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Efficacy of low-level laser therapy applied at acupuncture points in knee osteoarthritis: a randomised double-blind comparative trial☆

A.S. Al Rashoud, R.J. Abboud, W. Wang, C. Wigderowitz *

Institute of Motion Analysis and Research, Department of Orthopaedic and Trauma Surgery, University of Dundee, Ninewells Hospital and Medical School, Dundee, UK

Abstract

Objective To evaluate the efficacy of low-level laser therapy (LLLT) applied to acupuncture points on the knee joint in combination with exercise and advice in patients with knee osteoarthritis.

Design Randomised, double-blind, comparative clinical trial.

Participants Forty-nine patients with knee osteoarthritis were assigned at random into two groups: active laser group ($n = 26$) and placebo laser group ($n = 23$).

Intervention Using a gallium aluminium arsenide laser device, patients received either active or placebo LLLT at five acupuncture points on the affected knee during nine sessions.

Outcome measures Patients were assessed using a visual analogue scale (VAS) and the Saudi Knee Function Scale (SKFS) at baseline, the fifth treatment session, the last treatment session, 6 weeks post intervention and 6 months post intervention.

Results VAS scores showed a significant improvement in the active laser group compared with the placebo laser group at 6 weeks post intervention [mean difference −1.3, 95% confidence interval (CI) of the difference −2.4 to −0.3; $P = 0.014$] and 6 months post intervention (mean difference −1.8, 95% CI of the difference −3.0 to −0.7; $P = 0.003$) using the independent samples test. SKFS scores also showed a significant improvement in the active laser group compared with the placebo laser group at the last treatment session (median difference −15, 95% CI of the difference −27 to −2; $P = 0.035$) and 6 months post intervention (median difference −21, 95% CI of the difference −34 to −7; $P = 0.006$) using the Mann–Whitney U test.

Conclusions The results demonstrate that short-term application of LLLT to specific acupuncture points in association with exercise and advice is effective in reducing pain and improving quality of life in patients with knee osteoarthritis.

Keywords: Low-level laser therapy (LLLT); Laser therapy; Phototherapy; Acupuncture for knee joint; Laser acupuncture; Osteoarthritis of knee

Introduction

The prevalence of osteoarthritis is increasing rapidly, affecting approximately 14% of US adults [1,2]. In the UK and Australia, 40% of the population aged >65 years have symptoms associated with knee or hip osteoarthritis [3,4]. However, in Saudi Arabia, the incidence of knee osteoarthritis approaches 61% in individuals aged 66 to 75 years [5].

There are no disease-modifying treatments for osteoarthritis [6,7]. Non-steroidal anti-inflammatory drugs, the most commonly prescribed medications for knee osteoarthritis, are associated with serious side effects [6,8]. Elderly patients with osteoarthritis typically suffer comorbidities that increase the risk of drug-to-drug interactions [2,6].

As a result, both patients and health professionals are seeking alternative therapies with good effects, less toxicity and lower cost. Several modalities, such as acupuncture, transcutaneous electrical nerve stimulation and low-level laser therapy (LLLT), are non-pharmacological interventions that have been classified as non-invasive, safe treatments for osteoarthritis [9]. However, LLLT has advantages because it can be used where other modalities are contraindicated. LLLT can be applied to patients with pacemakers, metal implants,

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* Corresponding author at: Department of Orthopaedic and Trauma Surgery, Tayside Orthopaedic and Rehabilitation Technology Centre, Ninewells Hospital and Medical School, Dundee DD1 9SY, UK. Tel.: +44 1382 425746; fax: +44 (0) 1382 496200.

E-mail addresses: c.a.wigderowitz@dundee.ac.uk, cawigderowitz@lineone.net (C. Wigderowitz).

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burns and wounds, and to anatomically dangerous areas. It is a low-cost, short-application, non-infectious treatment (e.g. in cases of human immunodeficiency virus infection and hepatitis). Furthermore, LLLT has no heat or vibration, and is invisible above 770 nm, making it ideal to blind in randomised controlled trials [10–12].

Acupuncture has been shown to be effective in pain relief and dysfunction associated with musculoskeletal conditions, including knee osteoarthritis [13]. Recent studies have clearly shown that laser light can be used successfully as an alternative to metal needles (laser acupuncture) for effective acupuncture treatment. Furthermore, LLLT is safer and requires less time than needle acupuncture, and can avoid the pain and psychological fear of traditional acupuncture [10,11,14]. Tascioglu *et al.* [15] reported that several studies have shown that LLLT has anti-inflammatory, anti-oedema effects, and plays a role in pain reduction without side effects. Nonetheless, the results using LLLT on patients with knee osteoarthritis are conflicting. Although many studies showed significant improvement [16–19], others did not [20,21].

To the authors' knowledge, only two published studies have tested the efficacy of LLLT when applied to acupuncture points in patients with knee osteoarthritis, and only one acupuncture point was stimulated in each of these studies [19,21]. Results from both studies were conflicting; furthermore, one of them was a pilot study [19]. It has been recommended that randomised controlled trials are needed to investigate how the effectiveness of LLLT is affected by four important factors: wavelength, treatment duration, dosage and site of application (e.g. nerves instead of joints) [17]. The efficacy of LLLT for osteoarthritis, as well as its association with exercise, has been questioned previously [16].

The aim of this study was to evaluate the efficacy of LLLT when applied to five acupuncture points in combination with exercise and advice for patients with knee osteoarthritis. A randomised, double-blind, comparative trial was undertaken, where both groups received conventional treatment for osteoathritis in the form of exercise and advice. The trial compared a placebo laser group with an active laser group, which received active LLLT on specific acupuncture points in addition to exercise and advice.

Methods

Research design

Randomised, double-blind, comparative trial.

Patient recruitment

This study was conducted by a trained physiotherapist at the Physiotherapy Department of the Security Forces Hospital, Riyadh, Saudi Arabia from August 2010 to February 2011. In total, 49 patients completed the study. Inclusion criteria included female or male patients with knee osteoarthritis according to the American College of Rheumatology criteria [22], an average pain intensity of ≥ 3 on a 10-cm visual analogue scale (VAS), ability to perform all movements included in the evaluation forms, ability to read or understand the patient information sheets, and ability to sign a consent form. For those patients with bilateral knee osteoarthritis, the most painful knee was assessed.

Exclusion criteria included previous knee surgery, serious valgus or varus deformity, disease where laser treatment is contraindicated (cancer, uncontrolled diabetes mellitus, hypertension, etc.), and current use of medications that might interfere with LLLT treatment (e.g. corticosteroid injections) [17,21]. Patients were allowed to take analgesics as required for severe pain, and to discontinue any other medication related to their knee pain; their physicians were consulted about this point. Ethical approval was granted by the Research Committee of the Security Forces Hospital. Each participant signed an informed consent form before the study.

Randomisation

Before starting the study, a randomisation list was produced using software-generated randomised numbers; the randomisation depended on random blocks of 10 [23]. Patients were assigned at random to the active laser group ($n = 26$) or the placebo laser group ($n = 23$). Participants were enrolled by the research assistant.

Laser device and its parameters

This study used a gallium aluminium arsenide laser device (Endolaser 476, Enraf Nonius, Rotterdam, The Netherlands) with a single 30-mW diode probe, producing infra-red laser with a wavelength of 830 nm and an irradiation area of 0.28 cm^2. The probe and laser device were checked regularly to ensure proper function.

Treatment procedure

Patients received treatment in a supine position, with the affected knee slightly flexed and supported by a rolled towel. The investigator, research assistant and patients wore protective goggles to shield their eyes from active laser radiation. On the affected knee, the laser probe was placed sequentially and perpendicularly in full contact with the skin at five acupuncture points, commonly used for treating knee osteoarthritis [24–26] (Fig. A, see online supplementary material). In the active laser group, an active continuous laser beam irradiated each point for 40 seconds with a dose of 1.2 J/point, 6 J per session for each patient; this dose is somewhat lower than that recommended by the World Association for Laser Therapy for a 830-nm laser [27]. The energy density was 4 J/cm^2. The same procedures were applied to patients in the placebo laser group, but the device was inactive and only produced visible red light.

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In addition to supportive advice on coping with knee osteoarthritis, after each treatment session, patients in both groups were given a straight leg raise exercise and advised to repeat it five times daily.

Blinding

Neither the investigator nor the patient knew whether a placebo or active treatment was being administered; only the research assistant had the identifying code to determine which treatment was given. The same laser device was used for both groups, and the placebo and active emitters looked identical; no heat, sound or vibration was detectable.

Main outcome measures

The primary outcome measure was the change in VAS score for pain during movement. The VAS has been shown to be a reliable and valid measure of pain which is used frequently in clinical and research settings [28]. It consists of a 10-cm line anchored at each end. The left-hand anchor reads 'no pain' and the right-hand anchor reads 'worst possible pain'; the patients marked a line to represent their pain level.

Secondary outcome measures

Saudi Knee Function Scale (SKFS) scores were also used as an outcome (Appendix A, see online supplementary material). It is a reliable and valid Arabic language scale developed by Al-Sobayel [29]. The SKFS is a multidimensional self-administered instrument that emphasises eight pain items, two stiffness items, 12 physical function activity items, three social activities and three psychological activities as they relate to knee osteoarthritis. Each of the 28 questions in the SKFS is graded on a five-point Likert scale ranging from 0 (no symptoms) to 4 (maximum symptoms).The SKFS contains activity items that specifically relate to Arabic and Muslim societies, and are not present in other commonly used indexes.

Active range of motion was measured as an outcome; patients were asked to bend their affected knee as much as possible, and the flexion degree was measured using goniometry. Patient satisfaction was measured using a verbal numeric scale [from 0% ('no benefit') to 100% (full benefit); in blocks of 5%], with each participant asked to rate the benefits derived from the treatment.

Statistical analysis

Statistical analyses were conducted using SPSS Version 17 (IBM Corp., New York, USA). Student's *t*-test was applied when variables were normally distributed numerical data. Non-parametric tests, Chi-squared test, Wilcoxon's signed-rank test and the Mann–Whitney *U* test were applied when variables involved either ordinal or nominal data or a non-normal data distribution.

A power analysis was conducted to estimate the requisite sample size. From previous studies, a clinically significant difference reduction in the VAS was defined as 3 cm [30]; a standard deviation of 3.49 [21], probability of a Type I error of 0.05 and power of 0.8 resulted in an estimated sample size of 21 [31]. Consequently, a total of 49 subjects were recruited.

Results

Of 58 potential participants, 49 completed the study: 31 (63%) were female and 18 (37%) were male. The mean age was 54 (standard deviation 10) years. Fig. B (see online supplementary material) shows the study flow.

The demographic and baseline clinical characteristics of the groups were similar with no statistically significant differences between them (Table 1).

VAS scores showed a statistically significant improvement for the active laser group ($P<0.001$) at all assessment periods. Similarly, VAS scores showed a statistically significant improvement for the placebo laser group at all assessment periods ($P=0.022$, $P<0.001$ and $P=0.002$ for the fifth treatment session, last treatment session and 6 weeks post intervention, respectively) except 6 months post intervention ($P=0.103$). However, this improvement was both clinically and statistically significant for the active laser group at the last treatment session, 6 weeks post intervention and 6 months post intervention (Appendix B, Table i, see online supplementary material). Statistically, but not clinically, significant improvement in VAS scores was detected between the groups at 6 weeks post intervention ($P=0.014$) and 6 months post intervention ($P=0.003$) in favour of the active laser group (Fig. 1 and Appendix B, Table i, see online supplementary material).

Within the active laser group, when compared with baseline, statistically significant improvements were detected in SKFS scores in the post-intervention assessments ($P<0.001$) (Appendix B, Table ii, see online supplementary material). Similarly, within the placebo laser group, statistically significant improvements were detected in SKFS scores in the post-intervention assessments ($P<0.001$ for the first three assessment periods and $P=0.004$ for the last assessment period). There was a statistically significant improvement in the SKFS scores in the active laser group compared with the placebo laser group at the last treatment session ($P=0.035$) and 6 months post intervention ($P=0.006$) (Table 2).

There was no significant difference in the degree of active range of motion in the various assessment periods, except at 6 months post intervention when a statistically significant improvement in favour of the active laser group was found ($P=0.019$) (Appendix B, Table iii, see online supplementary material). Comparisons of patient satisfaction showed a statistically significant difference at 6 months post intervention in favour of the active laser group ($P<0.001$) (Appendix B, Table iv, see online supplementary material).

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Table 1
Baseline characteristics of patients of both groups.

Characteristics	Active laser group ($n=26$)	Placebo laser group ($n=23$)
Gender, *n* (%)		
Female	16 (62%)	15 (65%)
Male	10 (39%)	8 (35%)
Age (years), mean (SD)	52 (9)	56 (11)
Height (cm), mean (SD)	157.7 (7.3)	155.5 (6.4)
Weight (kg), mean (SD)	87.2 (12.4)	84.5 (11.9)
Body mass index (kg/m^2), mean (SD)	38.0 (5.6)	37.1 (5.3)
Affected knee, *n* (%)		
Left	16 (62%)	15 (65%)
Right	10 (39%)	8 (35%)
Level of education, *n* (%)		
Educated	9 (35%)	10 (44%)
Non-educated	17 (65%)	13 (57%)
Visual analogue scale score, mean (SD)	6.4 (1.9)	5.9 (1.8)
Range of motion (degrees), median (IQR)	130 (125 to 136)	130 (128 to 135)
Patient satisfaction (%), median (IQR)	35 (20 to 50)	15 (0 to 50)

Values are mean [standard deviation (SD)] (if the data are numeric and normally distributed) or median [interquartile range (IQR)] (if the data are nominal or ordinal or are not normally distributed) for all variables unless stated to be number of cases (%).

Discussion

This study found that LLLT in combination with quadriceps strengthening exercise and advice has a beneficial effect on pain reduction and improvement in knee joint function, with a substantial improvement in VAS and SKFS scores. The placebo effect was also beneficial, as demonstrated by improvements in most outcomes in virtually all study participants. However, 6 weeks and 6 months post intervention, the improvement in the primary outcome (VAS score) was superior in the active laser group, and the difference was both clinically (≥3 cm mean difference) and statistically significant ($P<0.05$). In agreement with Alfredo *et al.* [16], improvements seen in the active laser group can be attributed to the anti-inflammatory properties of LLLT applied to specific points on the articular capsule. Analgesia induced by LLLT resulted in improved exercise performance, and this combination resulted in the maintenance of benefits for up to 6 months after laser therapy was discontinued. Furthermore, analgesia can be a result of stimulating acupuncture points, where LLLT appears to exert equivalent effects to needle acupuncture at skin level through an inhibitory

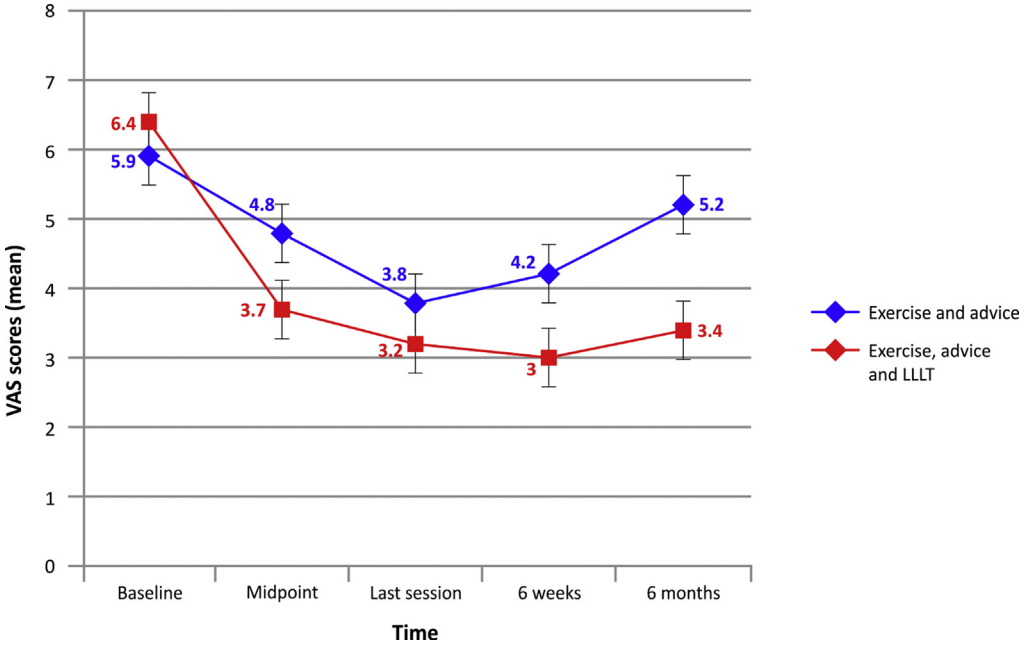

Fig. 1. Mean Visual analogue scale scores. Error bars indicate the standard error of the mean. All assessments were made at baseline, the fifth session (midpoint), the last session, 6 weeks post intervention and 6 months post intervention; $P<0.05$.

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Table 2
Saudi Knee Function Scale (SKFS) scores.

SKFS (total)	Groups	Median (IQR)	Median difference (95% CI)	*P*-value[a]
Baseline			1 (−11 to 11)	0.912
	Active	61 (44 to 71)		
	Placebo	60 (49 to 70)		
Fifth session			−8 (−21 to 5)	0.141
	Active	37 (20 to 54)		
	Placebo	45 (38 to 54)		
Last session			−15 (−27 to −2)	0.035
	Active	26 (14 to 43)		
	Placebo	41 (29 to 53)		
6 weeks post intervention			−10 (−23 to −4)	0.054
	Active	31 (12 to 44)		
	Placebo	40 (29 to 54)		
6 months post intervention			−21 (−34 to −7)	0.006
	Active	31 (19 to 43)		
	Placebo	51 (33 to 55)		

IQR, interquartile range; CI, confidence interval.
[a] Mann–Whitney *U*-test, two-tailed. $P < 0.05$ taken to indicate significant difference.

mechanism via neural blockade [32]. Also, this improvement can be attributed to the ability of LLLT to stimulate reparative properties in human cartilage [33,34].

Improvements seen in the placebo laser group can be attributed to a variety of factors, including the placebo effect, and the fact that all patients in both groups were exercising regularly and were better educated about their condition. Patients with knee osteoarthritis have a significant decrease in knee muscle strength, especially the quadriceps muscles, which increases knee pain; however, there is strong evidence that exercise can reduce pain and improve function in patients with osteoarthritis [35,36]. Education and self-help programmes can reduce symptoms and improve quality of life in many patients with knee osteoarthritis [37].

To the authors' knowledge, this is the first clinical trial to investigate the efficacy of LLLT when applied to more than one acupuncture point in patients with knee osteoarthritis, making it more comparable to clinical trials involving conventional acupuncture. Only two studies have been published on the efficacy of LLLT stimulation of acupuncture points in patients with knee osteoarthritis. Shen *et al.* [19] assessed the efficacy and safety of two types of laser irradiation in patients with knee osteoarthritis when acupuncture point ST-35 was irradiated. Yurtkuran *et al.* [21] investigated the efficacy of LLLT in patients with knee osteoarthritis when acupuncture point SP-9 was irradiated. The two studies showed conflicting results. Shen *et al.*'s study showed significant improvement in pain, stiffness and function of patients in the laser group compared with the placebo laser group, whereas the study by Yurtkuran *et al.* did not. While the results are similar to those of the current study, the study by Shen *et al.* has been criticised for its small sample size and the high dropout rate of patients in the placebo laser group.

Numerous studies have investigated the efficacy of LLLT when applied in areas other than acupuncture points in patients with knee osteoarthritis. Alfredo *et al.* [16] studied the effects of LLLT in combination with exercise. They suggested that LLLT is effective in reducing pain when associated with exercise, improving function and activity in patients with knee osteoarthritis.

Hegedus *et al.* [18] conducted a clinical trial to investigate LLLT in patients with knee osteoarthritis. Although different doses were used, the laser parameters in their study were almost identical to those in the present study. Both studies showed a significant reduction in pain with the active laser compared with the placebo. Gur *et al.* [17] evaluated the efficacy of LLLT in painful knee osteoarthritis. They also added the straight leg raise exercise to the LLLT regime, showing significant improvement in pain and function in the active laser group. Tascioglu *et al.* [20] conducted a clinical trial to investigate the efficacy of LLLT in patients with knee osteoarthritis; they found that LLLT had no effect on pain.

Interestingly, average knee range of motion of participants in the current study was 129° at baseline evaluation which is more than that reported in similar studies [16–18]. This supports the finding [38] that Arabs with knee osteoarthritis who follow the Muslim faith have a greater range of motion. This may be attributed to the lifestyle practised by Arab and Muslim societies, in which the traditional Arabic way of sitting and the Muslim way of praying force their knees into deep flexion for longer periods.

The present study is the first conducted in the Arabic world to use LLLT to treat patients with knee osteoarthritis. It is the first study to use the SKFS score as an outcome measure for knee osteoarthritis in clinical trials. It is also the first study to irradiate more than one acupuncture point to treat patients with knee osteoarthritis.

Despite the dearth of published studies on the use of laser therapy in knee osteoarthritis, many problems and limitations were found, including the lack of standard protocols for inclusion and exclusion criteria. Furthermore, there were no standard therapy programmes regarding dose, period, type of laser and therapy application.

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In conclusion, the results of this study demonstrate that short-term application of LLLT to specific acupuncture points in conjunction with exercise, education and advice are effective in reducing pain and improving quality of life in patients with knee osteoarthritis. No adverse effects were observed in this study. The results of this study support LLLT as an important adjunct intervention for the treatment of knee osteoarthritis and possibly for other joints. This modality may be particularly relevant for patients who do not respond to medical therapy, in whom other physical modalities are contraindicated, who suffer adverse effects to drug therapy or who are not candidates for surgery.

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Conflict of interest: None declared.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.physio.2013.09.007.

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