# COMPLETE DECONGESTIVE THERAPY IN LYMPHEDEMA

## Komplexná dekongestívna terapia lymfedému

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**Abstract**
Lymphedema, a chronic condition characterized by the accumulation of lymphatic fluid in the interstitial tissue, leads to swelling primarily in the extremities, though other parts of the body can be affected. This condition commonly arises following lymph node dissection, radiation therapy, or due to inherent defects in the lymphatic system. Effective management of lymphedema is crucial due to its impact on function and quality of life, with complete decongestive therapy (CDT) serving as the cornerstone of treatment. CDT, a multimodal approach involving manual lymphatic drainage (MLD), compression bandaging, skin care, and exercise, has been widely adopted *(Fig. 5, Ref. 74). Text in* PDF www.lekarsky.herba.sk.
*KEY WORDS:* lymphedema, decongestive therapy, vascular, angiology.
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**Abstrakt**
Lymfedém, chronický stav charakterizovaný akumuláciou lymfatickej tekutiny v intersticiálnom tkanive, vedie k opuchom predovšetkým končatín, hoci môžu byť postihnuté aj iné časti tela. Tento stav sa bežne vyskytuje po disekcii lymfatických uzlín, rádioterapii alebo v dôsledku vrodených defektov v lymfatickom systéme. Efektívna liečba lymfedému je kľúčová vzhľadom na jeho vplyv na funkciu a kvalitu života, pričom základom liečby je komplexná dekongestívna terapia (CDT). CDT, multimodálny prístup zahŕňajúci manuálnu lymfatickú drenáž (MLD), kompresné bandáže, starostlivosť o pokožku a cvičenie, je celosvetovo adaptovaná a používaná *(obr. 5, lit. 74). Text v PDF www.lekarsky.herba.sk.*
*KĽÚČOVÉ SLOVÁ:* lymfedém, dekongestívna terapia, cievne, angiológia.
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### Introduction

Lymphedema manifests as a persistent condition characterized by the accumulation of lymphatic fluid in the body, resulting in swelling and potential alterations in skin and tissue integrity (1). This chronic and progressive buildup of protein-rich fluid surpasses the lymphatic system's capacity for fluid transport. Swelling associated with lymphedema can affect various body regions, including the arms, legs, genitals, face, neck, chest wall, and oral cavity (2). The diagnosis of lymphedema carries numerous psychological, physical, and social implications. It is broadly categorized as either primary, with genetic basis, or secondary, acquired through external factors (2).

The lymphatic system functions to transport lymph, a fluid containing white blood cells, triglycerides, bacteria, cell debris, water, and protein, akin to blood plasma. This intricate drainage system comprises initial lymphatics (lymph capillaries), pre-collectors, collectors, lymphatic trunks, and lymph nodes (3). Topographically, the lymph system is divided into superficial (subcutaneous) and deep (subfascial) components. The superficial system drains the skin and subcutaneous tissues, while the deep system handles muscles, joints, tendon sheaths, and nerves. Perforating vessels serve as a connections between these systems, facilitating the transport of lymph from subfascial areas to the surface (4, 5).

Signs and symptoms of lymphedema encompass distal swelling in extremities such as the arms, hands, legs (Fig. 1), and feet, as well as proximal swelling in areas like the breast, chest, shoulder, pelvis, groin, genitals, face, and intraoral tissues. Restricted range of motion in joints due to swelling and tissue changes, skin discoloration, pain, altered sensation, limb heaviness, and difficulty fitting into clothing are also common manifestations (6, 7, 8).

### Lymphedema Etiology

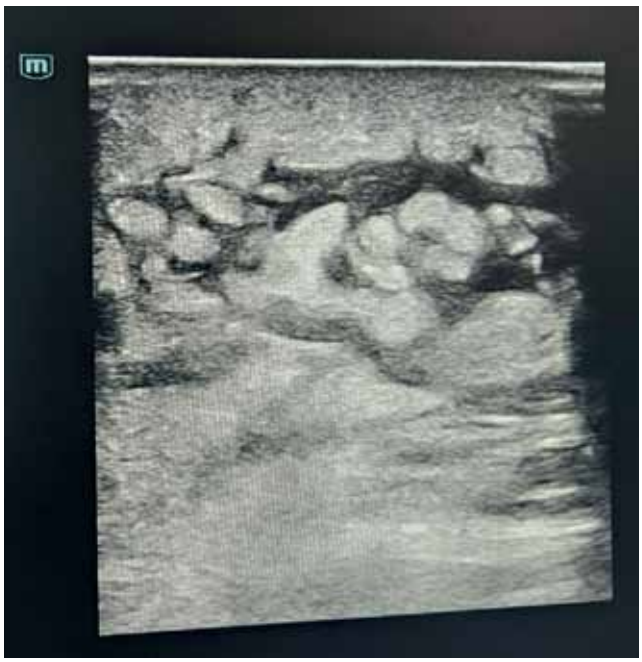
Understanding the etiology of lymphedema is essential for predicting disease progression, identifying individuals at risk, and optimizing treatment outcomes. Lymphedema can arise from various underlying causes, with primary and secondary etiologies playing distinct roles in disease manifestation and management.

#### *Primary Lymphedema*

Primary lymphedema is characterized by congenital abnormalities or developmental defects in the lymphatic system, leading to impaired lymphatic drainage and fluid accumulation. Genetic mutations or alterations in

lymphatic vessel development can contribute to primary lymphedema, which may manifest at birth or later in life. The age of onset and specific genetic factors associated with primary lymphedema can influence disease severity, progression, and treatment response (50) Finegold et al. (Fig. 2).

**Figure 1. Patient with late stage lymphedema and ultrasound image of late stage lymphedema with subcutaneous fluid with "fish eye signs".**



## Secondary Lymphedema

Secondary lymphedema occurs as a result of damage, obstruction, or dysfunction of the lymphatic system due to external factors such as surgery, radiation therapy, trauma, infection, or underlying medical conditions. Common causes of secondary lymphedema include cancer treatment, particularly surgery and radiation therapy for breast cancer, gynecologic cancers, or melanoma. The extent of lymphatic damage, the presence of comorbidities, and the timing of intervention can all impact the development and progression of secondary lymphedema (51) Shaitelman et al.

**Figure 2. Patient with massive primary late stage lymphedema with irreversible skin and subcutaneous changes.**

Understanding the etiology of lymphedema allows healthcare providers to tailor treatment approaches based on the underlying cause and individual patient characteristics. For example, primary lymphedema may require lifelong management strategies to address congenital lymphatic abnormalities, whereas secondary lymphedema may benefit from early intervention to prevent or minimize lymphatic damage following cancer treatment. Additionally, knowledge of lymphedema etiology can help identify individuals at higher risk for developing the condition and implement preventive measures accordingly. Patients undergoing cancer treatment, lymph node dissection, or radiation therapy should be educated about the risk of developing lymphedema and encouraged to adopt risk-reduction strategies such as proper skin care, exercise, and avoiding limb constriction.

## Decompressive therapy in lymphedema

Decompressive therapy in lymphedema is a treatment approach aimed at reducing swelling and managing the symptoms associated with lymphedema, which is a condition characterized by the buildup of lymph fluid in the body's tissues, typically due to a blockage in the lymphatic system. Decompressive therapy encompasses various techniques and modalities designed to alleviate swelling and improve lymphatic circulation (9, 10) (Fig. 3).

**Figure 3. Common methods of decompressive therapy in lymphedema and their effects.**


## Some common methods of decompressive therapy in lymphedema include

**1. Manual Lymphatic Drainage (MLD):** This is a gentle massage technique performed by a trained therapist to stimulate the flow of lymph fluid and encourage its drainage from the affected area (11, 12). Manual Lymphatic Drainage (MLD) is a specialized massage technique commonly used in the management of lymphedema. It involves gentle, rhythmic movements that stimulate the lymphatic system, promoting the drainage of excess lymphatic fluid and reducing swelling in affected areas. MLD is often performed by trained therapists who apply specific hand movements to redirect lymph fluid towards functional lymphatic pathways. Several studies have demonstrated the effectiveness of Manual Lymphatic Drainage in the treatment of lymphedema. A study published by Koul et al. assessed the impact of MLD on breast cancer-related lymphedema. The results showed significant reductions in limb volume and improvements in symptoms following MLD treatment (13). A systematic review and meta-analysis conducted by Ezzo et al. evaluated the efficacy of MLD in the management of lymphedema. The analysis included several randomized controlled trials and concluded that MLD was effective in reducing limb volume and improving quality of life in patients with lymphedema (12). Another study by Devoogdt et al. published in Cancer Nursing, investigated the long-term effects of MLD on breast cancer-related lymphedema (14). The findings indicated sustained improvements in limb volume and symptom relief over a 12-month follow-up period. These studies highlight the therapeutic benefits of Manual Lymphatic Drainage in reducing swelling and improving symptoms associated with lymphedema. However, it's important to note that MLD is often used as part of a comprehensive treatment approach, which may include compression therapy, exercise, skincare, and patient education.

**2. Compression Therapy:** Compression garments or bandages are applied to the affected limb to help reduce swelling by applying external pressure and supporting the lymphatic vessels (15,16,17). Compression therapy is a cornerstone of treatment for lymphedema, aimed at reducing swelling and improving lymphatic function through the application of external pressure. It typically involves the use of compression garments, bandages, or pneumatic compression devices to exert pressure on the affected limb or body part. Compression therapy helps to promote lymphatic drainage, prevent fluid accumulation, and maintain the reduced size of the limb achieved through other treatments such as manual lymphatic drainage. Several studies have investigated the efficacy of compression therapy in the management of lymphedema. A randomized controlled trial by (18) Ochalek et al. compared the effectiveness of different compression garments in reducing arm lymphedema following breast cancer treatment. The study found that compression therapy significantly reduced limb volume and improved symptoms compared to no treatment. A systematic review and meta-analysis by (19) McNeely et al. evaluated the evidence for compression therapy in breast cancer-related lymphedema. The analysis included several studies and concluded that compression garments were effective in reducing limb volume and improving quality of life in patients with lymphedema. A study by Mayrovitz et al. (20), investigated the effects of intermittent pneumatic compression on lower extremity lymphedema. The results demonstrated significant reductions in limb volume and improvements in tissue fluid content following pneumatic compression therapy. These studies provide evidence supporting the use of compression therapy as an effective intervention for managing lymphedema. However, it's important to note that the selection and application of compression garments or devices should be tailored to the individual patient's needs and preferences, and

proper monitoring is essential to ensure optimal outcomes.

**3. Exercise:** Specific exercises and movements may be prescribed to promote lymphatic flow and improve muscle pumping action, which can aid in reducing swelling (21, 22). Exercise plays a crucial role in the management of lymphedema by promoting lymphatic flow, improving muscle pump function, and enhancing overall physical and mental well-being. However, it is important that exercise programs are tailored to individual capabilities and carefully monitored to prevent injury and exacerbation of lymphedema symptoms. Here are some key points about exercise and lymphedema

*3.1. Benefits of Exercise:* Exercise can help reduce swelling, improve range of motion, increase strength and flexibility, and enhance overall quality of life for individuals with lymphedema. It also promotes cardiovascular health and aids in weight management, which are important considerations for lymphedema management.

*3.2. Types of Exercise:* Low-impact aerobic exercises such as walking, swimming, cycling, and aquatic exercises are generally safe and effective for individuals with lymphedema. Resistance training and flexibility exercises can also be beneficial, but should be performed with caution and under supervision, particularly for individuals at risk of developing or exacerbating lymphedema.

*3.3. Precautions and Guidelines:* It is important for individuals with lymphedema to follow specific precautions and guidelines when exercising, such as wearing compression garments during activity, avoiding repetitive or high-impact movements that may strain the affected limb, and gradually increasing exercise intensity and duration under the guidance of a healthcare professional.

Several studies have investigated the effects of exercise on lymphedema management. A randomized controlled trial by (23) Ahmed et al. evaluated the effects of supervised aerobic and resistance exercise in breast cancer survivors with lymphedema. The study found that exercise led to significant reductions in arm swelling and improvements in physical function and quality of life. A systematic review by (24) Cheema et al. (2014), published in Breast Cancer Research and Treatment, examined the effects of exercise on lymphedema-related outcomes in breast cancer survivors. The review concluded that exercise was safe and beneficial for individuals with lymphedema, leading to improvements in limb volume, physical function, and psychosocial well-being. Another study by (25) Czerniec et al. (2010), published in Breast Cancer Research and Treatment, investigated the effects of resistance training on breast cancer-related lymphedema. The study found that resistance training led to improvements in arm volume and strength without exacerbating lymphedema symptoms. These studies provide evidence supporting the inclusion of exercise as part of a comprehensive lymphedema management program. However, it's essential for individuals with lymphedema to consult with their healthcare providers before starting an exercise regimen and to receive guidance on safe and appropriate activities based on their individual needs and health status.

**4. Pneumatic Compression Therapy:** This involves the use of pneumatic compression devices that intermittently inflate and deflate sleeves or boots worn on the affected limb, promoting lymphatic drainage (15, 26). Pneumatic Compression Therapy (PCT) is a non-invasive treatment modality used in the management of lymphedema. It involves the application of sequential or intermittent pneumatic compression devices to the affected limb or body part, which exert external pressure and promote lymphatic drainage. PCT works by enhancing tissue fluid movement, reducing swelling, and improving lymphatic function. Pneumatic Compression Therapy applies external pressure via compression garments to the affected limb through sequential or intermittent inflation and deflation of air chambers within the compression device. This action helps to mimic the natural pumping action of muscles and promotes the movement of lymphatic fluid towards functional lymphatic pathways, facilitating drainage and reducing swelling. Several studies have demonstrated the effectiveness of Pneumatic Compression Therapy in the management of lymphedema. A randomized controlled trial by (27) Nelson et al. investigated the effects of intermittent pneumatic compression on lower extremity lymphedema. The study found significant reductions in limb volume and improvements in tissue fluid content following Pneumatic Compression Therapy. A systematic review and meta-analysis by (28) Uzkeser et al. evaluated the efficacy of Pneumatic Compression Therapy in the treatment of lymphedema. The analysis included several studies and concluded that Pneumatic Compression Therapy was effective in reducing limb volume and improving symptoms in individuals with lymphedema.

Pneumatic Compression Therapy is recommended as a treatment option for lymphedema in clinical practice guidelines, including those from organizations such as the National Lymphedema Network (NLN) and the International Society of Lymphology (ISL) (2, 29). These guidelines emphasize the importance of using Pneumatic Compression Therapy as part of a comprehensive lymphedema management program, which may include other modalities such as manual lymphatic drainage, compression garments, exercise, and skincare (2, 30, 31). Pneumatic Compression Therapy is generally well-tolerated by patients with lymphedema, but it is essential to consider individual factors such as comfort, mobility, and treatment preferences when prescribing PCT. Proper fitting of compression garments and regular monitoring of treatment progress are important aspects of patient care (32 – 34).

**5. Complete Decongestive Therapy (CDT):** CDT is a comprehensive treatment program for lymphedema that typically includes a combination of manual lymphatic drainage, compression therapy, exercise, skin care, and patient education (35, 36). Complete Decongestive

Therapy (CDT) is a comprehensive treatment approach commonly used in the management of lymphedema. It consists of several components, including manual lymphatic drainage (MLD), compression therapy, exercise, skincare, and patient education. CDT aims to reduce swelling, improve lymphatic function, and enhance the overall quality of life for individuals with lymphedema. Here are some key points about Complete Decongestive Therapy and lymphedema, along with references supporting its efficacy. A randomized controlled trial by (37, 38) Stout Gergich et al. published in Cancer, assessed the effectiveness of Complete Decongestive Therapy in breast cancer-related lymphedema. The study found significant reductions in limb volume and improvements in symptoms following CDT treatment. A systematic review by (39) Stout et al. evaluated the evidence for CDT in the management of lymphedema. The review concluded that CDT was effective in reducing limb volume, improving quality of life, and minimizing complications associated with lymphedema. Complete Decongestive Therapy is recommended as the standard of care for lymphedema management in clinical practice guidelines, including those from organizations such as the National Lymphedema Network (NLN) and the International Society of Lymphology (ISL). These guidelines emphasize the importance of a multidisciplinary approach and the integration of various components of CDT for optimal treatment outcomes. Individualized assessment and treatment planning are essential in CDT to tailor interventions to each patient's specific needs, preferences, and clinical presentation. Regular monitoring and adjustment of treatment regimens are also important to ensure ongoing effectiveness.

**6. Surgical Options:** In some cases, surgical procedures such as lymphaticovenous anastomosis (LVA) or vascularized lymph node transfer (VLNT) may be considered to improve lymphatic drainage and reduce swelling (40, 41, 42). Surgical options are available for the management of lymphedema, particularly in cases where conservative treatments such as Complete Decongestive Therapy (CDT) have not provided sufficient relief or when the condition is severe. Some surgical interventions can be performed in an outpatient setting and the key for successful outcome is time planning, whereas the surgery should be planned after intensive phase of CDT. Surgical interventions aim to improve lymphatic flow, reduce swelling, and alleviate symptoms. Some key surgical options for lymphedema management, along with references supporting their efficacy:

*6.1. Lymphaticovenous Anastomosis (LVA):* LVA is a microsurgical procedure that involves connecting lymphatic vessels to adjacent veins to bypass blocked or damaged lymphatic pathways. This allows lymphatic fluid to drain directly into the venous system, reducing swelling and improving lymphatic function. A study by (43) Chang et al. evaluated the outcomes of LVA in the treatment of lymphedema. The study demonstrated significant reductions in limb volume and improvements in symptoms following LVA surgery.

*6.2. Vascularized Lymph Node Transfer (VLNT):* VLNT involves transplanting healthy lymph nodes, along with their blood supply, from a donor site to the affected area in the body. This procedure aims to restore lymphatic function and improve drainage, thereby reducing swelling and alleviating symptoms. A systematic review by (44) Ciudad et al. examined the efficacy of VLNT in the treatment of lymphedema. The review found that VLNT led to significant reductions in limb volume and improvements in quality of life for patients with lymphedema.

*6.3. Liposuction:* Liposuction may be considered for individuals with lymphedema who have significant adipose tissue accumulation in the affected limb. Liposuction aims to remove excess fat deposits, reducing limb volume and improving mobility. A study by (45) Brorson et al. investigated the long-term outcomes of liposuction in the treatment of lymphedema. The study demonstrated sustained reductions in limb volume and improvements in symptoms following liposuction surgery.

*6.4. Combined Surgical Approaches:* In some cases, a combination of surgical techniques, such as LVA and VLNT or VLNT and liposuction, may be used to optimize outcomes and address multiple aspects of lymphedema pathophysiology. A study by (46) Cheng et al. evaluated the effectiveness of combined surgical approaches in the management of lymphedema. The study demonstrated favorable outcomes in terms of volume reduction and symptom improvement.

Decompressive therapy aims to manage the symptoms of lymphedema, improve quality of life, and reduce the risk of complications associated with the condition, such as recurrent infections and impaired limb function. It is typically tailored to the individual needs of the patient and may involve a combination of different therapeutic modalities.

## Influence of skin thickness on the success of decompressive therapy of lymphedema

Skin thickness can indeed play a significant role in the success of decompressive therapy for lymphedema. Lymphedema, characterized by the accumulation of protein-rich fluid in interstitial spaces due to impaired lymphatic drainage, often leads to tissue fibrosis and thickening of the skin over time. Skin changes in lymphedema include fibrosis, hyperkeratosis, and increased thickness, which can further compromise lymphatic function and exacerbate fluid accumulation. The effectiveness of decompressive therapy, such as manual lymphatic drainage (MLD), compression bandaging, and pneumatic compression devices, in managing lymphedema depends partly on the condition of the skin. Thickened skin can impede the efficacy of these therapies by reducing the ability of the lymphatic vessels to respond to external pressure and by limiting the mobility of underlying tissues. Studies have demonstrated

that individuals with thicker skin due to lymphedema may experience poorer outcomes with standard compression therapy compared to those with thinner skin. For instance, a study by Moffatt et al. found that patients with thicker skin in chronic lymphedema had reduced response rates to compression therapy (52). Similarly, research by Devoogdt et al. indicated that skin thickness was negatively correlated with the effectiveness of MLD in reducing limb volume in breast cancer-related lymphedema. Moreover, the presence of fibrotic tissue and increased skin thickness may necessitate modifications to conventional treatment approaches. Techniques such as scar tissue mobilization, deep tissue massage, or use of specialized bandaging materials may be required to address fibrosis and improve lymphatic drainage in individuals with thicker skin (81). Therefore, while decompressive therapies remain integral to the management of lymphedema, the influence of skin thickness on treatment outcomes cannot be overlooked. Clinicians should consider skin characteristics, including thickness and fibrosis, when designing individualized treatment plans for patients with lymphedema. Below are some of the ways how skin thickness can influence the success of decompressive therapy (Fig. 4).

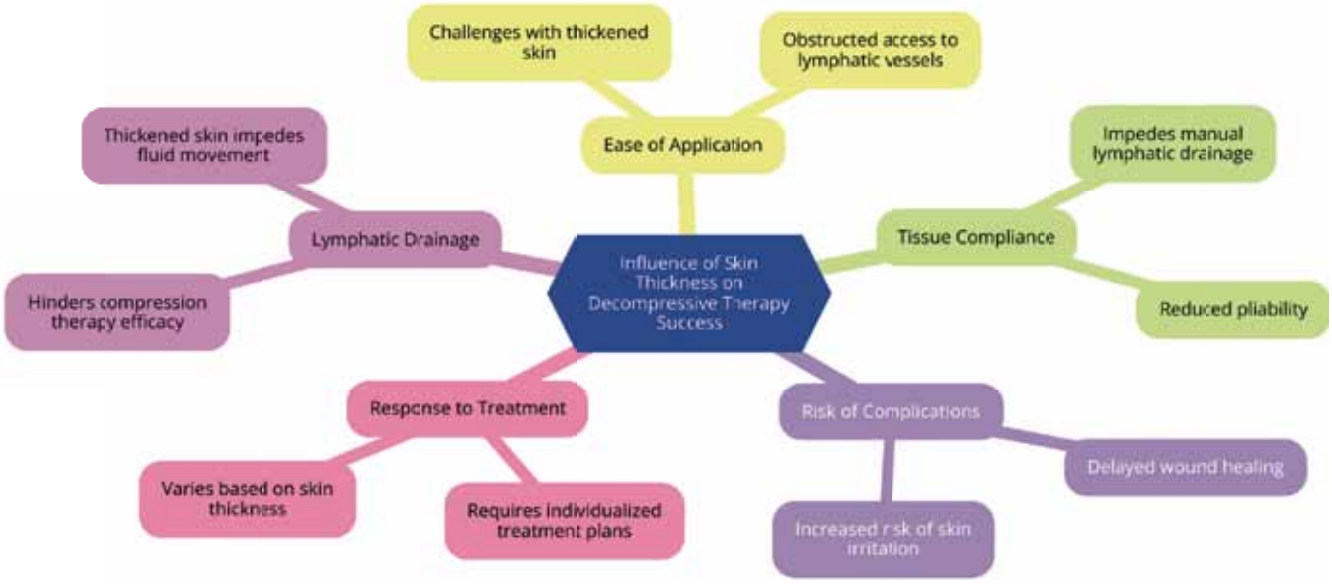
**1. Ease of Application:** The ease of application of decompressive therapy on thickened skin can significantly influence the success of lymphedema management. Thickened skin, a common manifestation of chronic lymphedema, poses challenges in applying compression bandaging, pneumatic compression devices, and other therapeutic modalities effectively. Thickened skin can obstruct access to lymphatic vessels, hindering the transmission of external pressure from compression therapy to deeper tissues. This obstruction reduces the effectiveness of compression in promoting lymphatic drainage and reducing limb swelling (53).

Thickened skin alters the distribution of compression forces applied during therapy. Instead of exerting uniform pressure on the affected limb, compression may become uneven or concentrated on superficial layers, limiting its ability to penetrate deeper tissues where lymphatic vessels reside (54). Thickened skin may restrict the mobility of underlying tissues, impeding the conformability of compression bandages or garments. Limited mobility can result in folds or creases in bandages, leading to pressure points, discomfort, and compromised efficacy of therapy (49). The difficulty in applying compression therapy on thickened skin may deter patients from adhering to treatment regimens. Cumbersome application processes, discomfort, or concerns about skin integrity may lead to non-compliance, undermining the long-term success of therapy (55).

To address these challenges, clinicians may employ strategies to enhance the ease of application and effectiveness of decompressive therapy on thickened skin. One approach is taking advanced pre-treatment measures such as skin moisturization, softening agents, or gentle massage can help improve skin pliability, facilitating the application of compression bandages or garments. Clinicians may also utilize specialized bandaging techniques or materials designed to accommodate thickened skin and promote optimal compression distribution. These may include multi-layer bandaging systems, custom-made compression garments, or alternative compression modalities such as intermittent pneumatic compression. Finally, providing patients with thorough education on proper application techniques, skin care practices, and the importance of adherence can empower them to overcome challenges associated with thickened skin and optimize treatment outcomes.

By addressing the ease of application on thickened skin, clinicians can enhance the effectiveness of decompressive therapy for lymphedema management, improve patient comfort, and promote long-term adherence to treatment regimens.

**Figure 4. Influence of skin thickness on the success of decompression therapy.**



**2. Tissue compliance:** Tissue compliance, particularly with regard to skin thickness, plays a significant role in determining the success of decompressive therapy for lymphedema. Skin thickness affects tissue pliability and elasticity, which can influence the effectiveness of therapeutic interventions such as compression therapy and manual lymphatic drainage (MLD) in reducing limb swelling and improving lymphatic function. Skin thickness influences the ability of compression garments to exert adequate pressure on the underlying tissues and lymphatic vessels. Thicker skin may require higher compression pressures to achieve optimal lymphatic drainage and fluid reduction. Inadequate compression due to skin thickness limitations may result in suboptimal treatment outcomes and reduced efficacy of compression therapy in managing lymphedema (56) Partsch et al. Skin thickness also affects the feasibility and effectiveness of manual techniques used in MLD. Thicker skin may present greater resistance to manual manipulation, making it challenging to mobilize lymph fluid and promote drainage. Additionally, excessive pressure or friction during MLD in individuals with thicker skin may lead to discomfort, skin irritation, or injury, compromising treatment adherence and efficacy (57, 58). Understanding the influence of skin thickness on tissue compliance is essential for tailoring decompressive therapy approaches to individual patient characteristics of each patient. Healthcare providers may need to adjust compression garment selection, compression bandaging techniques, or MLD protocols based on skin thickness measurements to ensure adequate tissue mobilization and lymphatic drainage. Strategies to improve tissue compliance, such as soft tissue mobilization, scar massage, or skin hydration, may also be incorporated into treatment plans to enhance treatment outcomes (59). Regular assessment of skin thickness and tissue compliance is important for monitoring treatment progress and adjusting therapeutic interventions as needed. Changes in skin thickness over time may indicate alterations in tissue pliability and lymphatic function, providing valuable insights into treatment response and guiding adjustments to therapy. Multidisciplinary collaboration among healthcare providers, including lymphedema specialists, physiotherapists, and dermatologists, may be necessary to optimize treatment approaches and address skin-related concerns in lymphedema management (60) Czerniec et al. By considering these factors and implementing tailored treatment approaches, healthcare providers can optimize treatment outcomes and improve quality of life for individuals living with lymphedema.

**3. Risk of complications:** Skin thickness is a crucial factor influencing the success of decompressive therapy for lymphedema, as it can affect treatment outcomes and the risk of complications. Variations in skin thickness may predispose individuals to certain complications during therapy, potentially impacting treatment efficacy and patient outcomes. Thickened skin in individuals with lymphedema may be more susceptible to irritation, chafing, or damage from compression garments or bandaging. Excessive pressure or friction on the skin due to inadequate fitting or prolonged wear of compression garments can lead to skin breakdown, ulceration, or dermatitis, compromising treatment adherence and effectiveness (25). Thickened skin associated with lymphedema may impair the skin's natural barrier function, making it more susceptible to bacterial or fungal infections. Compromised lymphatic drainage and impaired immune function in the affected limb further increase the risk of cellulitis, lymphangitis, or other infectious complications, requiring prompt medical intervention and potentially interrupting therapy (61). Thicker skin in individuals with lymphedema may pose challenges in wound healing, particularly in cases of skin breakdown or ulceration. Impaired tissue perfusion, reduced oxygenation, and compromised immune function in the affected limb can delay wound healing, prolonging recovery time and hindering treatment progress. Wound care strategies tailored to the unique needs of individuals with lymphedema are essential to optimize healing and prevent further complications (62). Skin thickness can influence treatment adherence and patient comfort during decompressive therapy for lymphedema. Individuals with thicker skin may experience discomfort, restriction of movement, or difficulty donning compression garments, leading to reduced compliance with treatment recommendations. Addressing skin-related concerns, optimizing garment fit, and providing supportive care can help enhance treatment adherence and improve patient comfort (63, 64). To address these issues healthcare providers should assess skin characteristics, monitor for signs of skin-related complications, and implement preventive measures to minimize risks and optimize treatment efficacy.

**4. Lymphatic drainage:** Skin thickness can significantly influence the success of decompressive therapy for lymphedema by affecting lymphatic drainage, which plays a crucial role in managing fluid accumulation and reducing limb swelling. Variations in skin thickness can impact lymphatic function and fluid dynamics, influencing treatment outcomes and the effectiveness of therapeutic interventions. Skin thickness may affect the capacity of lymphatic vessels to transport lymph fluid from the interstitial spaces back into circulation. Thicker skin may pose greater resistance to lymphatic flow, impairing the drainage of excess fluid from the affected limb and contributing to lymphedema progression. Reduced lymphatic transport capacity due to thicker skin can hinder the effectiveness of decompressive therapy in alleviating limb swelling and improving tissue health (48). Effective lymphatic drainage is essential for optimizing the benefits of compression therapy, a cornerstone of lymphedema management. Compression garments or bandaging exert external pressure on the tissues, promoting lymphatic uptake and enhancing fluid movement towards the lymphatic collectors. Thicker skin may impede the transmission of compression forces to deeper tissues, limiting the efficacy of compression therapy

in reducing limb volume and maintaining lymphatic function (65). Manual techniques such as MLD aim to stimulate lymphatic vessels and enhance lymphatic drainage, facilitating the removal of protein-rich fluid from the interstitial spaces. Thicker skin may present greater resistance to manual manipulation, making it challenging to mobilize lymph fluid and promote drainage. Adequate pressure and precise technique are essential to overcome skin resistance and achieve optimal lymphatic transport during MLD sessions (66). Advanced lymphedema therapies, such as pneumatic compression devices or low-level laser therapy, may complement decompressive therapy by promoting lymphatic drainage and reducing tissue fibrosis. These modalities target lymphatic vessels and surrounding tissues, aiming to improve lymphatic function and fluid clearance. However, the effectiveness of adjunctive therapies may be influenced by skin thickness and tissue compliance, highlighting the importance of individualized treatment approaches (67). Therefore, skin thickness can impact lymphatic drainage and fluid dynamics, influencing the success of decompressive therapy for lymphedema. Understanding the interplay between skin characteristics and lymphatic function is essential for optimizing treatment outcomes and improving quality of life for individuals living with lymphedema.

**5. Response to treatment:** The response to treatment in lymphedema management is influenced by various factors, including skin thickness, which can impact the success of decompressive therapy. Skin thickness affects tissue compliance, lymphatic drainage, and the effectiveness of therapeutic interventions, ultimately shaping treatment outcomes and patient satisfaction. Skin thickness may influence treatment adherence and patient compliance with decompressive therapy. Individuals with thicker skin may experience discomfort, restricted mobility, or difficulty donning compression garments, leading to reduced adherence to treatment recommendations. Poor treatment adherence can compromise treatment efficacy and hinder the achievement of optimal outcomes (25). Skin thickness can affect lymphatic drainage and fluid dynamics, which are essential for reducing limb swelling and improving tissue health in lymphedema. Thicker skin may impede lymphatic vessel function and hinder the removal of excess fluid from the interstitial spaces, limiting the effectiveness of decompressive therapy. Response to treatment may be influenced by the degree of tissue compliance and the ability to mobilize lymph fluid effectively (48). Response to treatment serves as a predictor for the success of decompressive therapy in lymphedema management. Patients who demonstrate favorable responses, such as reductions in limb volume, improvements in symptoms, and enhanced functional status, are more likely to achieve long-term treatment goals and maintain optimal outcomes. Monitoring treatment response allows healthcare providers to adjust therapeutic interventions and optimize treatment approaches based on individual patient needs (68). Understanding the relationship between skin thickness and treatment response is essential for tailoring decompressive therapy approaches to individual patient characteristics. Healthcare providers may need to adjust treatment protocols, compression garment selection, or manual techniques based on skin thickness measurements and treatment progress. Personalizing treatment plans according to patient-specific factors can enhance treatment efficacy and improve patient satisfaction (69). By considering skin characteristics and their impact on treatment outcomes, healthcare providers can optimize treatment approaches, improve treatment adherence, and enhance overall patient care.

However, some evidences show that skin thickness does not affect the success of decompressive therapy. Perez et al. showed that increased skin thickness due to biophysical alterations in lymphedema does not affect the success of decompressive therapy. This is inferred from the consistent increase in subcutaneous tissue thickness and echogenicity across various measurements, indicating fibrosis without differing outcomes between affected and unaffected limbs (70). In other study published by Yoshida et al., it is highlighted that skin thickness does not directly influence the success of decompressive therapy such as liposuction followed by compression therapy. Instead, the stability and level of compression applied postoperatively are critical for a successful outcome in lymphedema treatment (71). According to the review by Forte et al. successful management of lymphedema through lipoaspiration and controlled compressive therapy does not specifically depend on skin thickness. The main factor is the continuation of compressive therapy to maintain reduced limb volume and other benefits such as improved skin blood flow and decreased infection incidence (72). In another study by Lanza et al., the authors show that the success of decompressive therapy, measured by limb volume reduction and quality of life improvement, is more influenced by the frequency and method of treatment rather than skin thickness. The absence of direct correlation between skin thickness and therapeutic response underscores that other factors, such as treatment adherence and protocol, play a more significant role (73). In a study conducted by Can et al., although the study supports that while skin thickness might alter due to lymphedema, its impact on the efficacy of decompressive therapies like compression alone is less significant compared to other factors such as patient adherence and proper application of compression therapy (47). A report published by Tidhar et al. indicates that effective self-management and adherence to prescribed compression therapies can lead to significant edema volume reduction, regardless of skin thickness changes in lymphedema. The focus is on patient independence and adherence to therapy rather than physiological changes such as increased skin thickness (74).

While skin thickness can be a consideration in lymphedema management, it is just one of several factors that healthcare providers consider when planning and

implementing decompressive therapy. Individualized assessment, including evaluation of skin condition, tissue characteristics, and overall patient health, is necessary to tailor treatment approaches and optimize outcomes for each patient with lymphedema. Additionally, close monitoring and ongoing adjustments to the treatment plan may be needed to address changes in skin thickness and other factors over time.

## Conclusion

Lymphedema, a debilitating condition marked by the accumulation of lymphatic fluid and subsequent swelling, can significantly impair an individual's quality of life and functional capacity. The comprehensive management of lymphedema through decongestive therapy, which combines manual lymphatic drainage, compression therapy, skin care, and exercise, is essential for mitigating the physical and psychological burdens of the disease.

The efficacy of decongestive therapy largely hinges on several critical factors. Early diagnosis and the timely initiation of therapy play pivotal roles in preventing the progression of lymphedema to its more severe, often irreversible stages. Adherence to a meticulously tailored therapeutic regimen that includes all components of complete decongestive therapy is crucial for achieving optimal outcomes.

Moreover, recent research has illuminated the significant influence of both skin and adipose tissue characteristics on the success of decongestive therapy. Increased skin thickness and a higher volume of adipose tissue have been identified as factors that can diminish the effectiveness of traditional decongestive methods, necessitating adjustments in therapy that may include more advanced techniques such as surgical interventions or specialized compression protocols.

In conclusion, managing lymphedema effectively requires a nuanced approach that considers the individual characteristics of the lymphedema and the patient. Successful outcomes are most likely when therapy is personalized, initiated early, and diligently followed, with adaptations made as necessary to address the specific challenges posed by the physical properties of affected tissues. Continued research into the predictors of therapeutic success and the impacts of tissue characteristics will further enhance our ability to provide targeted and effective interventions for those suffering from lymphedema.*

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* The authors declare that the study was conducted in accordance with the ethical standards of the 1975 Helsinki Declaration, revised in 2000.

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