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Comparison of manual lymphatic drainage massage and negative pressure massage therapy efficacy in lymphedema patients: a randomized controlled study

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ABSTRACT

Objectives: Lower extremity lymphedema due to secondary causes is a lifelong complication that can be encountered. Its treatment is essential, because it has significant impact on quality of life and daily living activities related to lower extremity involvement. This research aims to compare the effects of Manual Lymphatic Drainage Massage (MLD) and Negative Pressure Massage Therapy (NPMT) treatments in order to provide maximum benefit to patients.

Methods: This prospective, randomized study included 30 patients with lower extremity lymphedema due to secondary causes. Patients, randomized using computer software, were divided into two groups. The first group (n =15) received 45 minutes, 15 sessions of MLD, while the second group (n =15) received 45 minutes of 15 sessions of NPMT using the LymphaTouch device. Compression bandaging was applied to both groups and self-drainage training was given to all patients. The circumference of the extremity at 6 reference points were measured and their pain and discomfort assessed by the Visual Analogue Scale (VAS) were recorded before and after treatment. Changes within the groups and between the groups were compared using the SPSS statistical program.

Results: Statistically significant improvement was observed in all parameters in both treatment groups. The decrease in VAS pain and VAS discomfort scores ($p < 0.05$ and $p < 0.01$; respectively), circumference measurement of the extremity ($p < 0.01$) was statistically greater in the NPMT group compared to the MLD group. Conclusions: In conclusion, NPMT appears to be a beneficial non-invasive treatment method for reducing extremity volumes and decreasing subjective pain and discomfort in lymphedema patients.

Keywords: Lymphedema, manual lymphatic drainage, topical negative pressure therapy, compression bandages

Lymphedema is defined as the abnormal accumulation of interstitial fluid and fibroadipose tissue resulting from injury, infection, or congenital abnormalities of the lymphatic system [1]. Surgical interventions, radiotherapy, trauma, infections, tumors, chronic venous insufficiency, and pathological, congenital, and/or hereditary etiologies can lead to the development of lymphedema. The most common factors

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contributing to lymphedema in the lower extremities are aplastic/hypoplastic/hyperplastic lymphatic abnormalities, gynecological cancers, surgical procedures, trauma, radiotherapy, and recurrent infections [2, 3]. In patients with lymphedema, affected limb circumference increase, swelling, changes in appearance, limited range of motion, in addition to edema that does not leave a trace, can lead to various problems such as pain, discomfort, decreased quality of life, depression, and more [4]. Due to these problems, a wide range of treatments are needed.

While there is no definitive cure for lymphedema, patients often benefit from conservative treatment methods. Surgical approaches are not curative and can even exacerbate lymphedema in some cases [5]. Treatment for lymphedema falls under three main categories: medical, surgical, and conservative. Pharmacological methods have not been reported to have a consistent role in lymphedema treatment. Unlike hydrostatic forms of extracellular fluid accumulation, lymphedema may respond very little to diuretic therapy [6]. In advanced-stage lymphedema patients who do not benefit from conservative treatment and show significant morbidity, surgical procedures may be indicated. Frequent recurrent infections, significant impact on the patient's quality of life and function, and advanced psychological distress due to appearance can also be indications for surgery [7].

Physical medicine and rehabilitation specialists have been observed using physical modalities as part of a comprehensive rehabilitation program to reduce pain, increase strength, accelerate tissue healing while preventing possible malignant tumor growth in lymphedema patients [8]. Low-power lasers, electrical stimulations using transcutaneous electric currents, and modalities such as extracorporeal shock wave therapy can be used in lymphedema treatment [8].
Lymphedema treatment is challenging, but lymphedema patients often benefit from conservative treatment and can remain stable with the gains from treatment [9]. After lymphedema is diagnosed, specific physiotherapy treatment methods are needed for its treatment (10). Patient education is crucial within conservative treatment. Attitude towards trauma, maintaining the natural moisture balance of the skin, recognizing and intervening in infections can be achieved through patient education [8, 9].

Intermittent Pneumatic Compression (IPC) is used in lymphedema treatment as an adjunct to Complex Decongestive Physical Therapy (CDPT) [11]. CDPT is currently considered the gold standard in lymphedema treatment (12). CDPT consists of two phases: the intensive treatment phase (phase 1) and the maintenance phase (phase 2). The intensive treatment phase includes manual lymphatic drainage (MLD), compression bandaging, exercise, and skin care. These two phases are also referred to as combined decongestive therapy. MLD is a special massage technique applied directly to the skin with low pressure to stretch lymph capillaries and increase lymphangiomotoricity and lymphatic drainage [13]. It has been shown that manual lymph drainage stimulates lympho-lymphatic and lympho-venous anastomoses and provides symptom reduction that compression alone cannot achieve [12, 14]. The basic working principle of compression bandages includes preventing and reducing edema, increasing venous flow rate, decreasing venous diameter, increasing venous and lymphatic pump activity, and increasing arterial flow [10, 12, 15].

In our country and around the world, there have been limited studies conducted on the rehabilitation of lower extremity lymphedema. Applications using negative pressure massage therapy devices are relatively new but have shown promise as a viable option for lymphedema treatment. This study aimed to compare this treatment method with the gold standard, manual lymphatic drainage, and two treatment protocols consisting of both treatments along with compression bandages, exercises, and skin care.

METHODS

Patients with lower extremity lymphedema associated with stage 1-2 secondary causes who applied to the Lymphedema Unit of Istanbul Physical Medicine and Rehabilitation Training and Research Hospital for treatment were included in the study. All patients had completed chemotherapy and radiotherapy. The inclusion criteria for the study were being between the ages of 18-75, having a diagnosis of unilateral lower extremity lymphedema, being willing to participate in the study. The exclusion criteria were having mental and cognitive disorders, being unable to communicate and cooperate, having an active infection, having bilateral lymphedema, excluding complications such as

pulmonary edema and congestive heart failure that would restrict treatment.

Using numbers obtained with computer software, patients were divided into two groups by randomization. The first group received 45 minutes of 15 sessions of manual lymphedema massage, and the second group received 45 minutes of 15 sessions of negative pressure massage therapy (NPMT) using the LymphaTouch device. Compression bandages were applied to both groups five days a week, and self-drainage training was provided to all patients after the sessions. Before treatment, patients' extremity circumference measurements at 6 reference points and their discomfort assessed by the visual analog scale (VAS) method were recorded. After completing 15 sessions, patients were re-evaluated with measurements at 6 reference points and evaluated for discomfort using the VAS.
For this study, ethical approval was obtained from the Istanbul Kanuni Sultan Süleyman Training and Research Hospital Ethics Committee with protocol number 2022.12234. Individuals who met the study criteria and voluntarily agreed to participate were provided with written and verbal information about the study. Informed consent forms were obtained from individuals both verbally and in writing for their participation in the study. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Measurements

VAS Pain and Discomfort

A 100-mm VAS was used to determine the severity of pain and discomfort. Patients quantified their pain and heaviness sensations on two separate VAS ratings on a scale ranging from 0 to 10, with 0 indicating no discomfort and 10 indicating the most severe discomfort. VAS satisfaction was assessed using the same 100 mm visual analog scale, with the level of satisfaction with the treatment being queried as 0 for not satisfied and 10 for very satisfied, and it was marked in the same way as VAS pain at the beginning and end of the treatment [16].

Lower Extremity Circumference Measurement

Patients' circumferences were measured at 6 levels with a flexible tape measure at 10 cm intervals starting from the metatarsophalangeal joint, with the ankle-ankle joint in a neutral position. Two measurements were taken, and their mean was used [17].

Interventions

The intervention group received treatment with the NPMT device (LymphaTouch) and the control group received MLD. The LymphaTouch is Food and Drug Administration approved as a therapeutic massage device in the United States. This handheld device administers negative pressure in the range of 80-250 mmHg under the treatment head, which gently pulls the underlying tissue into the suction cup [18]. MLD is a special massage technique applied directly to the skin with low pressure to stretch lymph capillaries and increase lymphangiomotoricity and lymphatic drainage. The basis of MLD is based on the 4 basic hand positions defined by Vodder [19].

Statistical Analysis

The power analysis method was used to determine the number of individuals to be included in the study, and it was calculated that at least 12 individuals should be included in each group, with a power ratio of 80% and an alpha risk of 0.05 accepted for each group. Considering a 10% dropout rate in both groups, 15 participants were determined per group according to

Table 1. Demographic data of patients

	NPMT (n = 15)	MLD (n = 15)	*p* value
Age (years)	57.73 ± 7.12	57.67 ± 5.95	0.569
Height (cm)	160.13 ± 4.29	159.20 ± 4.09	0.496
Weight (kg)	84.73 ± 15.07	83.27 ±1.06	0.877
BMI (kg/m^2)	31.03 ± 47.29	31.21 ± 47.18	0.833

Data are shown as mean ± standard deviation. NPMT = Negative Pressure Massage Therapy, MLD = Manual Lymphatic Drainage, BMI = Body Mass Index

the article of Corum *et al* [20].The MedCalc statistical program was used for sample size calculation. A total of 42 patients were screened for the study, and 30 participants who met the criteria were included. Descriptive statistics for categorical variables were presented as numbers and percentages, and descriptive statistics for numerical variables were presented as mean and standard deviation. Comparisons between two measurements were performed with the Wilcoxon signed-rank test. Mann-Whitney U test was used for intergroup comparisons. A significance level of $p < 0.05$ was accepted. SPSS version 10.0 statistical computer program was used for the analysis.

RESULTS

A total of 30 participants, all of whom were female, were included in the study. When comparing age, height, weight, and BMI between the groups, it was determined that there was no significant difference in weight and BMI ($p < 0.05$). Demographic data for the individuals are shown in Table 1.

Our patients were observed to be in stages 1 and 2 of lymphedema, and all of them have secondary lymphedema. It has been noted that individuals have had lymphedema for an average of 5 years (ranging from 1 to 12 years). Two-thirds of them have hypertension. When comparing the initial measurements, no statistically significant differences were found between all measurements. Initial measurements can be observed in Table 2.

When comparing the pre- and post-treatment results in both NPMT and MLD, ($p < 0.05$ and $p < 0.01$; respectively) statistically significant changes were observed (Table 3). When comparing between the groups, while some values were similar, overall, the NPMT ($p < 0.01$) group achieved more successful results (Table 3).

DISCUSSION

Lower extremity lymphedema is a chronic condition that requires lifelong treatment [21]. While treatment options are increasing with new developments, conservative treatments can still be insufficient in some cases [18]. Skin care, exercise, bandaging, and manual lymphatic drainage are standard treatment methods used in lymphedema. Options outside of these methods, which are part of the Complex Decongestive Therapy group, include pneumatic compression, medical treatment, electrotherapy, and surgery [21, 23]. Negative pressure massage therapy (NPMT) has started to be included in lymphedema treatment and its effectiveness has been investigated in recent years [24, 25]. There are few studies in the literature that investigate the effectiveness of NPMT compared to manual massage therapy in lymphedema patients. Moreover, there has been no similar research on lower

Table 2. Comparison of measurements before treatment

	NPMT (n = 15)	MLD (n = 15)	*p* value
VAS-pain	7.31 ± 3.82	7.23 ± 2.89	0.891
VAS-discomfort	6.43 ± 2.88	6.68 ± 31	0.766
MTP (cm)	25.60 ± 3.26	25.29 ± 3.18	0.801
Ankle (cm)	28.53 ± 4.01	29.01 ± 4.12	0.295
10 cm to ankle	40.40 ± 11.23	41.65 ± 9.8	0.324
20 cm to ankle	47.96 ± 8.96	46.12 ± 9.02	0.321
30 cm to ankle	47.60 ± 9.87	47.23 ± 7.76	0.801
40 cm to ankle	55.46 ± 8.40	54.35 ± 9.74	0.323

Data are shown as mean±standard deviation. NPMT = Negative Pressure Massage Therapy, MLD = Manual Lymphatic Drainage, VAS = Visual Analogue Scale, MTP = Metatarsophalangeal

Table 3. Comparison of the differences of before and treatment measurements within and between groups

	NPMT (n = 15) ΔBT-AT	*p* value	MLD (n = 15) ΔBT-AT	*p* value	Between Groups *p* value
VAS-pain	1.85 ± 1.86	**0.001**	1.97 ± 2.86	**0.001**	**< 0.05**
VAS-discomfort	3.21 ± 1.92	**0.001**	3.91 ± 2.42	**0.001**	**< 0.01**
MTP (cm)	1.20 ± 1.50	**0.008**	1.02 ± 1.04	**< 0.01**	**< 0.01**
Ankle(cm)	1.20 ± 1.37	**0.004**	1.01 ± 0.92	**< 0.01**	**< 0.05**
10 cm to ankle	3.43 ± 5.88	**0.040**	2.54 ± 6.10	**< 0.01**	**< 0.01**
20 cm to ankle	3.30 ± 4.81	**0.019**	2.14 ± 5.7	**< 0.01**	**< 0.01**
30 cm to ankle	2.23 ± 4.02	**0.019**	1.4 ± 5.7	**< 0.05**	**< 0.05**
40 cm to ankle	1.83 ± 2.16	**0.016**	1.01 ± 4.22	**< 0.05**	**< 0.01**

Data are shown as mean ± standard deviation. NPMT = Negative Pressure Massage Therapy, MLD = Manual Lymphatic Drainage, VAS = Visual Analogue Scale, MTP = Metatarsophalangeal

ΔBT-AT the difference between treatment and after treatment

extremity lymphedema patients. Therefore, our study is the first of its kind in this regard. Most of the existing studies have focused on upper extremity lymphedema patients associated with breast cancer, which is why the number of studies on lower extremity lymphedema is quite limited. With this research, we aim to determine the effectiveness of negative pressure massage therapy in lymphedema patients by evaluating changes in limb circumference measurements, pain, and discomfort and comparing it with manual massage therapy.

Manual massage therapy facilitates lymphatic drainage by creating a mild pressure gradient within the tissues [22]. While there are still some unclear points in the mechanism of negative pressure therapy, it is believed to stimulate lymphatic circulation by mobilizing and stretching the skin and subcutaneous tissue, thus exerting its effects. There are opinions in the literature that this mechanism is effective in achieving better results compared to manual massage therapy [18]. Mihara *et al*. [26] demonstrated in their study that lymphatic vessels in chronic lymphedema patients were sclerotic and in a constant state of contraction in advanced stages. It is thought that negative pressure therapy may facilitate mobilization in contracted vessels in chronic lymphedema patients. This study highlights that NPMT therapy may be a suitable option even in cases where the response to treatment is limited and the condition has become chronic.

The average age of the individuals included in our study, 57 years, is in line with the literature. Beesley *et al*. [27] mentioned in their study that individuals aged 50 and above are at a higher risk group. Deura *et al*. [28] also stated that the average age of individuals who developed lymphedema in their lower extremities after gynecological cancer was 55.

It is known that a BMI above 30 kg/m2 is an important risk factor for the development of lymphedema [29]. The average BMI of the lymphedema patients included in our study is above this value. The high average BMI in this population is consistent with the literature results regarding the relationship between lymphedema and obesity.

Measurement of volume and circumference is commonly used in the diagnosis and monitoring of lymphedema [17]. In addition to circumference and volume measurements, various other methods are also used, such as tonometry to measure the resistance of the tissue to applied compression, volumetry, bioimpedance spectroscopy, and tissue dielectric constant measurement. When we look at the literature, we see that circumference measurement is the most commonly used simple and objective criterion to measure the level of lymphedema [30]. Circumference meas-

urement is an objective assessment method that can easily be applied in repeated visits, and research has shown that it accurately identifies edema independently of volume measurement, with an accuracy rate of 84% [31]. Karges *et al*. [32] also demonstrated that circumference measurements made at 4 cm intervals in the upper extremity are a valid and reliable alternative to volume measurement. In our study, circumference measurements of the extremities were taken at the metatarsophalangeal joint, ankle level, and lateral malleolus of the ankle at 10 cm intervals, following this approach.

Devoogdt *et al*. [33] found that manual lymphatic drainage, in addition to education and exercise, was not effective in preventing lymphedema development in women who underwent unilateral axillary dissection due to breast cancer in both the short and long term. There are several studies in the literature that support the notion that MLD is insufficient in terms of preventing and treating lymphedema development [34, 35]. Lin *et al*. [36] published a meta-analysis in which they stated that MLD was effective in reducing pain in breast cancer-related lymphedema patients but did not result in a significant reduction in limb volume or improvement in quality of life. Similarly, Huang *et al*. [37] also found MLD to be insufficient in preventing and treating breast cancer-related lymphedema.
In contrast, in the study by Sitzia *et al*. [38], manual lymphatic drainage (MLD) and self-lymphatic drainage methods were compared, and volume reduction was found to be 33.8% in the MLD group, while this rate was determined as 22% in the self-lymphatic drainage group. This research emphasizes the effectiveness of MLD therapy and the importance of its application by trained therapists rather than by the patient themselves. Self-lymphatic drainage, on the other hand, maintains its value as an auxiliary method that the patient or a caregiver can use outside the hospital for the continuity of treatment. In a meta-analysis involving 457 patients, the efficacy of MLD in breast cancer-related lymphedema patients was evaluated. Although its volume-reducing effect was not significant, a significant reduction in extremity volume was recorded in applications lasting more than 2 weeks or with a total session count exceeding 20 [39]. This study demonstrates the importance of the number of sessions and the duration of MLD therapy in terms of effectiveness. In our research, we also observed a statistically significant reduction in extremity circumference measurements before and after treatment in the group receiving MLD therapy. Additionally, there was a significant decrease in the patient's pain and discomfort levels after treatment. Our total treatment duration was 3 weeks, which is consistent with the treatment duration emphasized in the study by Qiao *et al*. [39]. In a case report published by Borman *et al*. [40], a 48-year-old woman with polio sequelae who was mobilized with a wheelchair and had lymphedema and infected wounds in both lower extremities was mentioned. It was reported that significant improvements in extremity volumes and wound healing were achieved by applying a 4-week course of 20 sessions of skincare education, MLD, exercise, and bandaging treatment [40]. In another study, it was observed that a 20-session complex decongestive therapy was beneficial in reducing extremity volume and alleviating symptoms of depression and anxiety in 27 patients with unilateral lower extremity lymphedema [41]. In a study investigating the effects of manual lymphatic drainage in pediatric lymphedema patients, MLD was considered a useful non-invasive treatment method for reducing pain and achieving lymphedema decongestion [42]. Liu *et al*. [43]also found complex decongestive therapy to be effective in reducing extremity circumference measurements and improving the degree of lymphedema in patients with gynecological cancer-related lymphedema. As you can see, while there are conflicting results in the literature regarding MLD therapy, there are also many different studies that report its effectiveness (44-46).

There are only a few studies available in the literature regarding the effectiveness of negative pressure massage therapy. Campisi *et al*. [47] applied intermittent negative pressure therapy to 50 lymphedema patients and reported it as an effective treatment method. In the study by Lampinen *et al*. [18], the effectiveness of NPMT and MLD treatments was compared in patients with unilateral upper extremity lymphedema related to breast cancer. When the results were evaluated using extremity circumference measurements, it was observed that the group treated with NPMT showed a significantly greater reduction in volume [18].

In our study, similar to the mentioned study, circumferential measurements of the extremities signifi-

cantly decreased in both the MLD and NPMT groups compared to the beginning of treatment. This reduction was found to be significantly greater in the NPMT group compared to the MLD group. In the study by Vorinen and colleagues, 13 patients who had undergone mastectomy and axillary dissection due to breast cancer were divided into two treatment groups: 6 patients received MLD, and 7 patients received NPMT using the LymphaTouch® device. Patients were evaluated for upper extremity joint range of motion, grip strength, circumferential and volumetric measurements, skin elasticity, body composition analysis, and quality of life before and after treatment. While there were no significant changes in joint range of motion and grip strength measurements in both groups, NPMT treatment was found to provide better reductions in tissue stiffness and edematous muscle volume and improved quality of life [24]. However, it's important to consider the limited sample size when evaluating the study. In our study, a larger sample size has been maintained to enhance its reliability.

Weber and colleagues compared the effectiveness of manual lymphatic drainage and negative pressure therapy in patients who developed lymphedema after elbow surgery. In their results, they found that both methods led to a similar reduction in extremity circumference measurements, but the reduction in subjective pain sensation was more pronounced in the group receiving negative pressure therapy [48]. Similarly, Saul *et al*. [25] found negative pressure therapy effective in reducing upper extremity swelling after surgery.

In our study, in line with the literature, the subjective pain and discomfort caused by edema were evaluated using the VAS (Visual Analog Scale) score. We observed a significant reduction in pain and discomfort in both treatment groups compared to before treatment, with a higher decrease in the VAS score in the NPMT group ($p < 0.05$ and $p < 0.01$; respectively), which is consistent with the findings of these studies.

Limitations

However, it's important to note that there are limitations to this study, including the relatively small sample size and the lack of long-term follow-up. To further validate these findings, larger patient groups and randomized controlled trials with long-term assessments are needed.

CONCLUSION

Based on the results of this study, NPMT appears to be a beneficial non-invasive treatment method for reducing extremity volumes and decreasing subjective pain and discomfort in lymphedema patients. It is believed to be a preferred option over manual therapy methods due to its ease for therapists, reduced direct contact with the patient, lower risk of serious complications, and ease of patient compliance with the device. By preventing skin-to-skin contact, it can minimize the risk of transferring toxins or body fluids caused by chemotherapy and radiotherapy.

Authors' Contribution

Study Conception: SE; Study Design: NK; Supervision: NK; Funding: BŞ; Materials: SE; Data Collection and/or Processing: BŞ; Statistical Analysis and/or Data Interpretation: HK; Literature Review: NDB; Manuscript Preparation: SE and Critical Review: NP.

Conflict of interest

The authors disclosed no conflict of interest during the preparation or publication of this manuscript.

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