Extracorporeal Shock Wave Therapy and Low Level Laser Therapy in Treatment of Knee Osteoarthritis: A Comparative Study

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ABSTRACT

Background: Knee osteoarthritis is a joint degenerative disease characterized by joint pain, decreased mobility, and functional disability, resulting in difficulty with daily activities and a lower quality of life. **Purpose:** The study aim is to compare outcomes of applying extracorporeal shock wave therapy (ESWT) versus low-level laser therapy (LLL) on pain, and function in patients suffering osteoarthritis of the knee. **Subjects and methods:** Thirty patients with unilateral knee OA, age ranged from 50-60 years, were assigned randomly into two groups. The first group (n=15) received ESWT two sessions a week for four weeks. The second group (n=15) received low level laser three sessions a week for four weeks. Both groups received an exercise program in the form of strengthening for quadriceps, hip adductors, hip abductors, and stretching for the hamstrings, and calf muscles 3 sessions a week for four weeks. Visual Analogue Scale (VAS) was used to assess pain intensity, Western Ontario and McMaster Universities Osteoarthritis questionnaire (WOMAC) and Time up and go test were used to assess functional performance pre and post treatment. **Results:** There were statistically significant improvements in the dependent variables of both groups when comparing their pre and post treatment mean values ($P<0.05$). However, there were no statistically significant differences in the measured variables between the ESWT and the LLLT groups. **Conclusion:** Both ESWT and LLLT were effective in relieving knee pain, improving functional disability in knee osteoarthritis patients. However, outcomes showed that both interventions have comparable effects, where neither of ESWT or LLLT showed to be superior to the other.

KEY WORDS: Extracorporeal shockwave; Knee Osteoarthritis; Low-level laser; Pain.

INTRODUCTION

Knee osteoarthritis (KOA) is a prevalent chronic degenerative condition that is linked directly to the ageing process. Common symptoms of KOA are joint pain, decreased mobility, crepitus, and swelling, resulting in difficulty with daily activities and a lower quality of life [1].

Knee OA affects 13% of women and 10% of men over the age of 60, making it one of the most common causes of disability among the elderly [2].

Although the etiology of knee osteoarthritis is unknown, there are multiple risk factors linked to the disease's progression, including age, gender, obesity, and genetics, as well as diet, injury, excessive mechanical loading of the joints, and mal-alignment [3].

The main aims of conservative treatment for knee OA are to alleviate pain, increase joint mobility and improve functional capacity using treatments such as oral medication, intra-articular drug injections, and physiotherapy [4].

ESWT is a non-invasive modality that has long been used to treat a variety of musculoskeletal problems in recent years including tendinitis, lateral epicondylitis, plantar fasciitis, non-union fractures, avascular necrosis of the femoral head and recently knee OA [5]. Shockwave therapy has been investigated in cases of knee OA. Results showed the effectiveness of ESWT on improving clinical manifestations of KOA including pain and function [6].

LLLT has gained wide acceptance as a pain reliever, and it is suggested for its anti-inflammatory as well as healing properties. LLLT has been utilized to treat a variety of musculoskeletal conditions, including cervical spondylosis, epicondylitis, low back pain, and, more recently, knee OA [7].

To delay or avoid surgical options, it is essential to validate effective treatments that are beneficial in reducing pain, enhancing physical function, and blocking the progress of joint degeneration [8]. Pain management is shifting away from surgery and painkillers toward alternative modalities that accelerate the body's natural healing process. To our knowledge, no previous clinical trials have compared the effectiveness of ESWT versus LLL in treating knee OA. The goal of the current investigation was to show if there were different effects of using ESWT or LLLT for managing patients who had KOA.

Materials and methods

Design: This study is a pre-posttest two groups trial. It was carried out at the outpatient clinic of orthopedic at Damietta Specialized Hospital and Horus university in the period from November 2020 to March 2021. The ethics committee of Faculty of Physical Therapy, Cairo University accepted the study's protocol **(NO P.T.REC/012/002886).**

Participants: Thirty patients (12 male and 18 female) were diagnosed with unilateral knee osteoarthritis participated in this study. Their body mass index was between 30.1- 34.9 kg/m^2. Inclusion criteria were unilateral KOA showing clinical criteria that matches those suggested by the American College of Rheumatology (ACR); Kellgren-Lawrence grades II and III knee OA; and if they were between the ages of 50 and 60 [9]. Exclusion criteria were cardiovascular, metabolic, neurological, oncological diseases, previous lower limb surgery, Cognitive impairment, Intra-articular injection of the knee joint in the previous 6 months, any contraindication to ESWT (pregnancy, cancer, coagulation abnormalities, inflammatory disorder, pacemaker) or laser (pregnancy, cancer, thrombophlebitis, hemorrhagic conditions, and infection).

Procedures Thirty patients were recruited after checking inclusion/exclusion criteria. They were divided into two equal groups (ESWT and LLLT) by using opaque, sealed envelopes, containing the name of one of each group. After inclusion, patients were asked to sign a consent form after getting complete information about the study's goal, methods, potential benefits, privacy, and data usage. Both groups had an assessment of pain and function. The pain intensity was measured using a visual analogue scale. Patients' pain, joint stiffness, and functional disability had been evaluated by Western Ontario and McMaster Universities questionnaire for osteoarthritis (WOMAC). Timed up and go test (TUG) was applied as a functional performance test to evaluate patients' functional ability. All outcome measures were reported before and after the treatment.

The first group received ESWT (n=15) whereas the second group received LLLT (n=15). Patients in both groups underwent a 30-second stretching exercise for the hamstrings and calf muscles twice, followed by strengthening the quadriceps, hip adductors, and abductors in three sets of 10 repetitions.

Evaluation procedure

Patients in both ESWT and LLLT groups were evaluated for pain and function in the same way.

A) Pain: patients were assessed for pain using VAS that is a 10-cm horizontal line designated by "no pain" and "intolerable pain" at either ends of the line. Patients were asked to make a mark on this line that represented their pain intensity at the time of evaluation. The distance of VAS line was measured using a ruler from zero- pain end (no pain) to the mark set by the patient. Measure was recorded to the nearest millimeter [10].

B) Western Ontario and McMaster Universities Osteoarthritis questionnaire (WOMAC):

The WOMAC is a self-administrated questionnaire developed to evaluate individuals with knee OA that consists of 24 questions in three domains (pain, function and joint stiffness). Patients were asked to make their responses in five-point Liker scale opposite to each statement and scores were calculated as a percent. The overall score of the 3 domains was reported. Higher percent shows worse pain, function and stiffness and vice versa [11].

C) Timed up and go test (TUG)

The TUG is a clinical functional performance procedure used to evaluate function mobility in individuals with knee OA. Patients were instructed to sit on a standard chair, when instructed to "Go" they stood up and walk as fast as they could, given they were safe and comfortable. They were asked to cross a mark of the ground three meters away by both feet, then return to the sitting position. This task was recorded to the nearest millisecond. Patients were allowed a familiarization trail and two recorded runs. The average time of the two recorded runs was reported [12].

Treatment procedure

The ESWT group

Patients in group A was treated using ESWT with 2000 pulses, energy dose 0.20 mJ/mm2 and frequency of 8Hz by using (EMS Swiss piezoclast, FT-204W, Germany) for 8 sessions, given twice per week for four weeks [13]. Patients assumed a reclined position and the treated leg was flexed 90^0 at the knee joint, with the foot resting comfortably on the plinth. The shock wave probe was directed at the most painful points in the area, which was determined by palpating the anatomical marks around the knee joint; the peripatellar area, the lateral and medial condyles of femur, and the popliteal fossa). The 2000 treatment pulses were distributed into 2 sets; the first 1000 pulses evenly distributed among the pain points, while the remaining 1000 pulses were applied during probe sliding on the patellofemoral and tibiofemoral joints borders [14].

The LLLT group

LLLT was applied using Physio Go 400C Laser, class 3B (Astar, Poland), infrared laser point probe (wavelength 808 nm, continuous wave, power 100 mW). Patients assumed supine position with a slightly flexed knee and received LLLT onto the medial and lateral knee joint lines, medial and lateral epicondyles of femur and tibia, and the medial aspects of biceps femoris and semitendinosus tendons at popliteal fossa [15,16]. Each spot received 6 J/cm^2 of energy for 1 minute, for a total of 48 J/cm^2 per treatment session [15,17]**.** Therapy was applied 3 times each week for 4 weeks.

The exercise program: Patients in both groups were given the same program of exercise, which included 30-second stretching exercises for each of the hamstrings and calf muscles twice/session, followed by strengthening the quadriceps, hip adductors, and abductors in three sets of 10 repetitions (straight leg raising exercises, lateral leg raising exercises, and isometric strengthening exercises for the quadriceps and hip adductor muscles) [18].

Data analysis: SPSS for Windows, version 26 was used for statistical analysis (SPSS, Inc., Chicago, IL). Normality, homogeneity of variance, and existence of extreme values were checked before final analysis. As a result of the initial check, it was found that data can be analyzed using parametric statistics. Unpaired t-test was utilized to compare differences in means of outcome parameters between the two study groups both pre and post treatment evaluation times. Whereas paired t-test was applied to compare differences in means of outcome parameters within each study group between pre and post treatment evaluation times. The demographic features of the two study groups were compared using an unpaired t-test for continuous variables; age, weight, height, and body mass index (BMI), and chi square ($\chi 2$) for gender as a nominal data. The alpha level for this study was set at 0.05.

Results

Participants' demographic features

No significant differences were detected upon comparing patients in both study groups for age, weight, height, body mass index and gender (table 1).

Table 1. comparing patient's characteristics in ESWT and LLLT groups

	(ESWT) $\bar{x} \pm SD$	(LLLT) $\bar{x} \pm SD$	P- value
Age (Years)	53.9 ± 2.90	53.2 ± 2.39	0.477
Height (cm)	163.6 ± 5.60	164.53 ± 7.67	0.766
Weight (kg)	88.1 ± 8.01	90.0 ± 10.38	0.579
BMI (kg/m2)	32.88 ± 1.97	33.13 ± 1.36	0.694
Gender			
Male	5 (33.33%)	7 (46.66 %)	0.710
Female	10 (66.66 %)	8 (53.33 %)	

*P<0.05

Outcome parameters

Comparison within groups showed significant improvements of means of VAS, WOMAC, and TUG at post-treatment evaluation compared to pretreatment evaluation in both ESWT and LLLT groups.

On the contrary, between groups means comparisons showed no statistically significant differences between the two groups at both pretreatment and post- treatment evaluations in all evaluated variables (table 2).

Table 2. Comparison of mean values between and within both groups for VAS, WOMAC, and TUG

Variable	Time	(ESWT) $\bar{x} \pm SD$	(LLLT) $\bar{x} \pm SD$	*P*- Value
VAS (score)	Before	7.93 ± 1.14	8.16 ± 1.15	0.584
	After	4.43 ± 1.20	4.36 ± 1.23	0.882
	P Value	0.0001*	0.0001*	
WOMAC (score)	Before	45.00 ± 12.69	42.60 ± 12.28	0.603
	After	19.26 ± 7.50	17.60 ± 8.33	0.569
	P Value	0.0001*	0.0001*	
TUG (seconds)	Before	11.28 ± 1.75	12.25 ± 1.19	0.085
	After	9.60 ± 1.09	9.67 ± 1.10	0.864
	P Value	0.0001*	0.0001*	

P<0.05

Discussion

The current investigation aimed to compare effects of ESWT and LLLT on pain and functional disability in KOA. In this study results revealed that both treatment modalities were effective but not superior to one another in terms of pain relief as measured by VAS and functional improvement as measured by WOMAC and TUG.

Results of the current comparison may be attributed to the relatively close suggested mechanisms of action of both modalities; ESWT and LLLT. The mechanisms suggested in previous studies to explain how both modalities affect pain intensity are two- folds, affecting pain transmission and local effects on tissues.

The analgesic effect of shock wave therapy may be due to overstimulation of axons (gate-control theory), which elevates a person's pain threshold [19]**.** Other hypothesized mechanism of action includes destruction of unmyelinated nerve fibers, which inhibits transmission of painful stimuli, besides chemical change involving pain receptors and neurotransmitters. As a result, perception of pain is prevented [20]**.** Moreover, after a given number of shocks, endorphins are released locally, which may aid in pain reduction. Furthermore, ESWT may lower calcitonin gene-related peptide expression in dorsal root ganglia contributing to reduction of joint pain [5]**.**

Likewise, Furthermore, LLLT is another conservative treatment approach. It induces analgesic effects by modulating pain regulation mechanisms, altering nerve transmission or suppressing sensory neural activity in order to increase the pain threshold. Moreover, laser irradiations treat pain by reducing edema and enhancing tissue oxygenation, resulting in pain reduction [15].

An alternative explanation of the effect of ESWT in cases of KOA are tissue changes probably induced through increased metabolic activity and enhancing blood flow in the joints and neighboring structures, stimulating the body repair mechanisms [21]**.**

A closely related mechanism has been also suggested to explain the effect of LLLT on KOA. LLLT is suggested to induce tissue repair and bio-stimulatory effects, thus it might promote joint cartilage regeneration through stimulating chondrocyte synthesis and secretion of the extracellular matrix [15]**.**

As secondary outcomes, the findings of this study showed within groups significant pain reduction and functional enhancement in both ESWT and LLLT groups. These findings agreed with the previous researches that investigated the effects of both modalities on pain and function in KOA.

These results in the ESWT group come in agreement with previous studies reporting that shock wave therapy is effective in reducing pain and improving function ability in patients with KOA [6]. Likewise, **Lee et al., 2017** studied the effects of ESWT on patients with chronic knee arthritis, dividing twenty patients into two groups: ESWT and conservative physical therapy. The VAS and WOMAC ratings of the ESWT group revealed statistically significant declines. Therefore, ESWT has been suggested as a nonsurgical treatment option for alleviating pain and enhancing function in people with KOA [22]**. Elerian et al., 2016** compared ESWT to intra-articular corticosteroid injections in individuals with knee osteoarthritis. In comparison to the control group, shock wave therapy and intra-articular corticosteroid injection were beneficial in reducing knee pain, decreasing functional impairment, and improving knee range of motion. In addition, these effects were observed more in the ESWT group than in the intra-articular corticosteroids' injection group [23]**. Kim et al., 2015** ESWT was found to be beneficial in relieving OA patients' knee pain and improving their physical functions. In addition, their findings revealed that medium-energy ESWT had more curative effects than low-energy ESWT with regard to pain relief and function restoration [24]. **Zhao et al.,2013** who conducted a randomized control trial to compare the efficacy of ESWT with placebo over 12 weeks in patients with knee osteoarthritis. They found that ESWT was more effective than a placebo in improving pain and function at three months' follow-up after ESWT [25].

Likewise, according to the findings of this study, there was a significant reduction in pain intensity and significant improvement in function after treatment in group B who received low level laser. Many prior clinical trials have shown that LLLT lowers pain severity and enhances physical function [15,16]. **Youssef et al 2016**, who investigated the effect of laser therapy on knee osteoarthritis in elderly. The findings of their study showed that combining LLLT with an exercise program could be a more effective treatment for older people with osteoarthritis than exercise alone. The active laser groups (3 or 6 J/cm²) showed a significant decline in pain severity on VAS and WOMAC, an improvement in physical function, an increase in muscular strength of the quadriceps and hamstrings, and a gain in ROM [16]**.** Moreover, **Alghadir et al., 2014** investigated the effects of LLLT compared to placebo on pain reduction and functional ability in people with osteoarthritis of the knee. The active laser group received laser on eight spots at a dose of 6 J/point and a total dose of 48 J/cm2 twice per week for four weeks. The laser group demonstrated significant differences in pain alleviation and functional performance when compared to the placebo group [15]**.** Furthermore, **Rayegani et al.,2012** who compared between low level laser, ultrasound and placebo in individuals with knee OA. The result of their study revealed a significant improvements regarding pain, stiffness, and disability in the group treated by LLLT in comparison with placebo and US groups as measured by VAS and WOMAC [26] **. Alfredo et al., 2012** studied the effects of LLLT combined with exercise in patients with knee OA. They found that the laser group showed a statistically significant reduction in pain, improved range of motion, function, and activity. The authors concluded that LLLT paired with exercise was effective in reducing pain and improving function in individuals with knee OA [27].

Conclusion

The authors of the currents study concluded that both ESWT and LLLT were equally effective for pain relief and functional improvement in knee osteoarthritis patients. Moreover, Both treatment approaches were successful but not superior to one another.

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