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RESEARCH ARTICLE

A Single Blinded Randomized Controlled Clinical Trial on the Efficacy of Low Level Laser Therapy on Phantom Pain after Mastectomy

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Abstract

Background: Phantom pain is pain caused by elimination or interruption of sensory nerve impulses by destroying or injuring the sensory nerve fibers. **Purpose**: The purpose of this study was to evaluate the efficacy of low level laser therapy (LLLT) on phantom pain after mastectomy. **Methods:** Sixty patients with unilateral mastectomy were participated in this study and were randomly assigned to one of two groups. The laser group received LLLT plus routine physical therapy program 3 times/week for 8-weeks, while the control group received placebo laser plus routine physical therapy program. **Outcome measures:** Visual Analogue scale (VAS) and shoulder range of motion (ROM) was evaluated for both groups at baseline (0wk) and after 8-weeks (8wk) of intervention. **Results:** The clinical and demographic characteristics of both groups were comparable at baseline. VAS, showed significant decrease post-treatment in the laser group than the placebo laser group. ROM significantly increased after 8-weeks of treatment in the laser group than placebo group ($P < 0.05$). **Conclusion:** Laser therapy was found to be an effective adjunctive modality for phantom pain reduction and increase ROM in post-mastectomy patients.

Introduction

Today breast cancer is the third leading cause of cancer in the world (after lung and gastric cancer) and the most common malignancy in women, accounting for 23% of cancers in women worldwide **(Jemal et al., 2005).**

Chronic pain following surgical procedures for breast cancer was once thought to be rare. The incidence of chronic pain following breast cancer surgery may be over 50% **(Tasmuth et al., 1995, Kwekkeboom, 1996; Fassoulaki et al., 2000).**

Post-operative sensations reported by patients can be transient or long-lasting, and can include pain, phantom sensations, and sensory loss or changes. Chronic pain can be a source of considerable disability and psychological distress (**Beth et al., 2003).**

The exact incidence of persistent postoperative pain remains controversial but has been reported after numerous surgical procedures, including limb amputation, thoracotomy, mastectomy, cholecystectomy, and inguinal hernia surgery **(Perkins and Kehlet 2000, Macrae and Davies 1999).**

Laser light has the unique properties of monochromaticity (a single wavelength), collimation (travels in a single direction without divergence) and coherence (with all waves in phase) **(Matic et al., 2003).** These properties are what allows laser light to penetrate the skin surface non-invasively (**Matic et al., 2003, Schindi et al., 1999)**.

Therapeutic lasers are athermic with no appreciable heat transfer (<0.65 °C) so the photonic energy is transferred directly to the target cells and thermal damage is avoided (**Matic et al., 2003)**. Therapeutic lasers use monochromatic light in the 630 to 905 nm range, known as the "therapeutic window" (**Stadler et al., 2004).**

Laser treatment is noninvasive, painless, and can be easily administered in primary care settings for a wide range of conditions **(Brown and Weber 2000).** It has been reported that the use of laser therapy significantly reduces pain levels in both acute and chronic conditions such as rheumatoid arthritis, chronic osteoarthritis, carpal tunnel syndrome, fibromyalgia, knee injury, shoulder pain, and postoperative pain (**Ozdemir et al., 2001, Gur et al., 2002, Peplow et al., 2010).**

Low level laser therapy (LLLT) is reported to have beneficial effects on cells and tissues. These remarkable effects are reported for treatment of a wide range of conditions (e.g. musculoskeletal disorder, wound healing problem, scar and pain). Laser was reported to have an efficacy for treatment of lymphedema **(Nouri et al., 2003, Piller and Thelander 1998).**

Range of motion (ROM) restrictions of the ipsilateral arm is almost universal and is the result of tissue manipulation and positioning during surgery. Even if successful, resolution of surgery-induced ROM restrictions occurs. Lymphedema, by itself, can cause ROM limitations of the shoulder, elbow, and wrist **(Brennan et al., 1996, Warmuth et al., 1998).**

The current study had been conducted to determine the effect of Helium-Neon laser therapy (which is a type of LLLT) in the treatment of phantom pain and shoulder mobility in post-mastectomy patients.

Material and methods

This was a single blinded, randomized, controlled trial with two measurements points (baseline and after 8-weeks). Sixty females were recruited from the surgical department at National Cancer Institute, Cairo, Egypt, their ages ranged from 45 to 55 years. They were examined carefully by the physician before the study procedures. All patients were free from any other pathological conditions or histories of other health abnormalities. Subjects who fulfilled the following criteria were eligible for enrollment in the study, unilateral mastectomy from 6 to 10 months, mild to moderate lymphedema and take the same medical treatment throughout the study period. All patients signed an informed consent before participation in the study. Patients were excluded if they had local recurrent or distant metastases, cellulites, chronic inflammatory diseases, recurrent malignancy, active infection, neurological and orthopedic problems, or diabetes, history of physical therapy other than skin care.

Randomization

Patients' randomization performed through 2 stages; first, eligible patients who fulfilled the inclusion criteria of the study and had no exclusion criteria were initially recorded. Secondly; all reported patients were randomly assigned to either laser group or the placebo laser group through opening an opaque envelope prepared by an independent person (not involved in any part of the study) with random number generation.

Outcome Measures

All patients were evaluated at the baseline (0wK) and after the end of 8-weeks of intervention (8wk) by a well-trained physical therapist who was blinded to the groups evaluated. Pain score and shoulder ROM were obtained by the blinded physical therapist.

Pain assessment

For the assessment of pain intensity, a visual analog scale (VAS) was used both pre- and post-treatment. The VAS has been shown to be a reliable and valid measure of pain. Pain was measured as the average level of pain over the past few days, using a 10-cm VAS. Patients were asked to estimate the severity of pain by placing a mark on a line, with 0 (no pain) and 10 (the worst imaginable pain) marking the ends of the VAS line (**Wewers and Lowe 1990)**.

Shoulder ROM measurement procedure

Electrogoniometer device was used to measure active ROM for shoulder flexion, abduction, and external rotation through a stander measuring procedure **(Goodwin et al., 1992, Norkin and White, 1985)**. For shoulder, abduction and external rotation, the range of motion measurement started from neutral zero position to the limit of pain. The patient is asked actively to move the limb in the desired direction as she can till the appearance of pain and the degree of joint movement was recorded (**Amis and Miller, 1982)**. Three repetitive measurements were taken continually, with their mean values was used for analysis.

Low level laser program

Before starting the first treatment session, each patient in the study group was instructed carefully about the laser therapy procedure as well as, its safety, values and effects to gain her confidence and cooperation during the treatment sessions. In the laser group each patient irradiated with the laser beam via fiber optic delivery system but in the placebo laser group treatment was identical except that the concealed switch on the laser was set on "off" position, a change which turned off the laser beam, but which did not alter the panel display. The laser unit was set at the following treatment parameters (frequency: 5000 Hz, duration: 15 min, pulse duration: 50 ns, power intensity: 5 mW, wave length: 632.8 nm and dosage: 6 J/cm^2). The patients were placed in a comfortable supine position. A plastic guide with a grid of 20 treatment points centered at 2 cm interval was placed in axilla and on both edges of the incision to guide application and determine the points of application for laser therapy. During the laser treatment, head was held in contact with and at right angles to the skin, after that the therapist presses on the emission enabling key to allow irradiation beam passages through laser aperture. Each point had been irradiated for one minute with a total duration of 20 min, 3 times/week for 8-weeks **(Carati et al., 2003).**

Statistical analysis

All data were assessed using SPSS version 16.0. Data were tested by Shapiro-Wilk test and were normally distributed. Data were statistically analyzed using repeated measures ANOVA to test hypothesis and to assess both within and between variabilities. Results are reported as means and standard deviations. For all procedures, significance was accepted at the alpha level of 0.05.

Results

For this study, seventy female patients were identified as potential participants Figure 1. Of these, six were excluded because they failed to fulfill the inclusion criteria and four refused to participate in the study. Thus, of the original pool, sixty patients with unilateral mastectomy associated with phantom breast pain included in the study .The demographic characteristics of patients in both groups are listed in table 1. Prior to the training period, there was no statistical difference in the age, BMI, postoperative period and Affected arm among both groups ($P > 0.05$), as in Table 1.

Visual analogue scale (VAS):

The mean values of pain score for both groups were reported in Table 2. There was a significant decrease in pain score after 8-weeks in the laser group and placebo laser group with favor to the laser group as compared with baseline values. By comparing the two values there was a significant decrease in pain score between baseline and after 8-weeks by about 75% and 36% for laser group and placebo laser group respectively (Figure 2).

Shoulder ROM.

The mean values of shoulder ROM for both groups were reported in Table 2. There was a significant increase in shoulder ROM after 8-weeks in the laser group and placebo laser group with favor to the laser group as compared with baseline values. By comparing the two values there was a significant increase in shoulder ROM between baseline and after 8-weeks for shoulder flexion by about 14% and 6%, for shoulder abduction by about 6% and 1% and for shoulder external rotation by about 75% and 36% for laser group and placebo laser group respectively (Figure 3).

Table 1. Demographic and clinical characteristics of the patients at baseline

Variables	Laser group (n=30)	placebo laser group (n=30)
Age (years)	55.4±5.13	53.6±4.2
BMI (kg/cm^2)	26.53±4.21	27.45±3.55
Postoperative period (mo)	8.13±2.38	9.5±3.34
Affected arm (%)		
Dominant	91%	93%
Non-dominant	9%	7%

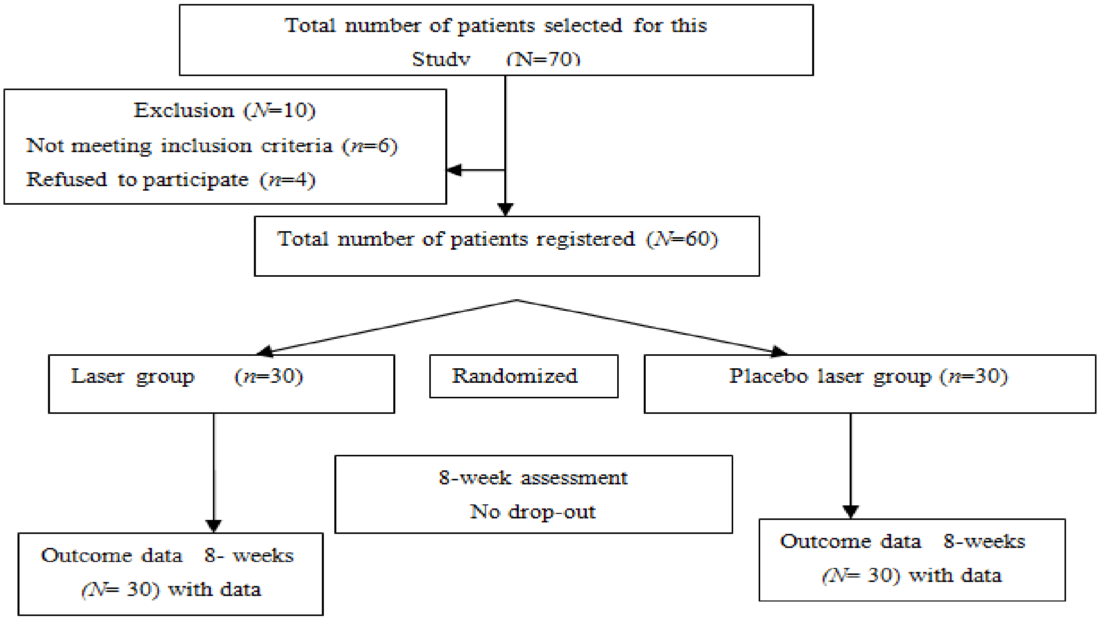
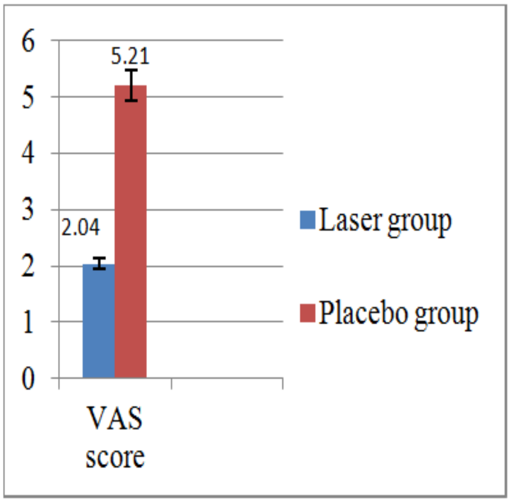
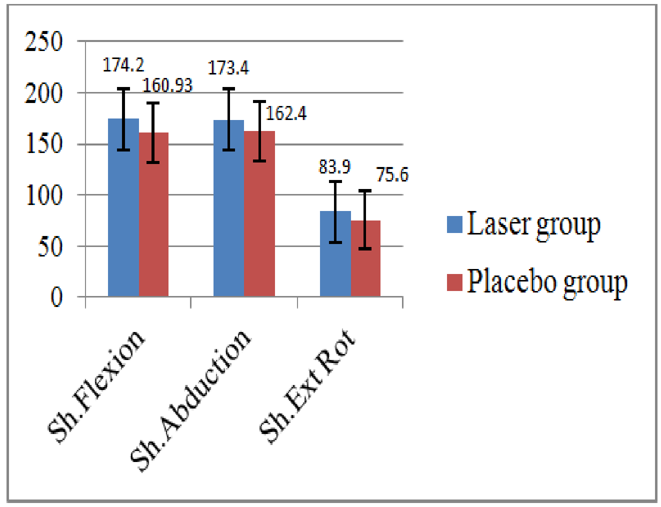


Figure 1: Flow diagram of the study.

Table 2: Values (mean ± SD) of VAS and shoulder mobility for both groups at baseline and after 8-weeks

	Laser group (N=30)		**Placebo Laser group (N=30)**	
VAS	baseline	8-weeks	baseline	8-weeks
Mean ±SD	8.36±0.95	2.04±1.25	8.21±1.1	5.21±1.83
P value	<0.0001*		<0.0001*	
% of change	75%		36%	
Shoulder flexion				
Mean ±SD	152.40±5.40	174.20±3.50	151.16±4.50	160.93±4.20
P value	<0.0001*		<0.0001*	
% of change	14%		6%	
Shoulder abduction				
Mean ±SD	163.28±4.50	173.40±4.30	159.36±4.50	162.40±5.20
P value	<0.0001*		<0.0001*	
% of change	6%		1%	
Shoulder external rotation				
Mean ±SD	71.37±3.60	83.90±4.50	70.38±5.50	75.60±5.30
P value	<0.0001*		<0.0001*	
% of change	17%		7%	





Discussion

The purpose of this study was to investigate the effect of 8-weeks laser program on phantom pain in patients after mastectomy. The results of this study found that laser significantly decrease the phantom pain and increase ROM of shoulder joint in the laser group after 8-weeks of laser program more than in the control group. Our study demonstrated that, laser therapy was significantly effective in reducing phantom pain and increasing shoulder mobility associated with mastectomy.

Pain arising from soft tissue and neural injury is a major contributor to Upper quarter dysfunction (UQD) (**Vadivelu et al., 2008)**. In a recent review, the prevalence of shoulder and/or arm pain was reported to be between 9% and 68%, and the prevalence of breast and/ or scar pain was between 15% and 72% at 6-56 months after surgery (**Lee et al., 2008)** .Damage to nerves can cause sensory disturbance such as numbness, pins and needles, and burning or prickling sensations (**Torres et al., 2010, Cheville and Tchou, 2007)**. In particular, injury to the intercostal-brachial nerve leads to sensory disturbances and sometimes pain involving the chest wall, axilla, and medial upper arm (**Stubblefield and Custodio, 2006).** Arm motion will stress the surgical incision and may thereby increase discomfort and lead to localized muscle guarding (**Kisner and Colby, 2007).**

Shoulder ROM, muscle strength, function, neural glide, and pain were assessed by (**Glassey et al., 2008)** in 22 subjects with latissimus dorsi muscle flap reconstruction preoperatively and at 6 weeks, 6 months, and 6 years, the study conclude that at 6 weeks, there was a mean reduction in flexion ROM, minor loss of strength as measured by a spring balance and increased pain (VASscale).

Laser treatment is noninvasive, painless, and can be easily administered in primary care settings for a wide range of conditions (**Brown and Weber 2000)**. It has been reported that the use of laser therapy significantly reduces pain levels in both acute and chronic conditions such as rheumatoid arthritis, chronic osteoarthritis, carpal tunnel syndrome, fibromyalgia, knee injury, shoulder pain, and postoperative pain (**Ozdemir et al., 2001, Gur et al., 2002, Peplow et al., 2010).** Although low level laser therapy does not elevate tissue temperatures more than a few degrees (**Ozdemir et al., 2001)**, studies have found that the treatment has the potential to reduce inflammation, pain and improve function (**Brown and Weber, 2000**, **Gur et al., 2003)**. Improved circulation due to LLLT irradiation is considered to be one of the possible mechanisms of clinical effectiveness of LLLT for the treatment of pain and edema reduction (**Kipshidze et al., 2001).**

Laser therapy used as an adjuvant treatment for pain reduction due its beneficial effects on reducing pain and inflammatory process without any significant complication. Many authors had reported significant pain reduction with LLLT in acute and chronic painful conditions (**Bjordal et al., 2003 and 2006)**. In this study patients in laser group received LLLT, 3 times/week for 8-weeks and there was reduction in phantom pain and increase shoulder ROM, this result supporting the view that laser treatment has analgesic effects.

Low-intensity laser therapy is currently used in the treatment of patients with chronic low back pain. It is considered an effective physical therapy modality for increasing ROM (**Gur et al., 2003 and Saggini et al., 2009)** and for decreasing pain levels (**Hadi et al., 2009)**, functional disability (**Gur et al., 2003 and Saggini et al., 2009).**

The analgesic effect of HILT is based on different mechanisms of action, including its ability to slow the transmission of the pain stimulus and to increase the production of morphine-mimetic substances in the body (**Zati and Valent, 2006)**. In addition, it may have a direct effect on nerve structures, which could increase the speed of recovery from conduction block or inhibit Aδ- and C-fiber transmission (**Chow et al., 2011)**. The treatment also increases blood flow, vascular permeability, and cell metabolism (**Kujawa et al., 2004)**. Laser therapy provide significant better results in reducing pain, swelling, disability and improving independency of patients after stroke with painful shoulder and shoulder-hand syndrome (**Karabegovi et al., 2009)**.

The analgesia provided by laser treatment allows other therapeutic procedures, such as exercise, to be performed more comfortably and beneficially and facilitates muscle relaxation. The analgesic effects of LLLT may be due to release of local neurotransmitters such as serotonin Walker,1983, increase release of endorphins Yamamoto et al.,1988, increase mitochondrial ATP production (**Passarella, 1989)** , or anti-inflammatory effects (**Bjordal et al.,2003 and Sakurai et al., 2000)** and/or by reducing interstitial swelling by stimulating the motoricity of lymphatics (**Carati et al., 2003)**. Other mechanisms may be related to its effects on endorphin levels and gate control theory of pain. By all these mechanisms, Laser can interrupt the vicious cycle of pain of the trigger point (Melzak: muscular tension > pain > increased tension > increased pain, etc.) (**Olavi et al., 1989)**. There is also in vivo and in vitro evidenced that 830 nm laser inhibits Ad and C nerve fiber transmission (**Tsuchiya et al., 1993 and Tsuchiya et al., 1994)**. The repeated application of laser may reduce tonic peripheral nociceptive afferent input to dorsal horn and facilitate reorganization of synaptic connections in the central nervous system producing pain modulation (**Coderre, et al., 1993 and Mense, 1993)**.It is possible that laser-induced neural blockade that may lead to long-term altered nociception, analogous to the prolonged analgesia seen in some patients with local anaesthetics (**Arner et al., 1990)**.

Our results in agree with many results as (**Olavi et al., 1989)** who suggested that infrared laser with 1.5J/point dose ad a significant effect in increasing pain threshold of trigger points than placebo laser, (**Chow et al., 2006 and 2009)** study showed that LLLT reduced pain immediately after treatment in acute neck pain ,Gur et al.2004 revealed that short period application of LLLT was effective in relief pain and in improving functional ability of patients with chronic myofascial syndrome in the neck. (**Stergioulas, 2008)** suggested that laser treatment was more effective in reducing pain and disability scores than placebo at the end of treatment of patients with frozen shoulder.Hakgüder et al.,2003 concluded that LLLT seemed to be beneficial for pain in the neck; Also (**Shirani et al., 2009)** found that LLLT with 660 nm and 890 nm was the effective treatment for reducing pain in patients with myofascial pain dysfunction syndrome .some studies revealed that there was no significant effect of LLLT (GaAlAs, 830 nm) for chronic myofascial pain in the neck and shoulder girdle (**Thorsen et al., 1991 and 1992)** ; also (**Altan et al., 2005 and Dundar et al., 2007)** revealed that laser therapy had no superiority over placebo groups in treatment of patients with chronic Myofascial pain syndrome (MPS) in the neck.

In the present study, the effect of combined laser therapy with exercise was greater than that of placebo laser with exercise. It has been suggested that placebo treatments are important tools that can be used by the medical community to complement regular therapies; most physicians reportedly believe their use to be ethically permissible (**Tilburt et al., 2008)**. However, the use of placebo treatments in clinical medicine remains controversial (**Miller and Colloca, 2009)**. The results of this study agree with the findings of many studies, that laser therapy has a greater effect than sham laser in treating pain and disability, as measured by VAS (**Gur et al., 2003, Djavid etal 2007, Stiglić-Rogoznica 2011).**

Conclusion

Low level laser therapy plus physical therapy program is effective method to decrease phantom mastectomy pain and increase shoulder range of motion as compared with placebo laser with physical therapy program.

Clinical Implications

The results of this study have clinical significance to physical therapists treating post-mastectomy patients. The laser program used in this study can be easily adapted to clinical practice and serve as guidelines of rehabilitation of patients with phantom pain.

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