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Treatment of Post-Mastectomy Lymphedema with Laser Therapy: Double Blind Placebo Control Randomized Study

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Background. **In post-mastectomy patients, lymphedema has the potential to become a permanent progressive condition and become extremely resistant to treatment. Thus, it can results in function impairment and decrease quality of life. The aim of this study was to evaluate the effect of low level laser therapy (LLLT) on limb volume, shoulder mobility, and hand grip strength.**

Material and Methods. **Fifty women with breast cancer-related lymphedema were enrolled in a double-blind, placebo controlled trial. Patients were randomly assigned to active laser ($n = 25$) and placebo ($n = 25$) groups and received irradiation with Ga–As laser device that had wavelength of 904 nm, power of 5 mW, and spot size of 0.2 cm^2 over the axillary and arm areas, three times a week for 12 wk. The total energy applied at each point was 300 mjoules over seven points, giving a dosage of 1.5 joules/cm^2 in the active group. The placebo group received placebo therapy in which the laser had been disabled without affecting its apparent function. Limb circumference, shoulder mobility, and grip strength were measured before treatment and at 4, 8, and 12 wk.**

Results. **The two groups had similar parameters at baseline. The reduction of limb volume tended to decline in both groups. The trend being more significantly pronounced in active LLLT group than placebo at 8 and 12 wk, respectively ($P < 0.05$). Goniometric data for shoulder mobility and hand grip strength were statistically significance for LLLT group than for placebo.**

Conclusion. **Laser treatment was found to be effective in reducing the limb volume, increase shoulder mobility, and hand grip strength in approximately 93% of patients with postmastectomy lymphedema.**

Key Words: **LLLT; postmastectomy lymphedema; breast cancer.**

INTRODUCTION

Lymphedema is the accumulation of protein rich interstitial fluid as a result of impaired lymphatic function [1]. Lymphedema related to breast cancer treatment may result from surgical removal of lymph nodes and lymphatic drainage pathways. Further damage to the lymphatic system may result from soft tissue fibrosis following inflammation, infection, or radiation and chemotherapy [2].

The incidence and prevalence of breast cancer related lymphedema vary considerably in the literature due to lack of consistency in defining lymphedema, variation in the measurement techniques, and in the length of patient follow-up [3]. A recent review reported that lymphedema remains an important problem in women treated for breast cancer, occurring in 12% to 28% of the cases even with modern therapies [2, 4, 5]. Another study of women with either modified or radical mastectomy plus axillary dissection found that lymphedema was at least reported by 62.5% of participants, as evaluated by questionnaire and arm circumferential self-measurements [6].

The breast cancer related lymphedema can lead to a feeling of heaviness, discomfort, weakness, pain, and restricted shoulder mobility in the involved extremity

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[7, 8]. Functionally, the distended tissue and the increased weight of the limb may result in impairment of upper extremity range of motion. This impairment has important implications because such difficulties in function influence daily living activities such as washing the hair, putting on clothing, and reaching for objects overhead, as well as psychologic aspect [9, 10].

The impairment of shoulder rang of motion is limited in up to 45% (24) of patients who have had sentinel node biopsy, and 86% (31) of patients who have undergone axillary dissection [11]. Clinical experience reveals that in moderate to severe cases, women often complain that there is a loss of power in the arm and hand grip and easily fatigued with use [9]. The authors concluded that more aggressive breast cancer treatments, such as mastectomy *versus* breast conserving surgery, and axillary node dissection *versus* sentinel node biopsy, are associated with greater deficits in shoulder range of motion [12–14].

Range of motion restrictions of the ipsilateral arm are almost universal and are a 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. As the expanding subcutaneous tissues reach maximum capacity, tissue spaces that are necessary for free movement of the joints become full of fluid, and joint mobility can be severely reduced. The sheer weight of the arm further limits movement, can negatively alter posture, and can reduce the functional abilities necessary for independent activities of daily living [15–17].

Treatment of lymphedema is difficult and multidisciplinary in nature, and even in the best outcome, costly and time-consuming. Therapy available for lymphedema can be divided into pharmacological, surgery, and rehabilitation. The latter is a multidisciplinary and comprehensive approach incorporating specialized massage, skin care, bandaging, exercises, pneumatic pump, and complex decongestive therapy [18].

Low-level laser therapy (LLLT) is reported to have beneficial effect on cell and tissues. These remarkable effects are reported for treatment of broad range of conditions such as musculoskeletal disorders [19, 20], wound healing problem, and scarring [21, 22]. Yet, few studies regarding the benefit of LLLT in the treatment of postmastectomy lymphedema have been reported [1, 23, 24]. It has been suggested that LLLT encourages lymphangiogenesis and stimulation of lymphatic motoricity as well as stimulation of macrophage cell and to stimulate the immune system [7]. Therefore, the purpose of this prospective, double-blind, placebo controlled randomized study was conducted to evaluate the effects of LLLT in the management of breast cancer related lymphedema.

MATERIAL AND METHODS

Subjects

Fifty-eight women were eligible for the study if they had undergone breast cancer surgery including axillary node dissection for stages II or III breast cancer and had subsequently developed unilateral lymphedema that was defined as an increase in arm circumference at any level by 2 cm and less than 8 cm compared with the contralateral side. A cut-off value of 2 cm (circumference difference) was the most common definition for lymphedema [25–28]. A difference in arm circumference of more than 8 cm represented severe lymphedema [29], and they excluded from the study. To control for other variables that may have affected the results of the study, subjects were excluded from the study if (1) they had current metastases, continuing radiotherapy, cellulites, venous thrombosis, chronic inflammatory diseases, history of sever trauma; (2) photosensitivity that made laser therapy prohibitive; (3) medication that affects body fluid and electrolyte balance; (4) history of physical therapy other than skin care, home exercises, and bandaging directed to lymphedema within the previous 6 mo (one) and (five) patients with bilateral lymphedema were also excluded because the contralateral normal limb was needed to predicate percentage of lymphedema [23]. All subjects participated in double blind, randomized, placebo control study. To avoid a type II error, a preliminary power analysis (power = 0.90, α=0.05, effect size = 0.65) determined a sample size of 50 for this study. This effect size was chosen because it yielded a realistic sample size [30]. Subjects were recruited from outpatient clinic at National Cancer Institute and Mataria Teaching Hospital, Cairo, Egypt, and all patients signed an informed consent. Then we generated a computerized random number list and the subject allocation sequence was created from the list. The patients met with the evaluator therapist who conducted the assessments. The therapist was blinded to the group assignment. Following their assessments, the patients were randomly assigned to either active laser or placebo groups. Therefore, neither patients nor the evaluator therapist knew who was in which group.

Measurements

All patients were evaluated every 4 wk for 12 wk, beginning with the baseline measurement, producing a total of four measurements. Follow-up assessment of lymphedema was conducted at 16 wk.

Assessment of Lymphedema

Although various methods exist for assessing the quantity and quality of lymphedema, the most commonly used assessment technique involves measuring the circumference of limb at several points along its length [31–33]. The arm circumference measurements were taken with the subjects in a prone position, arms relaxed by their sides, and elbows straight. Both arms were measured at each test date. Circumference was measured every 3 cm beginning at the ulnar styloid process and continuing 45 cm proximally, as well as at the metacarpals and mid-hand, which indicated presence of hand edema. The measuring tape was placed around the extremity so that there was no slack but also that there was no indentation in the tissue. The sum circumference of the normal side was calculated likewise. The difference between these two was considered as "circumference difference" [23, 34]. Reliability of the circumference measurements, expressed as an intra-class correlation, ranged from 0.96 to 0.99 for both surgical and contralateral upper extremities, and the standard error of measurement was reported as 0.09 cm to 0.20 cm [31].

$$CL_{affected} \_ CL_{normal} = CD$$

$$CD_{n} \_ CD_{0} = TRC$$

Where:

$CL_{affected}$	Circumference of affected limb for all anatomical points
CL_{normal}	Circumference of normal limb for all anatomical points
CD	Circumference difference of two limbs
CD_n	Circumference differences at each follow up session
CD_0	Circumference difference at pretreatment session
TRC	Total reduction in circumference

Assessment of Hand Grip Strength

Grip strength was measured by portable hand Jamar dynamometer (Lafayette Instrument 78010 Hand Dynamometer; Lafayette Instrument Co., Loughboroug, Leics, UK), the measurements were made while the patients were seated in a chair with a back, with the shoulder adducted, elbow flexed 90° and forearm in neutral rotation. A mean of three trials was calculated, with a 15 s rest between each of the three contractions [35]. Mathiowetz [36] reported the inter-rater reliability in his norm study to have an ICC of 0.99 for reading a dynamometer. Peolsson *et al.* [37] found the inter-rater reliability ICC to be 0.98 for handgrip using the Jamar dynamometer.

Assessment of the Shoulder Mobility

A standard plastic goniometer was used to measure active ROM for shoulder flexion, abduction, and external rotation. For measurement the patient was placed supine with the thorax firmly strapped to the table to prevent body shift, which would tend to compensate for movement of the shoulder. The reliability ($r > 0.84$) of this goniometric measurement technique for the assessment of shoulder ROM has been shown previously [38]. In addition, measurements of active ROM tend to be more reliable than measurements of passive ROM [39, 40]. Most likely, this is because passive ROM is influenced by the degree of force exerted by the examiner upon a subject's limb at the end range of motion. Differences in passive stretch imposed by the examiner will affect the ultimate measurement of passive ROM; active ROM measurements are not affected by variations in the examiner's manipulations [41, 42].

For shoulder flexion, the arms were initially relaxed at the side of the body (neutral position of 0°); the arm under test was raised in a sagittal plane from 0 to 180°, but affected arm was raised to the limit of pain. For shoulder abduction, the normal arm was moved away from the side of the body in a coronal plane from 0 to 180°, but affected arm was moved to the limit of pain. For shoulder external rotation, the normal arm was abducted to 90°, and the elbow flexed 90°, with forearm in pronation, movement at radioulnar joint where the palm facing downward toward the floor or facing the feet, but the other arm moved according to pain.

Intervention

Patients in the active laser group received irradiation with (Ga-As laser device that had wavelength of 904 nm, power of 5 mW, and spot size of 0.2 cm^2 (RianCorp Pty Ltd., Henley Beach, South Australia, Australia; Pagani IR27/4), average of 1.5 J/cm^2 dosage delivered continuously for 20 min, with pulse duration of 50 ns, and maximum frequency of 2800 Hz, three times per week for 36 sessions. Laser therapy was administered at three points on the antecubital fossa (modified from Kozanoglu *et al.* [1] and at seven points on the axilla modified from Carati *et al.* [7] where the lymph nodes accumulated. (The axillary zone is the location of the lymph nodes through which the upper limb lymph principally drains, and is the supposed site of blockage of lymphatic drainage from the PML limb). The probe was held vertically against each point by direct contact with slight pressure to minimize power loss due to beam divergence. Each point had been irradiated for 2 min with total duration of 20 min. The total energy applied at each point was 300 mjoules over 20 points giving a dosage of 1.5 J/cm^2 in the active group. All patients wore safety goggles. For patients in placebo group, the following parameters of therapy were set up without switching the machines [1]. Cellular studies support the use of low dose of (e.g., 1.5J/cm^2) to improve absorption of extracellular fluid. The finding includes increased neutrophil activity, increased secretion of macrophage growth factors, enhanced DNA synthesis, and enhanced electron respiratory chain reaction increased endothelial PGI2 secretion and degradation of fibrin networks [43–45]. High dosages of LILT (8-32J/cm^2) generally have an inhibitory effect on tissue metabolism [46–48]. In review of literature, laser therapy giving three times per week at 1.5 J/cm^2 was recommended as actual doses for human clinical trial, especially for those suffering from post-mastectomy lymphedema [1, 7].

All patients were given advice to perform daily limb exercise program including the following [49]:

(1) Arm elevation to 180° with elbows straight
(2) Internal rotation with the hand on the back trying to reach as high as possible
(3) Abduction with the fingertips on the shoulders
(4) Elbows together and apart with the hands behind the neck

And the following exercises in the standing position:

(1) Arm extension with a stick held horizontally behind the back
(2) Shoulders forward, backwards, upwards, and downwards
(3) Shoulder circles with the fingertips on the shoulder
(4) Arm elevation standing in a corner with the back of the hand gliding along the wall.

Patients were told to perform each exercise five times in every set, daily. Participants were instructed in skin care to protect against infections. It consists of maintaining the affected area clean and dry to decrease the risk of infection. All women were instructed to wear pressure garment that provides pressure of (40 to 60 mmHg), and for 20 h daily during the period of the study as reported in our previous work [49]. All patients were given a diary logbook to complete on a daily basis during the intervention period. They were asked to maintain a daily self-report of their daily exercise activities and duration of wearing garment. The content of the logbooks did not differ between active laser and placebo groups

Statistical Analysis

The data were expressed as mean and standard deviation (mean ± SD). For normally distributed data, student unpaired *t*-test was used to identify differences between the two groups. Repeated-measures analysis of variance (ANOVA) was done for comparison of independent variables within groups. The α level of significance was <0.05.

RESULTS

Figure 1 depicts a CONSORT flowchart of the trial. Fifty-eight women who fulfilled the criteria were randomized to the active laser group or the placebo laser group, and each group had 29 subjects. Four women who were randomized to the active laser group withdrew from the study because of cellulitis ($n = 1$) and poor adherence to treatment ($n = 3$). For the placebo laser therapy, four women were withdrawn due to cellulitis ($n = 2$) and poor adherence ($n = 2$). Participant with poor adherence to the program (defined as missing more than three consecutive sessions or more than 20% of all sessions) were excluded from the program, and their data were not

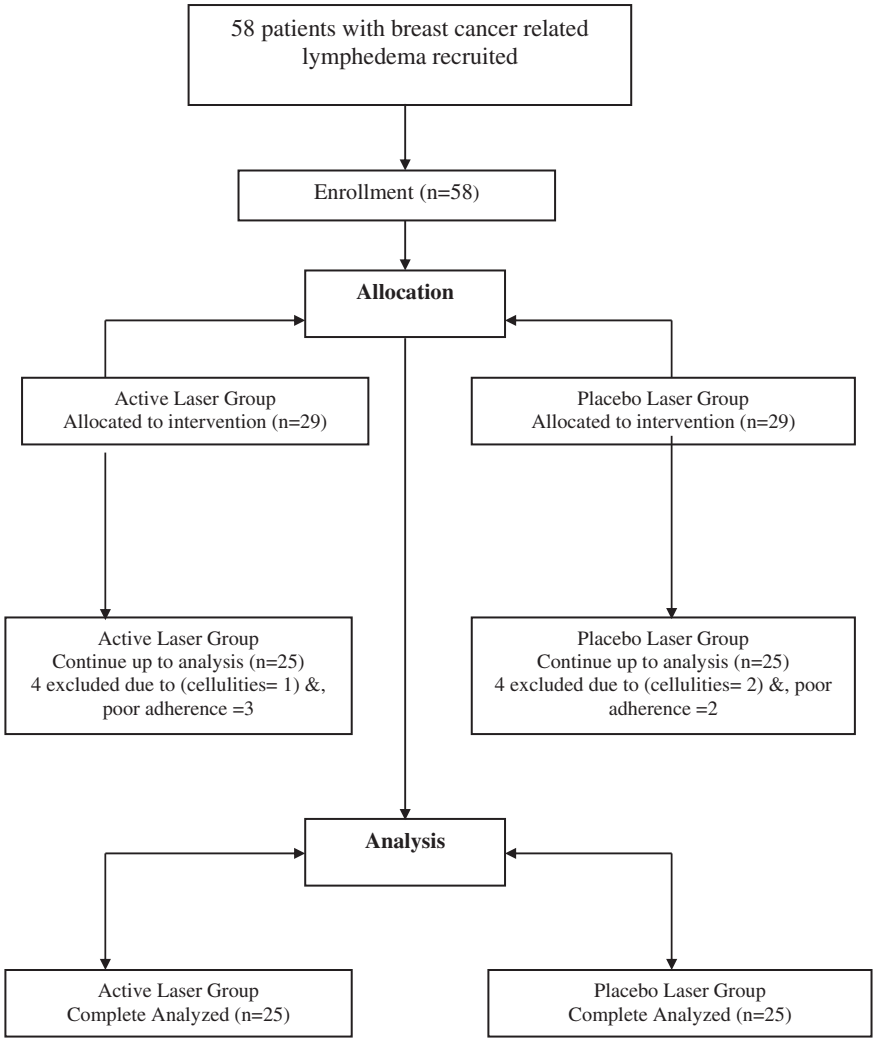

FIG. 1. Flow of participants through the study.

used in the statistical analysis. The rest ($n = 50$) completed the entire trial to the follow-up, and were equally assigned to active laser ($n = 25$) and placebo laser ($n = 25$).

Table 1 lists the clinical and demographic characteristics of the groups. The age of the women ranged from 45 to 55 y, with a mean age of 54.06 y (SD = 3.49). The postoperative duration ranged from 32 to 50 mo, with a mean of 40.3 mo (SD = 8.5). Self-report of length of time that subjects had swelling ranged from 12 to 36 mo, with a mean of 13.98 mo (SD = 2.85). Radiotherapy and hormonal therapy had been given to 14% of patients, radiotherapy and chemotherapy to 38% of patients, and radiotherapy, chemotherapy, and hormonal therapy to 48% of patients. All patients had undergone axillary dissection; with a range of 7 to 25 nodes removed and mean of 15.0 (SD = 5.3). The two groups did not differ significantly ($P > 0.05$) at baseline regarding demographic, and clinical characteristics.

Limb Circumference Measurement

The reduction of total limb circumference at each assessment session at 4, 8, 12, and 16 wk tended to decline after initiation of laser therapy is shown in Fig. 2 and Table 2. The total reduction in limb circumference in the active laser group was greater than in the placebo group in all session with greater significant ($P < 0.01$) reduction observed at 8 wk (20 ± 3.05 *versus* 16.4 ± 3.05), and at 12 wk (29 ± 3.75 *versus* 21.8.4 ± 6.9), for active laser compared with placebo group, respectively. Follow-up assessment of lymphedema at 16 wk revealed non-significant increase in limb circumferences compared with 12 wk values within each group, while significant reduction in total limb circumference (31 ± 6.75) for active laser group was observed in comparison to placebo laser group (23 ± 9.75).

TABLE 1

Characteristics of Patients

	Active laser ($n = 25$)	Placebo laser ($n = 25$)	Total ($n = 50$)
Age (y)	54.76 ± 3.33	53.36 ± 3.56	54.06 ± 3.49
BMI (kg/cm^2)	29.1 ± 6.6	25.6 ± 3.3	27.35 ± 5.3
Postoperative period (mo)	40.4 ± 7.5	41.9 ± 5.5	40.3 ± 8.5
Lymphedema duration (mo)	13.8 ± 1.77	14.16 ± 2.23	13.98 ± 2
Circ. diff.	109.6 ± 5.9	113.3 ± 4.3	111.5 ± 5.0
Types of operations n(%)			
Radical mastectomy + CALD	2 (8%)	3 (12%)	5 (10%)
Modified radical mastectomy + PALD	19 (76%)	17 (68%)	36 (72%)
Lumpectomy	4 (16%)	5 (20%)	9 (18%)
Number of lymph node removed	15.6 ± 4.1	14.4 ± 4.7	15.0 ± 5.3
Adjuvant therapy n(%)			
RT+CT	10 (40%)	9 (36%)	19 (38%)
RT+HT	4 (16%)	3 (12%)	7 (14%)
RT+CT=HT	11 (44%)	13 (52%)	24 (48%)
Affected arm (%)			
Dominant	20 (80%)	19 (76%)	39 (78%)
Non-dominant	5 (20%)	6 (24%)	11 (22%)

There were no statistically significant differences between groups.

Values are mean ± SD.

BMI = body mass index; Circ. diff. = circumference difference between the affected and normal arm; CALD = complete axillary lymph node dissection; PALD = partial axillary lymph node dissection; RT= radiotherapy; HT = hormonal therapy; CT = chemotherapy.

Shoulder Mobility

A comparison of two groups in relation to active ROM (shoulder flexion, abduction, external rotation) at 4 wk revealed clinical improvement in laser therapy group but not statistically significant ($P > 0.05$), while at 8 and 12 wk, there was statistically significant ($P < 0.01$) improvement in shoulder mobility (flexion and abduction) for the laser therapy, compared with placebo group, while shoulder external rotation showed no statistically significant differences at any point of evaluation between two groups (Table 2, Figs. 3 and 4). The percentages of increase in shoulder flexion and abduction (16.79% *versus* 10.74% and 14.9% *versus* 6.56%) were significant for active laser therapy compared with placebo at 12 wk.

Grip Strength

Grip strength improved post-treatment at 8 and 12 wk in both groups, with significant ($P < 0.01$) percentage of improvement (38.85 %) for active laser therapy group compared with placebo laser group (16.59%), at 12 wk (Table 2, and Fig 5).

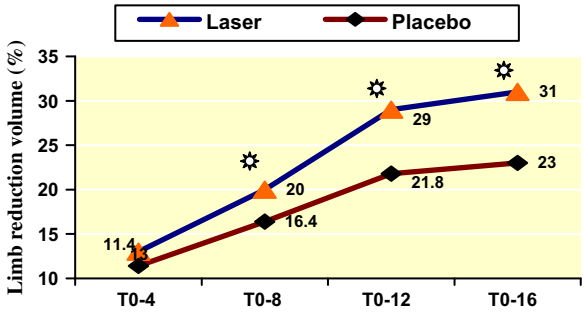

FIG. 2. Circumference difference between laser and control groups. (Color version of figure is available online.)

DISCUSSION

The primary finding of this double-blind, randomized, placebo, control study is that laser therapy reduced the volume of the upper extremities, increases shoulder mobility, and hand grip strength in women with postmastectomy lymphedema with the benefit maintained for at least during the period of the study.

It has been reported that LLLT has anti-inflammatory and anti-edematous actions by increasing prostaglandin I2 and, consequently, inhibition of platelet aggregation and vasodilatation that lead to reduction of edema and better oxygenation of tissues. There are several reasons to suggest the use of a LLLT in postmastectomy lymphedema: (1) aids in resorption of both microscopic and gross edema fluid (2) increases lymph vessel diameter, contractility, lymphatic regeneration; (3) stimulates phagocytic activity of neutrophils and monocytes; (4) improves wound healing and reduces scar adhesion to underlying tissues, and (5) reduces the risk of skin infections [7, 19, 20].

Further improvements in postmastectomy lymphedema secondary to the use of LLLT depend on its mode of action. At the molecular level, there are suggestions that LLLT affects cells by interacting with cytochromes of the mitochondrial electron transport chain [50] and/or may produce local gradients in energy because of laser speckle, resulting in local gradients in

TABLE 2

Comparison of Total Circumference Reduction, Range of Motion, and Grip Strength Between Groups

Variables	Active laser ($n = 28$)	Placebo laser ($n = 26$)
TRC(cm)		
Wk 0–4	13 ± 2.06*†	11.4 ± 3.8
Wk 0–8	20 ± 3.05*†	16.4 ± 5.3*
Wk 0–12	29 ± 3.75*†	21.8 ± 6.9*
Wk 0–16	31 ± 6.75*†	23 ± 9.75*,†
Shoulder ROM(degrees)		
Flexion		
Wk 0	156 ± 12.1	154.5 ± 4.07
Wk 4	167 ± 13.7*	161.2 ± 13.8
Wk 8	171.9 ± 11.4*†	163.6 ± 13.4
Wk 12	182.2 ± 8.1*†	171.1 ± 6.6*
Abduction		
W 0	161.05 ± 9.9	163.2 ± 6.8
Wk 4	173.6 ± 7.12*	167.2 ± 4.8
Wk 8	178.6 ± 7.12*†	170.09 ± 11.4*
Wk 12	185.2 ± 6.5*†	173. 9 ± 5.9*
External rotation		
W 0	74.7 ± 5.02	72.7 ± 5.38
Wk 4	82.7 ± 12.3	76.96 ± 14.8
Wk 8	84.6 ± 8.1*	78.7 ± 11.4
Wk 12	85.7 ± 6.5*	82.7 ± 7.13*
Grip strength (Kg)		
Wk 0	18.87 ± 2.13	19.22 ± 1.54
Wk 4	24.2 ± 4.6	22.1 ± 4.7
Wk 8	25.6 ± 4.6*	23.9 ± 4.6*
Wk 12	26.2 ± 4.7*†	22.41 ± 5.2

*$P < 0.05$ compared with baseline within group.
†$P < 0.05$, compared between groups.

cellular heating [51]. At the cellular level, LLLT is reported to stimulate mitogenic activity, adhesion, synthetic activity, and viability of fibroblasts [52–56]. Macrophages were stimulated by LLLT to produce factors that increased or decreased fibroblast proliferation, depending on the wavelength of laser used [57]. LLLT stimulated lymphocytes to proliferate and to become activated, both *in vitro* and *in vivo* [58, 59], although again this may be true only in pathologic settings, in which LLLT "primes" lymphocytes to be more responsive to natural stimulatory products induced by pathophysiologic conditions [60]. All these cell types may be compromised in lymphedema, and may respond to LLLT sufficiently to play a role in resolution of the lymphedema. At the microcirculatory level, there may be stimulatory/protective effects of LLLT on endothelial cells and vascular endothelium in situ [61].

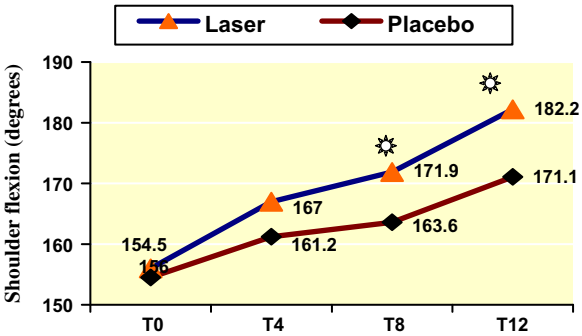

FIG. 3. Mean shoulder flexion between laser and control groups. (Color version of figure is available online.)

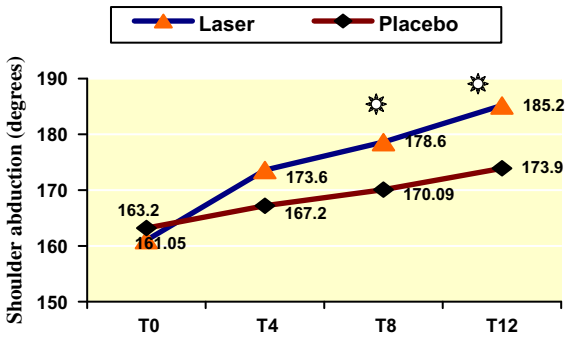

FIG. 4. Mean shoulder abduction between laser and control groups. (Color version of figure is available online.)

This may involve angiogenic factor production by T-lymphocytes (associated with endothelial cell proliferation [62], or increased vascular endothelial growth factor (VEGF) production by smooth muscle cells or fibroblasts [63]. Use of LLLT is reported to enhance endothelial regeneration after damage in animal models [64, 65] and in humans after coronary arterial stent implantation [66]. We have not found any reports of LLLT affecting lymphangiogenesis, but it appears reasonable to propose that lymphatic vessels may respond similarly to blood vessels because members of the VEGF family, VEGF-C and VEGF-D, stimulate lymphangiogenesis [67]. There are reports of stimulation of local fluid circulation [51] and stimulatory effects on lymphatic vessels [68], perhaps in response to increased fluid mobility in laser-irradiated tissues. There does not appear to be a consistent effect of LLLT on normal mesenteric lymphatic vessel contractility when it is applied directly to the vessels alone *in vivo* [69].

There are few studies regarding low-level laser in the treatment of postmastectomy lymphedema. Piller and Thelander [24] studied low-level laser therapy in 10 women with unilateral postmastectomy lymphedema who received radiotherapy. Ten patients received 16

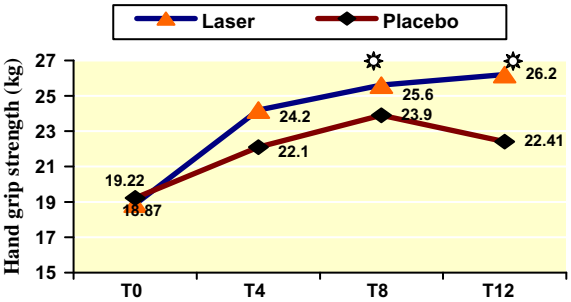

FIG. 5. Mean hand grip strength between laser and control groups. (Color version of figure is available online.)

sessions of low-level laser therapy over 10 wk and seven patients were followed for 36 mo. They found that after the treatment, edema volume was decreased and mobility of the arm was reported to be improved. This improvement continued at 1, 3, and 6 mo. A 29% volume reduction of the affected arm with subjective symptoms returning to pretreatment levels between 30 and 36 mo was also reported [24]. In another study, patients in one group received two cycles of active laser ($n = 37$) and the other group received one cycle of placebo laser and one cycle of active laser ($n = 27$) to the axillary region three times a week for 3 wk . Although no significant improvements were reported immediately after any of the treatments, mean affected limb volume was significantly reduced at 1 and 3 mo of follow-up after two cycles of active laser treatment. The authors concluded that two cycles of low-level laser was effective in reducing the limb volume, extracellular fluid, and tissue hardness in approximately one-third of the patients at 3 mo after the treatment [7]. The authors did not explain if their patients were wearing pressure garment, performing exercisers and activities during period of the study or follow-up.

In a study by Kaviani *et al.* [23] postmastectomy lymphedema patients were enrolled and randomly assigned to receive low-level laser therapy ($n = 6$) and sham laser ($n = 5$) groups. Assessments were made at 3, 9, 12, 18, and 22 wk. Reduction in limb circumference occurred in both groups but it was greater in the laser group up to the end of the 22nd week. Pain reduction was greater in the laser group except at wk 3 and 9. The authors also stressed that the desire to continue treatment was greater in the laser group than sham group in all sessions.

The limitations of the current study include (1) small number of patients because of the long-term follow-up and inadequate referral. Nevertheless, there are limited numbers of studies concerning the use of low-level laser in the treatment of postmastectomy lymphedema. There are some similarities between these studies [1, 7, 8, 23] and ours (e.g., patient selection criteria and protocols of laser therapy); there are also some differences in study protocols and measuring techniques of main objective outcomes. For evaluation of limb volume changes, Piller [24, 25] used arm circumference in several anatomical points on the affected arm only, whereas we used sum circumference difference between the affected and unaffected limbs. Due to anatomical variations of patient's limbs, using the subject's normal arm should serve as control for the affected arm.

We suggest that low level laser therapy has positive effects in the treatment of postmastectomy lymphedema. It seems that LLLT has beneficial results in postmastectomy lymphedema patients maintained for period of study. Prospective randomized controlled studies with a larger sample size are needed to better understand the efficacy of low-level laser therapy in the treatment of postmastectomy lymphedema. In addition to these suggested treatment modalities, patients are recommended to perform daily limb exercises and follow skin care instructions throughout their lives.

In conclusion, we found that LLLT may be effective in reducing arm circumference and increase shoulder mobility and hand grip in increasing the desire to continue treatment in patients with postmastectomy lymphedema. Despite these results, further studies on the effects of LLLT should be taken to determine the optimal physiologic and physical parameters to obtain the most effective clinical response. However, LLLT could be considered as an adjuvant therapy in addition to gold standard therapy that includes manual lymph drainage, compression garment, and skin care.

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