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A LITERATURE REVIEW OF USING COMPRESSION TECHNIQUES FOR THE MANAGEMENT OF LYMPHOEDEMA

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ABSTRACT

Background: Lymphoedema is generally defined as the formation of fluid or fluid retention causing swelling. It can be divided into primary or secondary lymphoedema based on its cause, as well as into three stages based on its pathology and severity of occurrence. Breast cancer among women is considered as the main cause of lymphoedema, but the condition occurs in both men and women.

Objective: To provide a comprehensive, up-to-date literature review of lymphoedema management and the effect of compression therapy on lymphoedema reduction.

Methods: A literature review was conducted utilizing the following databases PubMed, Medline, PEDro, and Science Direct.

Results: The current evidence supports the use of compression therapy for lymphoedema reduction, but its mechanism of action is still not well understood.

Conclusion: Although many studies recommend the use of compression therapy as an effective method for treating lymphoedema in both stages, the optimum treatment methods for lymphoedema are still unknown.

Keywords: Lymphoedema, Lymphatic Oedema, Lymphatic System, Compression Therapy, Compression Techniques.

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INTRODUCTION

Lymphoedema can be defined as a generalized or regional accumulation of protein-rich interstitial fluid, causing oedema and may progress to chronic with or without fibrosis [1]. One of the causes of lymphoedema is an imbalance in lymphatic flow and capacity of lymphatic circulation [2], initially occurring as a result of malformed or acquired impaired lymphatic circulation [1]. Breast cancer is the most common type of cancer among women globally and the leading cause of cancer mortality cause as well as lymphoedema progression [3]. Lymphoedema is classified as primary or secondary. Primary lymphoedema is defined as the congenital absence or malformation of lymphatic circulation and may appear at birth or later in life [4], while secondary lymphoedema, also called acquired lymphoedema, is mainly chronic oedema resulting from a decreased capacity in lymphatic circulation following a surgical operation or disease. Chronic lymphoedema is also known as brawny oedema [5].

Lymphoedema can be categorized depending on the region of swelling, for instance, breast cancer-related lymphoedema (BCRL) is chronic oedema in the upper extremity. It is the most common type of lymphoedema, mainly occurring after surgical operation of the lymph nodes located in the axilla. It was first described by Handley in 1908 [6] and is an unpleasant side effect of breast carcinoma surgery accompanied by pain, changing of skin colour and texture, decreased joint mobility and infection [3]. The appearance of lymphoedema is usually associated with a poor psychological situation, morbidity and overall decreased quality of life (QOL) [7]. Indeed, arm lymphoedema was initially described by Halsted (1921) as "elephantiasis chirirgica" [8]. According to Parbhoo (2006), young females are more susceptible to re-accumulation of lymphoedema due to increased daily activity such as work and shopping compared with older females [9]. In the United States, axillary lymph-node dissection is known as the main cause of arm lymphoedema [2]. It is difficult to determine and unify incidence, risk factors, and intervention strategy for lymphoedema management due to a lack of consensus among lymphoedema researchers [10].

Diagnosis and Risk Factors

An effective clinical evaluation for lymphoedema patients should provide a detailed history involving family history and clinical examinations [11]. Early detection of breast carcinoma presents as small cancer area and less nodal involvement which reduces its consequences [9]. A study carried out by Britton in 2009 showed that 75% of women who have breast carcinoma will develop BCRL within one year and 90% of them will develop BCRL within three years [12]. In some cases, another form of lymphoedema may develop, called "sub-clinical lymphoedema", that refers to decreased lymphatic flow but without any obvious clinical symptoms [13].

Lymphoedema volume varies through the day, sometimes it decreases in the morning, increases at the end of the day [1]. Volumetric measures and circumferential measures are the most commonly used measuring techniques to diagnose lymphoedema [1]. The major symptoms of lymphoedema are chronic oedema, pain, decreased extremity function, morbidity and depression [2]. Secondary lymphoedema may arise even after two decades of initial therapy. However, almost 75% of lymphoedema cases appear within one year post-surgery [11]. Women who had undergone surgery for full axillary dissection, followed by sessions of radiotherapy, are more at risk of developing lymphoedema than other survivors [14]. Although some studies reported that there is no relationship between developing lymphoedema and the number of lymph nodes removed [14], other researchers have shown that there is a significant correlation between the number of lymph nodes removed and the degree of lymphoedema [15].

Radiotherapy has been recognized as the most important risk factor in the occurrence of lymphoedema, consequently, it should be considered in the initial diagnosis [14]. However, Edwards (2000) has claimed that radiotherapy does not correlate to lymphoedema development [16]. Lymphoedema incidence in developed countries such as United States, Australia, and France has significantly declined because of early detection and management of breast cancers utilising advanced diagnostic devices such as mammogram [17]. Progression of lymphoedema can be restricted by early intervention and perfect physical assessment, especially in the short term [18]. A study by Fu *et al.* (2011) on 130 breast carcinoma patients reported that those who suffered from seromas after intervention were nearly eight times more susceptible to develop oedema in the arm and approximately 11 times more susceptible to develop oedema in chest and breast areas. Furthermore, patients with a body mass index (BMI) more than 30 were three and a half times more likely to develop lymphoedema than others [20].

Assessment and Measurement

Swelling may develop at any point during or post-treatment of breast cancer [21]. Volumetric and circumferential measures are the most commonly used techniques to diagnose lymphoedema [1]. The method of volumetric measures and water displacement is based on Archimedes' principles and is considered reliable [10]. On the day of measurement, patients should not use any compression modality due to measurement accuracy, but normal daily activity is allowed [1]. Upper extremity lymphoedema volume is measured by the water displacement method, in which both arms are immersed in a water tank, then the amount of displaced water is measured and scaled. This technique of water displacement was first discovered in 290-211 BC by a Greek mathematician called Archimedes and was suggested to be applied for use with lymphoedema patients by Kettle [1]. Circumference measures are conducted using a tape and interval of 4 cm [22], starting from the styloid process of the ulna at the wrist up to the axillary fold [23]. Assessment can also be performed using the Stemmer sign technique, which detects if the skin fold in the toes or fingers can be raised, a sign of lymphostasis.

In addition, skinfold thickness can be measured to report if there is any connective tissue fibrosis [24].

Bio-impedance spectroscopy (BIS) is used to assess interstitial fluid differences between both arms of lymphoedema clients [25]. However, this measuring technique may not be successful for assessing advanced stages of lymphoedema, when a large number of fluid changes to fibrotic tissue [25]. The perometer is a new reliable and accurate method for assessing and measuring lymphoedema [10]. Wick-in-needle is method was used before for measuring tissue fluid [26]. Estimating of pitting oedema can be achieved by hard pressing by the thumb for one minute, with the size of the depression reported in millimetres [27]. Chronic inflammation might cause the fat tissue to raise the volume, which can lead to misdiagnosis as it is measured as lymphoedema [27]. Care must be taken during the assessment and measurement of lymphoedema to avoid mistakes that could affect the accuracy of the measurements, but such errors can be avoided if the measurements are conducted by well trained and professional specialists [28]. Pain assessment using the visual analogue scale (VAS) is crucial to determine progression or deterioration [24].

Management of Lymphoedema

The treatment of lymphoedema is divided into three forms, surgical, pharmaceutical and conservative.

i. *Surgical treatment*: This treatment form is rarely used in lymphoedema patients, only in very severe and advanced cases. The role of surgery is either to debulk tissue or divert lymphatic drainage [12].
ii. *Pharmaceutical treatment*: This method mainly focuses on the use of benzopyrones to break down proteins by enhancing macrophages and stimulating them to initiate proteolysis [12].
iii. *Conservative treatment*: This form of treatment or management is widely used. It has a positive long-term effect and an example is complex decongestive therapy (CDT).

The most effective method of treating patients with lymphoedema is CDT, also called complex decongestive physiotherapy (CDP). It mainly consists of a multi-layer low-stretch bandage, manual lymphatic drainage, exercises and skin and wound care [29]. The non-invasive therapy is a two-phase intervention protocol, the first phase reduces the lymphoedema using skin care, manual lymphatic drainage, a range of motion (ROM) exercises and multi-layer compression bandages. The aim of the second phase is to maintain the optimal findings from phase one. The initial intensive stage of lymphoedema management ranges from one to six weeks to obtain extreme effectiveness and is estimated to achieve between 35% and 60% of total lymphoedema reduction [30].

Health-related quality of life (HRQOL) is highly crucial for lymphoedema patients to identify and measure outcomes because lymphoedema has negative effects on health, structural and psychosocial aspects of those affected [31]. Lymphoedema management requires multidisciplinary care, involving physical, mental, social and financial support for the affected person [4]. Patients diagnosed with lymphoedema may also suffer from depression and anxiety due to their perceived undesirable body image, resulting in reduced confidence [32]. Thus, the priority of managing lymphoedema patients is to focus on supporting emotional and psychological aspects, rather than focusing on lymphoedema reduction [33]. CPT is believed to induce lymphoedema reduction from 51% to 81% based on the severity of the lymphoedema [34].

Compression Therapy

Compression therapy is the most effective method for the treatment of lymphoedema. The purpose of this treatment is to initially decrease the lymphoedema volume, to stabilize and prevent progression of lymphoedema accumulation [13], as well as sustaining this reduction in the long term [22]. Compression stockings have been found to enhance and improve the overall QOL [35]. Positive outcomes of compression are not only in the treatment of lymphoedema, but it also prevents re-accumulation of fluid, enhancing the lymph to flow freely [1]. A study conducted by Chen *et al.* (2001) reported that wave-like compression provides the most effective technique of venous emptying [36]. This study found that low-grade compression (10-30 mmHg) prevents swelling and deep venous thrombosis (DVT), while high-grade compression (30-40 mmHg) applied by compression garments or compression bandages is beneficial for healing of ulcers, preventing post-thrombotic syndrome and long-term management of lymphoedema. Continued compression therapy is likely to prevent worsening of lymphoedema and its further physical and physiological complications. However, compression may interfere with blood circulation in bedridden patients, depending on the severity of their condition.

Some studies mentioned that applying compression garments results in significant outcomes for maintenance therapy, but it does not produce limb volume reduction when applied alone on the untreated limb [22]. Compression bandages must be applied during exercise to prohibit fluid accumulation and to elevate lymph flow [2]. Patients should be instructed to wear the compression garment in the maintenance phase during the day, taking it off at night [23]. Studies have reported compression bandaging is beneficial for lymphoedema reduction, even if applied alone without manual lymphatic drainage [37]. The Elvarex compression garment is widely used in Europe due to its reported effects on lymphoedema reduction [23]. The positive aspects of compression therapy are reducing the swelling of the extremity to a minimum, maintaining this reduction, thereby allowing the patient to participant in any management program at any time [38]. Compression therapies change the gradient of tissue pressure, which reduces swelling and increases fluid absorption, minimizing the gauge of the veins and maximizing the velocity of venous flow, decreasing "orthostatic reflux" by reducing reflux in perforating vessels and improve muscle pumping effectiveness [38]. The combination of applying a compres-

sion sleeve during the day and a compression bandage at night during the maintenance phase is the gold standard for stabilising maximum lymphoedema reduction reached during the intensive phase [39]. Weight loss is essential during compression therapy to manage arm lymphoedema [39].

Multi-chambered compression devices with pressure declined proximally are more efficient than mono-chamber devices [40]. Compression devices vary in terms of the number of chambers, the time of inflation/deflation, inflation pressure, gradient pressure and design [26]. Pneumatic compression is widely used due to the increased tissue fluid pressure, which generates a gradient between the compressed and non-compressed areas, thereby creating a pressure gradient which promotes the flow of the fluid [26]. Inflation for less than 20 seconds is insufficient to generate tissue fluid movement, even with a pressure of 120 mmHg. The optimum duration for enhancing tissue fluid flow should not be less than 50 seconds. Tissue fluid pressure varies depending on tissue mass [41].

The Coban 2 compression system has the capability to supply high working pressure and low resting pressure as it's essential for better oedema reduction. It has been reported that the Coban 2 system facilitates faster and easier wrapping, enhanced movement increases patient's trust, improves sensation and improves overall QOL [42]. The negative aspect of this system is that it generates heat, causing an itching sensation in some patients, so the system should be modified to decrease heat generation and allow patients to self-applicate and self-care. Professional wrapping techniques must involve padding to protect bony prominences like elbows and malleoli [43]. Compression therapy can increase the ejection fraction (EF) and an inelastic bandage is more effective in improving EF [44]. The pressure generated under the bandages is determined by fabric tension [45]. Intermittent pneumatic compression (IPC) is the best solution for patients who are sensitive to bandages due to allergies [46]. Although compression therapy is very effective for lymphoedema reduction, its mechanism of action is still not well understood [47].

DISCUSSION

This section will only discuss the currently available studies that have been conducted to manage patients with lymphoedema using compression techniques. The following databases were searched from the date of their establishment in 2014 to identify relevant studies: PubMed, Medline, PEDro, and ScienceDirect. After the screening, six studies were identified and are summarised in Table 1.

Vignes *et al.* (2007) assessed the factors that influence lymphoedema volume within the treatment stage [48]. This cohort study of 537 clients suffering from arm lymphoedema post-breast carcinoma followed for 12 months using a treatment plan used of decongestive therapy that comprised manual lymphatic drainage, stretch bandage and elastic sleeve for 12 months maintenance therapy. The mean lymphoedema volume at the start was 1054 ml +/- 633 ml, reducing to 647 ml +/- 351 after treatment. These results show a significant decrease in mean lymphoedema volume. The researchers recommended the use of compression therapy (elastic sleeve and low stretch bandage) during the maintenance phase to stabilise the lymphoedema volume.

A study by Karadibak, Yavuzsen, and Saydam (2008) assessed the use of decongestive physiotherapy in women with upper limp lymphoedema [49]. The study participants were female patients post-mastectomies who were treated by manual lymphatic drainage, use of compression garments and skin care. The compression garments and skin care were applied as part of a home program. The total number of participants was 62 and they were classified depending on the arm circumference as mild lymphoedema (the difference in arm circumference up to 2 cm), moderate lymphoedema (the difference in arm circumference 2-5 cm) and severe lymphoedema (the difference in arm circumference more than 5 cm or the lymphoedema exist more than 1 year). Before treatment, the mean lymphoedema volume was 925 ml and the percentage was 47.1%. After the intervention, the mean lymphoedema volume reduced to 510 ml and the percentage became 21.3%, indicating that decongestive physiotherapy is effective in the management of lymphoedema.

Sawan *et al.* (2009) investigated the effect of the early use of leg compression stockings in patients with vulval cancer lymphoedema post-inguinofemoral lymphadenectomy [50]. The participants were classified into two groups, supportive care group (control) and supportive care group with use of a gradual compression stocking (treatment) for 6 months. The results of this study showed a major increase in the mean leg volume in the control group, with improvement in the treatment group. However, there was no major difference in the QOL questionnaire among both groups.

Kim (2012) used manual skills to test different types of compression garments and compression bandages for breast carcinoma lymphoedema patients [51]. The participants in the study were divided into two groups, the treatment, and the control. The control consisted of persons who had no lymphoedema. The research examined the grip strength that was performed varying situations, in the situations for the grip strength there was no compression, with either the compression garment or bandage. The results of this trial show an inverse relationship between the thickness of the compression tools and performed skills so that when the thickness of compression tools increased, the grip strength decreased. Also, there was a significant decrease in grip strength under bandaging conditions, while there was a slight decrease in using a compression garment. These results show that the compression material used plays a significant role in determining the performance of the patients, thus the selection of material for management of lymphoedema is of high importance.

A study conducted by King *et al.* (2012) assessed the effect of decongestive lymphatic therapy on acquired lymphoedema by application of two management techniques [52].

The research participants (23) were classified as mild to moderate lymphoedema patients depending on the volume difference (10-40% volume difference). The two groups in the study were the compression garment group and the bandaging group. The measured outcomes were lymphoedema volume and symptoms. Symptom measurement was evaluated by VAS and Disability of Arm Shoulder and Hand (DASH) questionnaire. The results indicated a better volume reduction in the bandaging group compared to the garment group. The median volume reduction at 10th day was 70 ml for bandaging group, while for the compression group was 5 ml. After three months, the median volume reduction was 97.5 ml for bandaging group and 50 ml for garment group. However, the bandaging group had a worse upper limb functional status based on the DASH questionnaire, with poorer hand, arm and shoulder scores. The findings show that the median volume reduction does not indicate a significant difference among the groups. Additionally, symptoms were better in bandaging group according to DASH questionnaire. This study only included 23 participants who were later divided into two groups, this number is very small and it may not show good correlation.

A study by Dayes *et al.* (2013) evaluated the outcomes of decongestive therapy in a randomized trial [53]. The participants were female patients post-mastectomy, with a minimum of 10% volume difference between arms. The sample population was 103 and the patients were divided into two garment groups, the control group used a compression garment and the experiment group had daily manual lymph drainage and subsequent bandaging followed by compression. The study was carried out for six weeks. There was a 29% reduction in the experimental group and 22.6% in the control group, with a volume reduction of 250 ml in the experimental group and 143 ml in the control group. The study was comprehensive in the investigation of the effectiveness of the decongestive therapy compared to the garment compression therapy, providing measurements before and after the management. However, the study did not provide enough data regarding the methods utilized to measure the lymphoedema and the reasons for using the selected method.

Table 1: Summary of the current studies using compression as an intervention for patients with lymphoedema

Study	Sample	Treatment	Measurement	Duration	Results
Vignes *et al.* (2007) [48]	N=537 Arm lymphoedema post-breast carcinoma	Intensive decongestive physiotherapy (manual lymphatic drainage, stretch bandage and elastic sleeve)	Lymphoedema volume	12 months	Decrease in lymphoedema volume from 1,054 +/- 633 ml to 647 +/- 351 ml
Karadibak *et al.* 2008 [49]	N=62 Post-mastectomy	Complete decongestive therapy (manual lymphatic drainage, compression garments, skin care, and remedial exercises)	Lymphoedema volume	12 weeks	Decrease in lymphoedema volume from 925 ml (47.1%) to 510 ml (21.3%)
Sawan *et al.* 2009 [50]	N=14 Vulval cancer lymphoedema	1. Gradual compression stocking plus supportive care 2. Supportive care	Leg volume	6 months	Increase in the mean leg volume in the supportive care group
Kim (2012) [51]	N=26 Breast carcinoma lymphoedema	1. Compression garment 2. Compression bandage	Grip strength	Not reported	Decrease in grip strength under bandaging condition while there was a slight decrease in using compression garment
King *et al.* (2012) [52]	N=21 Mild to moderate lymphoedema	1. Compression garment 2. Compression bandage	Lymphoedema volume	3 months	Greater volume reduction in bandaging group compared to garment group
Dayes *et al.* (2013) [53]	N=95 Post-mastectomy	1. Compression garment group (control) 2. manual lymph drainage, bandaging compression garments (experimental)	Arm volume	6 weeks	The volume loss was 250 ml in the experimental group and 143 ml in the control group

Vignes and Arraut (2009) investigated the side effects of different types of compression used in lymphoedema patients [54]. The authors recorded some side effects, such as the elastic garment used for arm up to wrist was found to cause lymphoedema in fingers. There was also the development of ulcers between the thumb and the forefinger due to friction caused by the sleeve. They also found that the open-toe elastic stock could increase lymphoedema and may cause oozing lymph vessels in the foot compression. Over-pressure was also found to lead to severe pain in the first and fifth toes. "Silicone-banded soft-fit elastic garments" was associated with pain, eczema, and urticaria, while the elastic bandage was sometimes painful or could cause purpuric lesions. The study established that different management approaches of lymphoedema can lead to side effects. Furthermore, the study duration of four years strengthened the findings and gave good validity. The study established that the side effects normally occurred due to the type of compression materials used, thus it is imperative to select the appropriate compression material, taking into consideration the potential side effects. In addition, it is important to note that the compression therapy efficacy depends on two main aspects: 1) interface pressure of the material on the affected organ, and 2) stiffness of the material which sets the effectiveness of the material during the static and dynamic positions [55].

CONCLUSION

This study reviewed the literature regarding the use of compression techniques for the management of lymphoedema. Although many studies recommended the use of compression therapy as an effective method for treating lymphoedema in both stages, there is still a lack of consensus on the optimal intervention method for lymphoedema.

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