Human Kinetics
CRITICALLY APPRAISED TOPIC

The Effectiveness of Manual Lymphatic Drainage in Patients With Orthopedic Injuries

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Clinical Scenario: Managing edema after trauma or injury is a primary concern for health care profession-als, as it is theorized that delaying the removal of edema will increase secondary injury and result in a longer recovery period. The inflammatory process generates a series of events, starting with bleeding and ultimately leading to fluid accumulation in intercellular spaces and the formation of edema. Once edema is formed, the lymphatic system plays a tremendous role in removing excess interstitial fluid and returning the fluid to the circulatory system. Therefore, rehabilitation specialists ought to use therapies that enhance the uptake of edema via the lymphatic system to manage edema; however, the modalities commonly used are ice, compression, and elevation. Modalities such as these may be effective at preventing swelling but present limited evidence to suggest that the function of the lymphatic system is enhanced. Manual lymphatic drainage (MLD) is a manual therapy technique that assists the lymphatic system function by promoting variations in interstitial pressures by applying light pressure using different hand movements. *Focused Clinical Question:* Does MLD improve patient- and disease-oriented outcomes for patients with orthopedic injuries?

Keywords: manual therapy, edema removal, outcomes

Clinical Scenario

Managing edema after trauma or injury is a primary con-cern for health care professionals, as it is theorized that delaying the removal of edema will increase secondary injury and result in a longer recovery period. The inflam-matory process generates a series of events, starting with bleeding and ultimately leading to fluid accumulation in intercellular spaces and the formation of edema.[1] Once edema is formed, the lymphatic system plays a tremendous role in removing excess interstitial fluid and returning the fluid to the circulatory system.[1] Therefore, rehabilitation specialists ought to use therapies that enhance the uptake of edema via the lymphatic system to manage edema; however, the modalities commonly used are ice, compression, and elevation. Modalities such as these may be effective at preventing swelling, but evidence is limited to suggest that the function of the lymphatic system is enhanced as a result of these treatment applications.[2–4] Manual lymphatic drainage (MLD) is a manual therapy technique that involves the use of different hand movements with light pressure to promote variations in interstitial pressure.[5] The variation of interstitial pressure assists the lymphatic system func-tion and is the ultimate goal of MLD.[5]

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Focused Clinical Question

Does MLD improve patient-oriented and disease-oriented outcomes for patients with orthopedic injuries?

Summary of Search, "Best Evidence" Appraised, and Key Findings

- The literature was searched for level 2 evidence[6] or higher that investigated the effects of MLD tech-niques on patients with orthopedic injuries.

- A systematic review was published in 2009[7] that examined the evidence to support MLD techniques in sports medicine. The review included 2 level 1 stud-ies and 1 level 2 study[8–10] that compared outcomes after MLD treatments with a control treatment. The findings revealed significant decreases in edema and pain,[8] volume,[9] and aspartate aminotransferase and lactate dehydrogenase[10] in patients who received MLD treatment compared with those who received the control treatment.

- The literature search revealed 4 possible studies related to the clinical question that were not included in the systematic review published in 2009. One study[11] was excluded because it was rated as level 4 evidence, using 5 participants in a single-subject A-B design. Therefore, 3 met the inclusion criteria[12–14] and were included.

- All 3 of the studies included in this CAT reported improvements in at least 1 outcome measure after the lymphatic drainage treatments.[12-14]
- The primary outcome that was common to the 3 studies was edema, as determined by volumeter measurements or girth circumference. Secondary outcomes included pain, range of motion, activities of daily living, and perceived performance and satisfaction.

Clinical Bottom Line

There is moderate evidence to support the use of MLD techniques for improving patient- and disease-oriented outcomes, including edema, range of motion, and activities of daily living in patients with orthopedic injuries. Patients who received MLD treatment experienced significant improvements in at least 1 outcome in all 3 studies. Those who did not receive MLD also experienced significant improvements in other measured outcomes. Due of the lack of homogeneity between studies, we cannot conclude that MLD is superior over no treatment; however, it may help decrease edema and increase range of motion and activities of living.

Strength of Recommendation: Level 2 evidence[6] supports the use of MLD for improving both patient- and disease-oriented outcomes for orthopedic conditions.

Search Strategy

Terms Used to Guide Search Strategy

- Patient/Client group: patients with musculoskeletal conditions
- Intervention: manual lymphatic drainage treatment
- Comparison: control group
- Outcomes: edema, pain, range of motion, patient-oriented evidence

Sources of Evidence Searched

- MEDLINE/PubMed
- CINAHL
- PEDro database
- SPORTDiscus
- Google Scholar

Inclusion and Exclusion Criteria

Inclusion Criteria

- Studies investigating MLD techniques
- Studies including participants with orthopedic-related conditions
- Human subjects

- Level 2 evidence or higher
- Limited to English language
- Published within the last 12 years (2003–14)

Exclusion Criteria

- Studies including participants with nonorthopedic conditions (eg, cancer, lymphedema, etc)

Results of Search

Three relevant studies[8-10] were located and categorized as shown in Table 1 (Oxford Levels of Evidence 2).[6]

Best Evidence

The studies in Table 2 were identified as the best available evidence and selected for inclusion in this CAT. These studies were selected because they met the inclusion criteria.

Implications for Practice, Education, and Future Research

Preventing or reducing posttraumatic edema is a primary concern in the treatment of many orthopedic injuries. The intricate process through which edema is produced is often underappreciated, and careful consideration of the lymphatic system in removing edema is frequently overlooked.[15] Edema formation occurs subsequent to a traumatic event that initiates the inflammatory process. In response to the inflammatory process, fluid accumulates in the intercellular spaces through a series of synchronous events, the result of which is edema formation.[1] The phases include bleeding, coagulation, acute inflammatory response, regeneration, migration, proliferation, and synthesis of extracellular matrix proteins.[16]

Although bleeding, the first phase, is a natural response to trauma, it causes disruption in homeostasis and therefore must be controlled. The body's first attempt to control the bleeding is by vasoconstriction and blood-clot formation.[17] Tissue factor XII is responsible for initiating an intrinsic coagulation cascade.[17,18] An extrinsic coagulation cascade also occurs when factor

Table 1   Summary of Study Designs of Articles Retrieved

Level of evidence	Study design	Number located	Reference
2	Randomized controlled trial	3	Ebert et al[12]
			Kessler et al[13]
			Knygsand-Roenhoej and Maribo[14]

Table 2 Characteristics of Included Studies

	Ebert et al[12]	Kessler et al[13]	Knygsand-Roenhoej and Maribo[14]
Design	RCT	RCT	RCT
Participants	41 patients (50 knees) with a primary diagnosis of knee osteoarthritis and TKA. 36 men and 14 women, mean age 70 y (range 48–89). *Exclusion criteria*: body-mass index >40, active infection, malignant tumor, major cardiac pathology, or thrombus or venous obstruction. *Random allocation*: postoperative MLD treatment group (n = 24) or no-treatment group (n = 26).	22 patients with diagnosed postoperative swelling after hind-foot surgery. 12 men and 10 women, mean age 51 y (range 27–69). *Exclusion criteria*: previous operations or diseases of the circulatory system, traumatic injury leading to the operation, inability to elevate the lower extremity, and contraindications to lymph-drainage therapy. *Random allocation*: MLD therapy intervention group (n = 10) or control group (n = 12).	29 patients with diagnosed subacute edema at 4–10 wk after a unilateral distal radius fracture (n = 28 Colles, n = 1 Smith), 8 men and 21 women, mean age 64 y. *Exclusion criteria*: mental impairments, infection, disease of internal organs, and/or lymphedema. *Random allocation*: MEM group (n = 14) or traditional edema treatment control group (n = 15).
Interventions	Patients in both groups underwent a TKA, with a midline incision and medial parapatellar arthrotomy. Postoperative rehabilitation included ROM exercises, strengthening, cryotherapy, and continuous passive motion for both groups. Rehabilitation was performed twice daily for the first 3 days, then once daily until discharge. The MLD group also received 30 min of MLD treatment on postoperative days 2, 3, and 4.	Patients in both groups underwent a hind-foot surgery (n = 10 total ankle arthroplasty, n = 5 ankle arthrodesis, n = 1 ankle rearthrodesis, n = 2 calcaneus osteotomy, n = 3 double ankle and subtalar arthrodesis). Postoperative rehabilitation included preventive thrombosis instructions, ROM exercises, and gait training. The MLD therapy intervention group had an additional daily 30-min MLD treatment.	Patients in both groups underwent treatment for a unilateral postdistal radius fracture (n = 11 plaster cast, n = 9 internal fixation, n = 9 external fixation). Patients in both groups received treatment for subacute edema 3 times/wk for 4 wk, then twice a week for 2 wk. Edema treatment for both groups included elevation, compression, and functional training, in addition to therapy for ROM and strengthening. The MEM group also received 30-min modified MEM treatment sessions to the trunk region (session 1) and to the trunk and pump points in the elbow, wrist, and hand (subsequent sessions). The MEM group also wore an Isotoner glove and performed a home MEM and functional training program.
Outcome measures	Lower-limb girth using circumference measurements at the knee, ankle, thigh, and shank; active knee-flexion and -extension ROM using a handheld goniometer; knee pain using the numeric rating scale and Knee Injury and Osteoarthritis Outcome Score. Outcome measurements were taken before surgery and days 2, 3, 4, and 6 postsurgery by blinded physiotherapists.	Lower-limb volume using volumetric measurements with a water-displacement technique. Measurements were taken on the second day after surgery and on the day of hospital discharge.	Subacute edema using a volumeter, pain using a visual analog scale, active ROM using the pulpa vola distance and thumb-opposition distance, ADL using a questionnaire for bilateral activities, and perceived performance and satisfaction with ADL using the Canadian Occupational Performance Measure. Outcomes measurements were taken at baseline and 1, 3, 6, 9, and 26 wk after allocation.
Main findings	Active knee flexion was significantly greater in the MLD group on days 4 ($P = .014$) and 6 ($P = .012$) postsurgery than in the no-treatment group. No significant differences ($P > .05$) for active knee flexion, girth measurements, or pain rating.	Only the MLD group had significant reductions in limb volume on the day of hospital discharge ($P = .011$). Volumetric measurements were significantly lower in the MLD therapy intervention group on the day of hospital discharge than in the control group ($P = .032$).	After 3 wk, a significant difference was observed in ADL in the MEM group compared with the control group ($P = .03$), but not after 6 wk. The MEM group had significantly fewer edema treatment sessions ($P = .03$). At 6 and 9 wk, no significant differences in edema reduction, pain, active ROM, and ADL between the groups.
Level of evidence	2	2	2
Validity score	PEDro 7/10	PEDro 4/10	PEDro 6/10
Conclusion	MLD, in combination with conventional therapy, improves active knee flexion in the initial postsurgical stages, up to 6 wk. after TKA.	MLD, along with standard rehabilitation exercises, produces greater decreases in limb volume after hind-foot operations than exercise alone.	Decreasing subacute hand and arm edema after distal radius fracture can be achieved by using MEM or traditional edema-reduction techniques. MEM enabled quicker return to bilateral ADL and fewer treatment sessions than traditional edema treatment.

Abbreviations: TKA, total knee arthroplasty; MEM, manual edema mobilization; MLD, manual lymphatic drainage; ROM, range of motion; ADL, activities of daily living.

VII is released after cellular trauma. Both intrinsic and extrinsic cascades produce thrombin.[18] Thrombin production is an essential part of clot formation as it releases several important components such as serotonin, thromboxane A2, and ADP that accelerate the transformation of fibrinogen to fibrin.[18] Platelets begin to cluster together once they make contact with the fibrin–fibrinectin matrix, creating a clot.[17,18]

Once a clot is formed, homeostasis is regained and the inflammatory process begins.[17] The presence of specific markers such as vessel distention, an increase in vascular permeability, and the recruitment of leukocytes indicates that inflammation has ensued.[17] Vasodilation increases blood flow and quickly transports mediators such as kinins, histamine, prostaglandins, and leukotrienes to the site of injury.[17] Each mediator plays a vital role in the inflammatory process. Prostaglandins, histamine, and thrombin create an increase in vascular permeability, which permits intravascular fluid, cellular components, and protein into the extravascular space.[17,18] This excess intercellular fluid results in edema.[1]

After edema formation, the lymphatic system plays a primary role in eliminating excess fluid in the interstitial spaces and returning the fluid to the circulatory system.[1] The lymphatic system is responsible for fluid elimination and maintenance of tissue homeostasis and has recently been discovered to play a more significant role in these processes than previously postulated.[19] The function of the lymphatic system is augmented in the presence of exudate. In most instances, the lymphatic system is solely responsible for eliminating extravasated fluid and macromolecules.[20]

The lymphatic system returns fluid to the circulatory system via lymphatic vessels. The lymphatic vessels are typically located alongside vascular structures.[21] Fluid is propelled through the lymphatic system by means of 2 distinct pumps: an extrinsic pump and an intrinsic pump. The extrinsic pump relies on passive contractility such as respiratory movements and skeletal-muscle contractions. Smooth muscles in the lymphatic vessels function as an intrinsic pump.[22] The fluid is pushed through a series of channels, beginning with the lymphatic capillaries, to precollector vessels, collector vessels, lymph nodes, lymph trunks, and finally lymph ducts.[21]

The fluid that enters the initial vessels of the lymph system is known as lymph. Lymph consists of water, antigens, dying cells, lipids, macromolecules, and particulate matter.[23] Lymph enters the initial capillaries when pressure variations are present.[24] Capillaries are located in the superficial dermis and differ from blood vessels or other lymph vessels in that they are made up of flat endothelial cells.[25] The cells overlap, so junctions exist between adjacent cells. These gaps may increase considerably under certain circumstances such as increases in interstitial fluid.[26] As fluid volume increases, the interstitial space and pressure increase and the junction's gap becomes larger, allowing lymph to enter the capillary. One may speculate that a delicate vessel would collapse due to increased pressure outside the vessel. However, another

feature of the lymphatic capillaries, called anchoring filaments, causes the cells to pull apart instead of collapse. The anchoring fibers connect the outside endothelial cells to the surrounding connective tissue.[27] When pressure increases, the anchoring filaments become taut and act as a rope, opening the junctions between the cells and allowing lymph to flow inside the capillary.[28]

The lymph is then propelled from the lymphatic capillaries to the precollector vessels. These vessels have properties similar to those of capillaries but are made of epithelial cells.[26] The primary function of the precollector vessels is to propel lymph from the lymphatic capillaries to the larger collecting vessels located in the subcutaneous tissue. The precollector vessels located closer to the subcutaneous tissue possess more valves, as well as smooth muscle. These 2 characteristics are basic components of the larger collector vessels. The section between 2 neighboring valves is called a lymphangion.[29] The lymph is propelled from one lymphangion to the next through a 1-way valve. Collection of lymph in a lymphangion pushes the 1-way valve open. The lymph flows through the valve to the adjacent lymphangion and the 1-way valve closes, allowing the lymph to flow in a unidirectional pattern through the vessel.

The collector vessels located deep in subcutaneous tissue become larger in diameter but fewer in number. The lymph from the collector vessels is forced toward lymph nodes. These sites hold lymphocytes, which act as a filter for the lymph.[12] The lymphocytes produce immune bodies to fight off any infection present in the lymph.

Lymphatic trunks carry the lymph from the lymph node to the final destination in the process, the lymphatic duct. Two ducts allow dispersal of the fluid back into the circulatory system: the thoracic and right lymphatic ducts. The thoracic duct receives lymph from the lower half and upper-left quadrant of the body. Fluid leaving the thoracic duct will eventually empty into the left jugular vein. The right lymphatic duct collects lymph from the upper-right quadrant of the body. Lymph is drained into the right subclavian vein once it leaves the right lymphatic duct.[30]

Therapeutically, several techniques are used with the intention of enhancing the function of the lymphatic system. One treatment technique used to facilitate the drainage of edema via the lymphatic system is MLD. Through the use of light touch, the objective of the treatment is to open up the lymphatic vessels, allowing drainage of the excess fluid.[5] Originally developed by Vodder, the technique consists of 4 basic strokes: stationary circle, rotary, pump, and scoop.[31] Comparable variations have been developed, including the Foldi, Leduc, and Casley-Smith technqiues.[5] Treatment is initiated through proximal pretreatment by emptying the truncal regions to stimulate lymphangion activity, remove static fluid, and ultimately allow distal fluid to be transferred through the lymph vessels. Subsequent extremity-specific massage is then commenced. The proximal region is cleared first, working distally to push lymph into emptied proximal regions. Strokes are applied with very light pressure, allowing the skin to slightly stretch rather than simply

sliding over the surface. A pumping effect is achieved through 2 different stroke phases. A thrust phase is followed by a relaxation phase, allowing the vessel to accumulate fluid. Treatment patterns are methodically directed toward the proper lymph nodes.[32,33] MLD treatment for lower-leg edema after an ankle sprain, for example, would begin with pretreatment of the truncal regions in the neck. The inguinal lymph nodes in the proximal leg would be subsequently treated, followed by the upper thigh, knee, lower leg, and foot.[33]

The studies included in this CAT indicate that MLD techniques may be an effective treatment option for managing edema in patients with musculoskeletal injuries. Each study revealed significant outcome improvements after applying MLD. Two studies revealed significant improvements in disease-oriented outcome measures.[12,13] Specifically, after knee arthroscopy, Ebert et al[12] observed significant increases in knee flexion after MLD treatment compared with conventional therapy. Patients in both groups (MLD and conventional therapy) received a standardized inpatient rehabilitation protocol that was conducted 2 times a day for 3 days postoperatively and once daily from the fourth day until discharge from the hospital. The protocol began with crutch, ambulation, and transfer activities; breathing exercises; active ankle dorsiflexion and plantar flexion; and quadriceps, hamstrings, and gluteal isometric setting exercises. Specific knee exercises were conducted 3 times daily the first 3 days postoperatively, including supine and seated active-assistive knee flexion, followed by standing knee and hip exercises. A 1-hour continuous passive-motion treatment was administered 2 times a day, along with a 20-minute cryotherapy treatment 3 or 4 times per day. In addition to the aforementioned protocol, patients assigned to the MLD group received a 30-minute MDL treatment that was standardized for all patients.

Significant reductions in postoperative foot swelling, compared with exercise alone, have also been observed subsequent to MLD treatments.[13] Standard rehabilitation was implemented for all patients, including gait training and active ankle range-of-motion exercises with and without light resistance. Activities were conducted according to the patient's abilities; therefore, some patients did not receive an exercise protocol. Constant lower-extremity elevation of 10° was accomplished by raising the lower end of the bed for the patient. Patients randomly assigned to the MLD group also received a 30-minute daily treatment session after their exercise protocol, at the same time each day.

In further support of the clinical application of MLD, Knygsand-Roenhoej and Maribo[14] revealed significant improvements in patient-oriented outcome measures in patients receiving MLD for subacute hand and arm edema after distal radius fractures. All patients in this study received edema treatment until their functional needs were achieved. Patients had treatments 3 times a week for the first 5 weeks and 2 times a week during weeks 5 and 6, which was continued until discharge. In addition to edema treatments, all patients completed range-of-motion

and strengthening exercises during therapy and at home. The traditional-edema-therapy group completed elevation and compression treatments using wraps, a compression glove, and an intermittent compression system. The other group received a modified manual edema mobilization treatment, which is comparable to MLD. The modified manual edema mobilization procedure consisted of exercises, a sequence of light massage techniques, breathing exercises, a bandaging method, and, if necessary, a manual edema mobilization home program. The manual edema mobilization procedure took about 30 minutes. Patients in the manual edema mobilization group were able to return to bilateral activities of daily living sooner than individuals who received traditional edema therapy.

The findings from the 3 aforementioned studies are consistent with conclusions from a systematic review published in 2009,[7] which indicated that MLD may be effective at treating musculoskeletal injuries by decreasing pain, edema, and aspartate aminotransferase and lactate dehydrogenase in skeletal muscle. These findings reveal significant implications that may call for a paradigm shift in the treatment of posttraumatic edema. The reputed protocol of rest, ice, compression, and elevation (RICE) tends to occlude the delicate lymphatic vessels. In contrast, MLD provides a light pressure that theoretically facilitates lymph uptake and propulsion. Therefore, MLD may be a valuable procedure to expedite edema drainage because it targets the lymphatic system.

Clinicians should consider implementing MDL in their clinical practice. The 3 studies included in this CAT involved 30-minute treatment sessions. This time frame is appropriate, yet not a standard. Clinicians have the autonomy to determine the amount of time taken for appropriate individualized care. The MLD procedures used in each of the 3 studies were slightly different due to the location of affected area. The amount of pressure and pattern in which it is applied should be individualized for each patient. It is common practice for each treatment, however, to consist of light skin traction, in the sequence of clearing the proximal lymphatics, followed by moving proximal to distal to clear the pathways before working distal to proximal. Similar to each study presented in this CAT, range-of-motion exercises are commonly accompanied with the MLD technique to facilitate lymphatic pumping. The MLD technique was performed by therapists trained in MDL in 2 of the 3 studies. Specialized courses offer formal instruction in MLD, similar to other manual therapies (eg, joint mobilizations, instrument-assisted soft-tissue mobilization).

This CAT suggests that the MLD technique may be an effective method for improving both patient- and disease-oriented outcomes in patients with edema resulting from musculoskeletal injuries. However, future research is still needed to provide stronger evidence to support the use of MLD for patients with other musculoskeletal conditions that have not been investigated. Considerations for future research should also consider a favored MLD protocol to facilitate the improvement of patient outcomes.

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