.0001***	 5.25±1.38 3.95±1.43 0.0006** 3.8±1.15 0.0058***	 0.54* 0.0004* 0.029*
Pain at work Before treatment After treatment P value Follow up *P value*	 6.7±1.17 2.95±0.94 0.0004** 3.95±1.05 0.0001***	 6.25±0.78 4.55±1.23 0.0006** 4.8±1.15 0.0001***	 0.16* 0.0003* 0.015*
Pain at rest Before treatment After treatment P value Follow up *P value*	 4.0±1.21 0.85±0.87 0.0001** 2.05±0.94 0.0001***	 4.3±0.94 2.1±1.17 0.0001** 3.2±1.11 0.0051***	 0.5060* 0.0005* 0.0011*

*Comparison between the studies groups before, after, and 6 months follow up.
**Comparison between before and after treatment within each group.
***Comparison between before treatment and 6 month follow up.

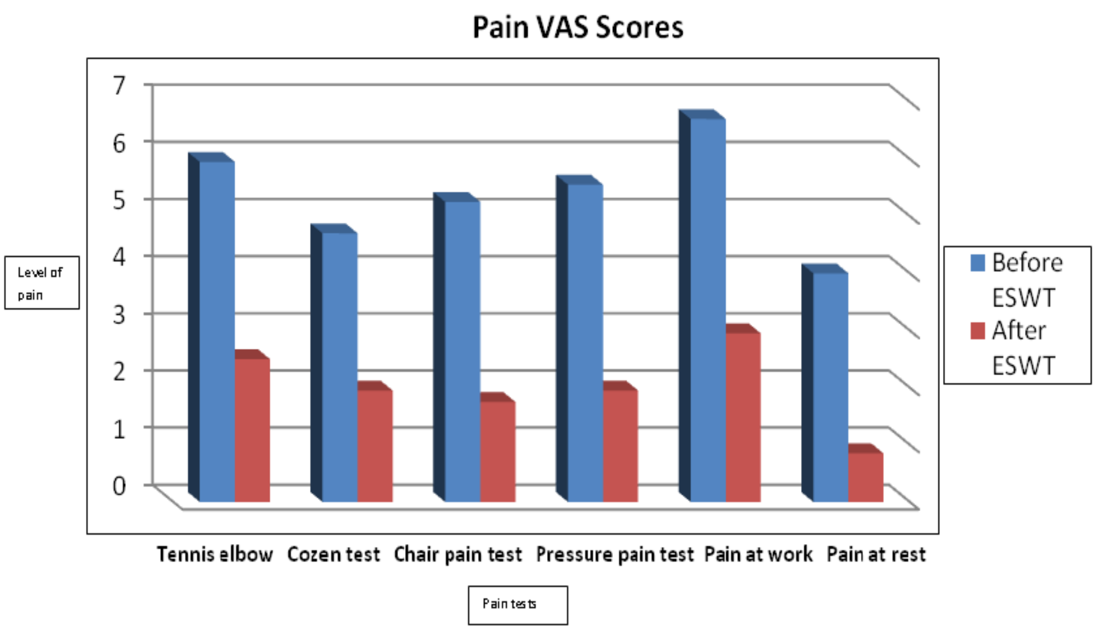

Figure 1. Pain VAS scores pre and post-treatment with ESWT in group A

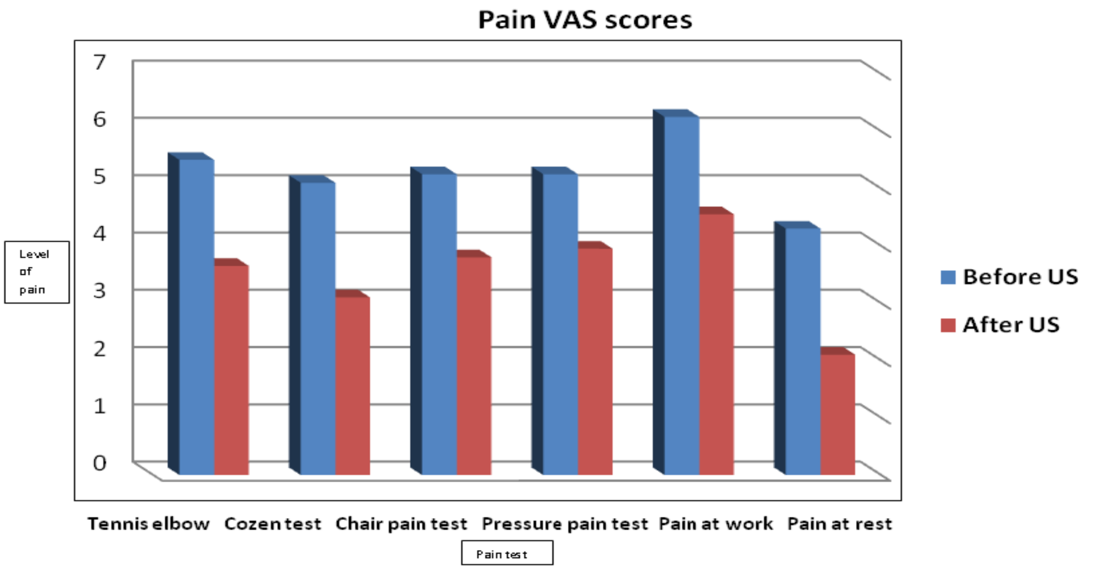

Figure 2. Pain VAS scores pre and post-treatment with US in group B

Paired t-test of **pain-free grip** strength demonstrated a significant effect of treatment with group A, pre treatment value was18.25±1.37 and after treatment value was 18.25±1.37, (p=0.0002) and group B pre treatment value was 18.35±2.13 and after treatment value was 19.3±2.38, (p=0.0006), comparing after treatment and follow up (22.20±1.15, 20.35±0.93) for group A and group B respectively within each group have shown a statistical significant increase (improvement) as shown (Table 3, Figure. 3) (p=0.0001) of both groups. Unpaired t-test comparison demonstrated significant difference between groups after treatment (p=0.0003), and 6 months follow up (p=0.0001) favour of group A.

Table 3. The mean values of pain-free hand grip strength in groups A, B

Score	Group A	Group B	P value
Before treatment	18.25±1.37	18.35±2.13	0.86*
After treatment	21.8±1.6	19.3±2.38	0.0003*
P value	0.0002**	0.0006**	
Follow up	22.20±1.15	20.35±0.93	0.0001*
P value	0.0001**	0.0001***	

*Comparison between the study groups before, after, and 6 months follow up
**Comparison between before and after treatment within each group
***Comparison between before treatment and 6 month follow up

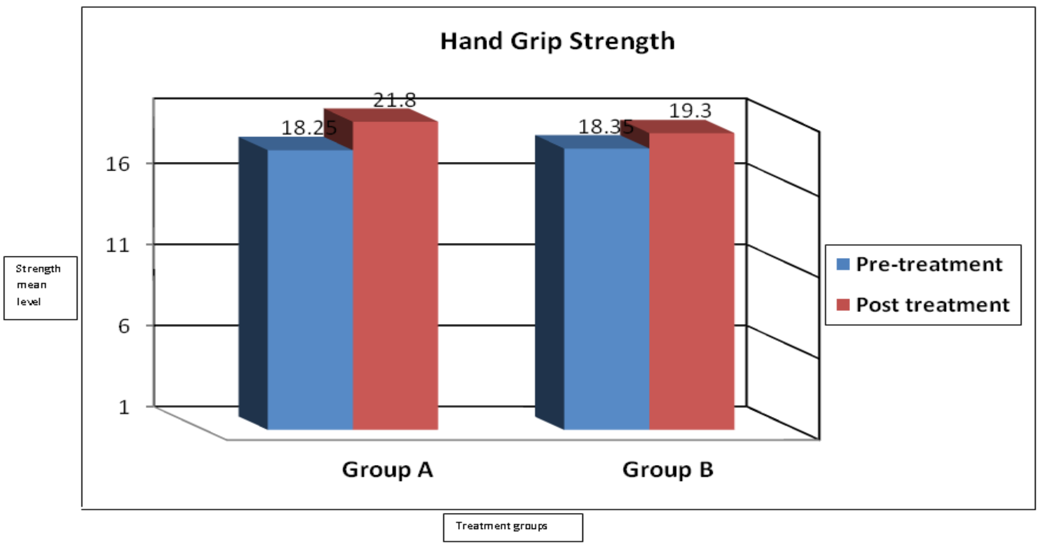

Figure 3. Hand grip strength mean values of pre and post treatment with ESWT in group A and US in group

Discussion

Conservative treatment is the primary treatment for lateral epicondylitis patients. Physiotherapy is a type of conservative treatment for this case. Now shock waves therapy has become the first choice by many physiotherapists for treating such condition; while others may keep using ultrasound. Both, ESWT and US were found to be an effective and safe modality to decrease pain and improve function in lateral elbow pain in lateral epicondylitis[22,23].

Many studies compared the effect of ultrasound to placebo or to other modalities on lateral epicondylitis. Binder et al 1985, Lundberg et al 1988 compared ultrasound to placebo and ultrasound to phonophoresis[19,24], Halle et al. 1986 compared ultrasound to transcutaneous neuromuscular stimulation[25], Holdsworth and Anderson 1993 compared ultrasound to exercises[26]. To our knowledge our study is the first to compare the effectiveness of ultrasound to extracorporeal shock wave therapy by comparing their effects on pain and function of patients in lateral epicondylitis.

Results has shown that comparison between groups of the values for each analyzed parameter, VAS scores and pain-free hand grip strength test were always statistically significant after treatment and 6 months after treatment. It was observed that Group A showed significant improvement compared to Group B. This significant difference in the short term effect (after treatment) and the long term effect (6 month follow-up) between ESWT and ultrasound despite of the shorter duration of treatment with ESWT rather than ultrasound may be attributed to the difference in the mechanism of action by which each of the previous modalities strike tissues to heal them.

Studies that investigated the effect of ESWT on pain have postulated that shock waves provoke an intense stimulation or hyperstimulation which activates the fibres of small diameter which project to cells in the periaqueductal grey area that activate serotoninergic system which modulates transmission of pain stimuli through posterior horns; this causes the patient's pain tolerance above their existing original pain level[17, 27,22,28]. ESWT was hypothesized to cause physical alteration of small axons, thereby inhibiting pain impulse conduction; chemical alteration of pain receptor neurotransmitter, thereby preventing pain perception[28]. Schimtz 2010 have stated that analysis of pain induced by ESWT is mediated mainly by the reduction of substance P in the target tissue in conjunction with reduced synthesis of this molecule in dorsal root ganglia cells as well as by selective destruction of unmyelinated nerve fibres within the focal zone of extracorporeal shockwaves[29].

Ultrasound has different mechanisms of pain reduction; the analgesic effect of ultrasound therapy is attributed to thermal and non thermal physical effect in tissue. Thermal effect may include increased blood flow, reduction in muscle spasm, increased extensibility of collagen, the non-thermal effect of ultrasound, including cavitation and acuosting microstreaming may lead to decrease pain perception by slowing nerve conduction velocity fibers and pro – inflammatory response[19].

Some considerations can be made related to the study of Lebrun 2005 who referred to the mechanisms by which shock waves can reduce inflammation is that shock waves induce tissue changes by increasing metabolic activity and blood flow through the area, and activating the body's own repair mechanisms[27]. Malay et al. 2006 hypothesized that ESWT stimulates healing by creating a wound environment at the site of shockwave delivery. ESWT attenuates acute pro-inflammatory cytokine expression and extra cellular matrix proteolytic activity[28]. ESWT induces the growth of neovascularization which play a role to improve blood supply and tissue regeneration at bone tendon junction[17,27].

Ultrasound was proved to be effective in tissue repair which are somewhat different from ESWT. The mechanisms by which ultrasound reduces inflammation are that it enhances blood and increase membrane permeability, and alter connective tissue extensibility and nerve conduction[15]. Ultrasound induces the degranulation of mast cells, causing the release of arachidonic acid which itself is a precursor for the synthesis of prostaglandins and leukotreine – which act as inflammatory mediator[30]. It is effective at promoting the normality of the inflammatory events, and as such has a therapeutic value in promoting the overall repair events[31]. Ultrasound also has a simulative effect on the fibroblasts, endothelial cells and myofibroblasts[32], therefore it is pro-proliferative in the same way that it is pro-inflammatory[11].

Conclusion

ESWT gave better results than ultrasound; it has also faster effect than ultrasound as it needs lesser number of sessions 3 sessions in two alternative weeks to 12 sessions ultrasound in four weeks. The better results gained by Shock wave may be attributed to that shock wave is characterized by high peak pressure so focused on focal point of pain rather than ultrasound not focused on painful point, this stimulates inflammatory and healing effect at these points. It achieves better results in a shorter time than ultrasound.

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