Case Report

Treatment of Leg Edema and Wounds in a Patient With Severe Musculoskeletal Injuries

This case report describes the application of a technique for the treatment of leg edema and wounds resulting from a severe distal tibiofibular fracture. Following injury and numerous fracture- and wound-related surgeries in the first year postinjury, this patient developed leg edema, required daily treatment of 2 leg wounds, and was unable to wear a shoe due to foot swelling. He was referred to the physical therapy clinic 1 year postinjury for ankle rehabilitation and to diminish the leg edema. Therapy consisting of manual lymph drainage, compressive bandaging, exercise, and skin care was provided for 7 weeks. A compression stocking was issued near the end of treatment, which the patient continued to wear daily thereafter. At the time of discharge from therapy, the leg edema had decreased 74% and the wound area of both wounds had decreased 89%. Improvements continued following discharge. By 10 weeks after the start of treatment, edema had decreased 80.9%, one wound had healed, and the second wound was 93% improved. The patient was able to wear a shoe and resume recreational activities. This case report provides insight into a treatment that may shorten rehabilitation and control the cost of caring for injuries complicated by prolonged edema. [Weiss JM. Treatment of leg edema and wounds in a patient with severe musculoskeletal injuries. *Phys Ther.* 1998;78:1104–1113.]

Key Words: *Complete decongestive physiotherapy, Edema, Fracture, Manual lymph drainage, Wound healing.*

Janet M Weiss

Physical therapists often work with patients who have severe injuries and subsequent surgical intervention that create wounds that upset the patients' homeostasis, necessitating care for optimal healing. Interruption of blood supply, nutrition, and oxygenation or the presence of mechanical stress or infection can hinder connective tissue repair and delay healing.[1] Edema is a natural consequence of tissue trauma. When edema persists, however, it can also delay healing. The purposes of this case report are to review the factors responsible for edema formation and its inhibitory effect on healing and to describe a treatment for reducing edema and promoting wound healing.

"Complete decongestive physiotherapy" may play an important role in the care of injuries complicated by prolonged edema.

Wound healing is a process of restoring integrity to injured tissue following creation of a wound.[2] The initial, or inflammatory, stage of healing includes local vasodilation, increased vascular permeability, fluid leakage into the extravascular space, and blocking of lymph drainage, producing the cardinal signs of inflammation: redness, swelling, heat, and pain.[1,2] Fluid leakage is due primarily to histamine and serotonin-mediated response.[3] The blockage of lymph drainage is presumably due to fibrin plugs effectively sealing the damaged lymphatic vessels in an attempt to confine the inflammatory reaction to a localized area.[4] The inflammatory stage lasts 24 to 48 hours and is generally complete within 2 weeks. In the event of unimpeded repair, the inflammatory stage is followed by the proliferative and matrix formation/remodeling phases to complete the wound healing. Under less-optimal conditions, however, chronic inflammation may persist, which can hinder wounds from healing for many months. Chronic inflammation may occur due to unresolved acute inflammation, repeated microtrauma, persistent irritation from a foreign substance, or contamination of a wound by necrotic debris or pathogens.[1,5]

A complication that may impede wound healing is persistent tissue edema, which may occur with damage to or blockage of the lymphatic vessels.[6] The lymphatic system assists in the prevention of edema by controlling the content and volume of interstitial fluids. Macromolecules, which are filtered out of circulation but are too large for direct reentry into venous circulation, are picked up by the lymphatic vessels and returned to the vascular system. The macromolecules consist of proteins, cellular byproducts, foreign material, and immune cells including T-lymphocytes and macrophages.[6] Lymphatic transport begins as a passive transport of interstitial fluids into valveless, noncontractile initial lymphatic vessels in the upper third of the dermis. The small valveless vessels continue through the middle third of the dermis, gradually increasing in size until they are quite large and have valves at the junction of the dermis and subcutaneous tissue.[7] In the subcutaneous layer, the vessels run through connective tissue, where they actively transport lymph fluid to be filtered by regional lymph nodes. Ultimately, the lymphatic fluid is drained into 2 main lymphatic trunks for return to the venous system at

JM Weiss, PT, is Staff Physical Therapist, Cox Regional Center for Sports Medicine and Rehabilitation, 3800 S National Ave, Springfield, MO 65807 (USA).

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the venous angles of the right and left internal jugular and subclavian veins.[7]

Lymphatic function may be compromised by trauma, infection, chronic venous insufficiency, or iatrogenic causes.[6] Impaired lymph drainage can predispose the local region to infection and further delay wound healing. To explore the relationship between lymphatic disruption and wound healing, a MEDLINE search of cases of lower-extremity surgery, disease, or trauma accompanied by swelling, published from 1985 to the present, was performed using key words including "fracture," "leg," "edema," "surgery," and "treatment." The intent was 3-fold: to better understand the reason for the development and perpetuation of the edema, how the edema was managed, and whether edema control influenced wound healing.

Three studies provided some insight. Hannequin et al[8] conducted a prospective study of patients who underwent femoropopliteal bypass graft surgery and found that edema developed in the postoperative limb in 50% of the patients. The investigators attributed the edema to surgical impairment of the lymphatic system.[8] A study of lymph drainage in patients under 65 years of age with chronic venous insufficiency revealed reduced lymphatic function when compared with control subjects.[9] Some researchers[6,9] suggested that bacteria from chronic wounds damaged nearby lymphatic vessels in the cases of ulcerated limbs and that chronic venous insufficiency induced damage in the lymphatic system in individuals with varicose veins. Seyfer and Lower[10] reported complications following surgery to create free-muscle flaps and delayed bone grafting in the treatment of individuals with type IIIB open distal tibial fractures. Lymphedema was one of the long-term complications contributing to the disability that ensued following this type of injury. No cause for the lymphedema was suggested, even though below-knee swelling was noted in all 7 individuals studied. The lymphedema never fully resolved during the 24- to 49-month follow-up period.

The investigators in all of the studies cited simply reported edema as a complication, and they did not address treatment. Treatments for edema customarily have included use of a compression pump or compression stockings. Some authors[11–14] have reported successful results when these treatments were used together and with the addition of exercise, massage, and hygienic skin care.

This case report describes the management of leg edema in a patient with severe musculoskeletal injuries using a procedure called "complete decongestive physiotherapy" (CDP) (originally called "complex decongestive physiotherapy"). The concept of CDP is that central

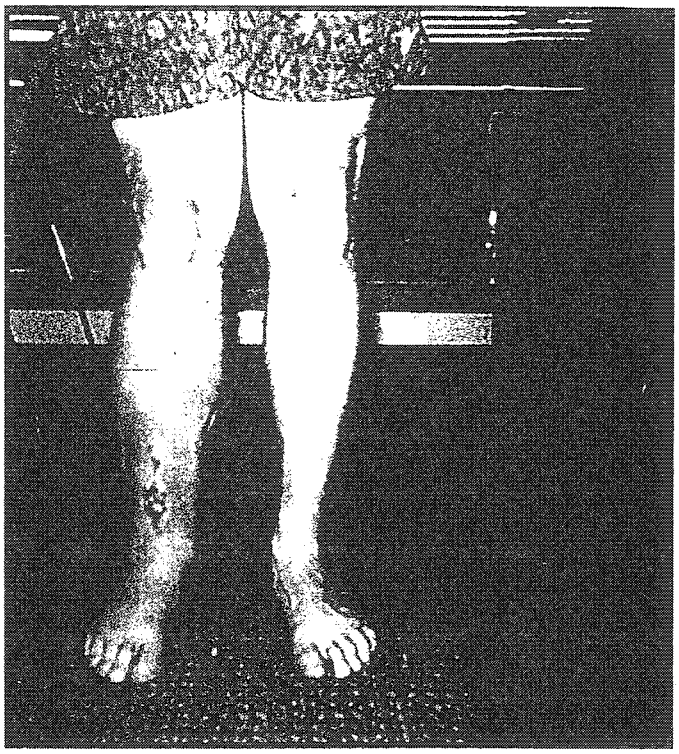

Figure 1.
Image of the right leg as initially presented for evaluation of right lower-extremity edema, 1 year after injury.

lymph drainage is maximized by opening collateral vessels so that the lymphedematous region can be drained into normally functioning lymphotomes.[15,16] The advantage of this treatment over previous efforts is that edema is reduced by stimulating lymphatic activity, not only in the affected limb but throughout the lymphatic system, for more effective drainage. Compression garments are fitted only when edema is greatly reduced, thus enhancing comfort and adherence with wear. Complete decongestive physiotherapy is reported here because it is a therapeutic measure within the realm of physical therapy and its application to musculoskeletal injuries is relatively new in the physical therapy literature.

The treatments for edema proposed by various authorities[17,18] are similar in nature, but the similarity has contributed to a confusing array of titles such as "complete decongestive physiotherapy," "complex decongestive physiotherapy," "combined decongestive physiotherapy," "combined decongestive therapy," and "complex lymphedema therapy." These names usually refer to treatment using a combination of therapies.

Complete decongestive physiotherapy consists of manual lymph drainage, compression bandaging, active exercise, and good skin hygiene. Manual lymph drainage is a form of light massaging strokes used to increase lymphatic activity and reduce edema. The technique

Table 1.
Exercises Performed in Physical Therapy Clinic 3 Times per Week for 7 Weeks

	Beginning of Treatment	End of Treatment
Strengthening exercises		
Resisted dorsiflexion, plantar flexion, inversion, and eversion with Thera-Band[a]	3 sets, 15 repetitions with green band	3 sets, 20 repetitions with blue band
Standing right-foot toe raises	3 sets, 15 repetitions	3 sets, 20 repetitions
Leg press, bilateral	90 lb, 3 sets, 20 repetitions	144 lb, 3 sets, 20 repetitions
Leg press, right leg	45 lb, 3 sets, 20 repetitions	90 lb, 3 sets, 20 repetitions
Knee extension, right	36 lb, 3 sets, 15 repetitions	54 lb, 3 sets, 15 repetitions
Wall squats	2 sets, 10 repetitions	3 sets, 15 repetitions
Forward lunges, right leg	3 sets, 10 repetitions	3 sets, 10 repetitions
Range of motion		
Supine hamstring muscle stretch with towel, side-lying quadriceps femoris muscle stretch	45 s	45 s
Therapist-assisted manual passive ankle plantar-flexor stretch	45 s, 10 min	45 s, 10 min
Proprioception/balance		
KAT 500[b] (balance board)	5 min	5 min
Single-limb stance, right leg	As able, up to 2 min	As able, up to 2 min

[a] The Hygenic Corp, 1245 Home Ave, Akron, OH 44310. Green band=moderate resistance; blue band=moderate-plus resistance.
[b] Breg Inc, 2611 Commerce Way, Vista, CA 92083.

involves deep abdominal massage to the trunk to increase lymphocinetic activity, followed by light massage to clear lymphostasis in the proximal, middle, and finally distal portions of the involved limb.[15–17] Compression bandaging provides increased tissue pressure to assist in evacuation of accumulated fluid and resistance to further ultrafiltration of excess fluid into the interstitial spaces.[15,16] Low-stretch elastic bandages are used to provide a relatively lower pressure on the limb at rest, but a higher working pressure.[17] They are thought to assist with lymph drainage better than high-stretch bandages during muscle activity due to their less yielding nature. Active exercise with the bandaged affected limb is supposed to promote further lymph drainage by means of muscle and joint pump activity on lymphatic vessels.[15–17] Good skin hygiene and use of a low-pH skin lotion are thought to be important in helping prevent infection because patients with lymphedema are at greater risk for infection.[16] Research indicates that CDP and similar treatments have provided reductions of lymphedema volume by 68% in the lower extremities.[17,18]

Case Description

Subject

The subject was a 53-year-old male attorney who was struck by a car while riding his bicycle. Injuries included grade IIIC open fractures at the junction of the middle and distal thirds of the right tibia and fibula. Review of the patient's medical record provided an account of his surgical management. He underwent wound debridement and an open reduction with internal fixation of the right tibial fracture on the day of injury and further wound debridement 2 days later. Wound infections and delayed bony union complicated his recovery, necessitating numerous other medical, surgical, and rehabilitative measures. These measures included 5 additional surgeries in the following 9 months for wound debridement secondary to infection, removal of internal fixation, application and eventual removal of an external fixator, and a partial fibular ostectomy and iliac bone grafting to the tibial nonunion site. When the fracture still failed to heal, open intramedullary nailing of the tibia was performed 9 months after the injury. Treatment also included prolonged use of antibiotics for a *Staphylococcus* infection and use of an electrical stimulation unit for promotion of bone growth.

The patient was initially referred to the physical therapy clinic 1 year after the injury for rehabilitation of his right ankle because of loss of motion and strength. He had not received any previous physical therapy. During the evaluation and early treatment sessions, the patient appeared to be highly motivated and mentioned that he was accustomed to being active. Having undergone numerous surgeries and a year of impairment due to problems with his right leg, he expressed a desire to quickly achieve his maximal potential in order to be able to return to recreational activities of hiking, biking, and canoeing. Of particular importance to him was to be able to wear a regular shoe, which was impossible because of foot swelling. He had a 2.54-cm (1-in) leg-length discrepancy, necessitating a built-up shoe on the right side. Without the shoe, he ambulated with a marked limp, causing pain in his right hip. At the

Table 2.
Circumferential Measurements (in Centimeters) of Both Lower Extremities at Initial Evaluation and Measurements of Affected Leg at Subsequent Visits[a]

	Left Leg	Beginning of Treatment of Right Leg	16 d After Start of Treatment	31 d After Start of Treatment	End of Treatment	4 wk Postdischarge	6 mo Postdischarge	Net Change
Ankle	27	30.75	29	28	27	27	27.5	−3.25
Distal leg	22	31	28	26	26.5	26	24.75	−6.25
Mid leg	24.5	35	30	29	29.5	29	27.5	−7.5
Proximal leg	35	40.5	34.5	33.5	35	35	34	−6.5
Tibial tubercle	38	38	36.5	36	36	35	35.5	−2.5
Total combined measurement	146.5	175.25	158	152.5	154	152	149.25	−26

[a] Ankle=9 cm proximal to the heel, distal leg=15 cm proximal to the heel, mid leg=20 cm proximal to the heel, proximal leg=30 cm proximal to the heel, tibial tubercle=40 cm proximal to the heel.

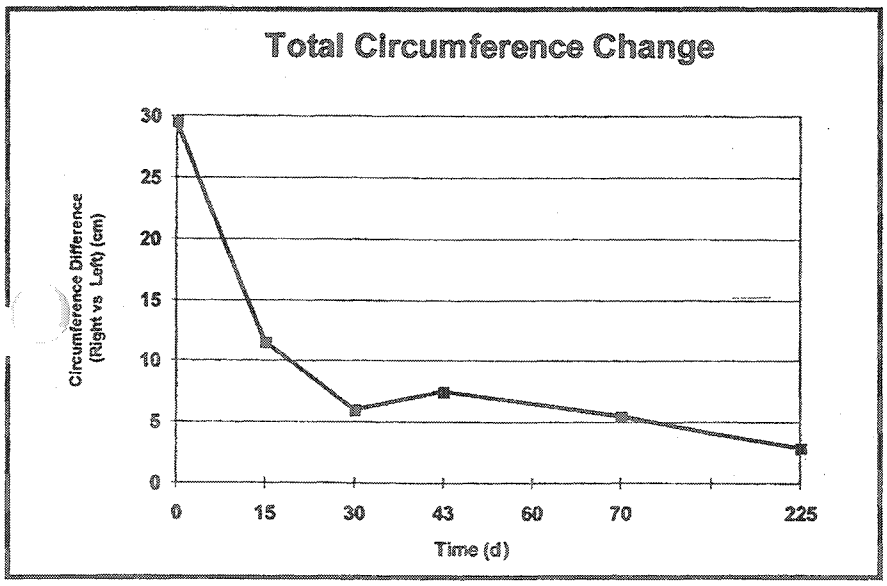

Figure 2.
Line graph illustrating the total circumference change of the right leg compared with the uninvolved leg for all 5 sites of measurement.

patient's request to receive treatment for his leg edema, the initial physical therapist referred the patient to a physical therapist certified in CDP. Certification in CDP indicates that the therapist has specialized training in the use of CDP. Certification was provided by Lerner Lymphedema Services, a nationally recognized treatment and training facility for lymphedema management.

Examination

The patient was initially evaluated by the CDP-certified physical therapist 1 year after the injury. He had moderate edema of the right lower leg and foot distal to the [illegible]. The distal half of the leg was shiny and red anteriorly (Fig. 1). The edema in that region was moderately indurated and pitting in nature. Skin mobility over the anterior compartment was poor due to underlying scar tissue adherence. Two well-healed skin grafts measuring 7 × 3 cm and 5 × 3 cm were noted along the medial aspect of the distal half of the leg, and 2 open draining wounds measuring 7 cm^2 and 13.5 cm^2 were present along the tibial crest.

Circumferential measurements of the right leg were taken during the initial visit and regularly throughout treatment. These measurements were taken with a tape measure at levels of 9, 15, 20, 30, and 40 cm proximal to the plantar aspect of the heel with the patient positioned supine. The patient had no edema proximal to the 40-cm point. All girth measurements were taken by the same physical therapist using a technique that has been shown to yield reliable measurements.[19] Circumferential drawings of the leg wounds were made by permanent marking on an overhead transparency placed over, but avoiding contact with, the wounds. High intratester reliability for physical therapists calculating wound surface area from transparency tracings has been shown in patients with venous stasis ulcers.[20]

Musculoskeletal evaluation of the leg revealed normal range of motion in the right hip and knee, 3 degrees of right ankle dorsiflexion, and 22 degrees of plantar flexion. Manual muscle test (MMT) grades were 4+/5 for hip and knee flexion and 4/5 for ankle dorsiflexion and plantar flexion.[21] All other MMT grades for the right leg were 5/5.

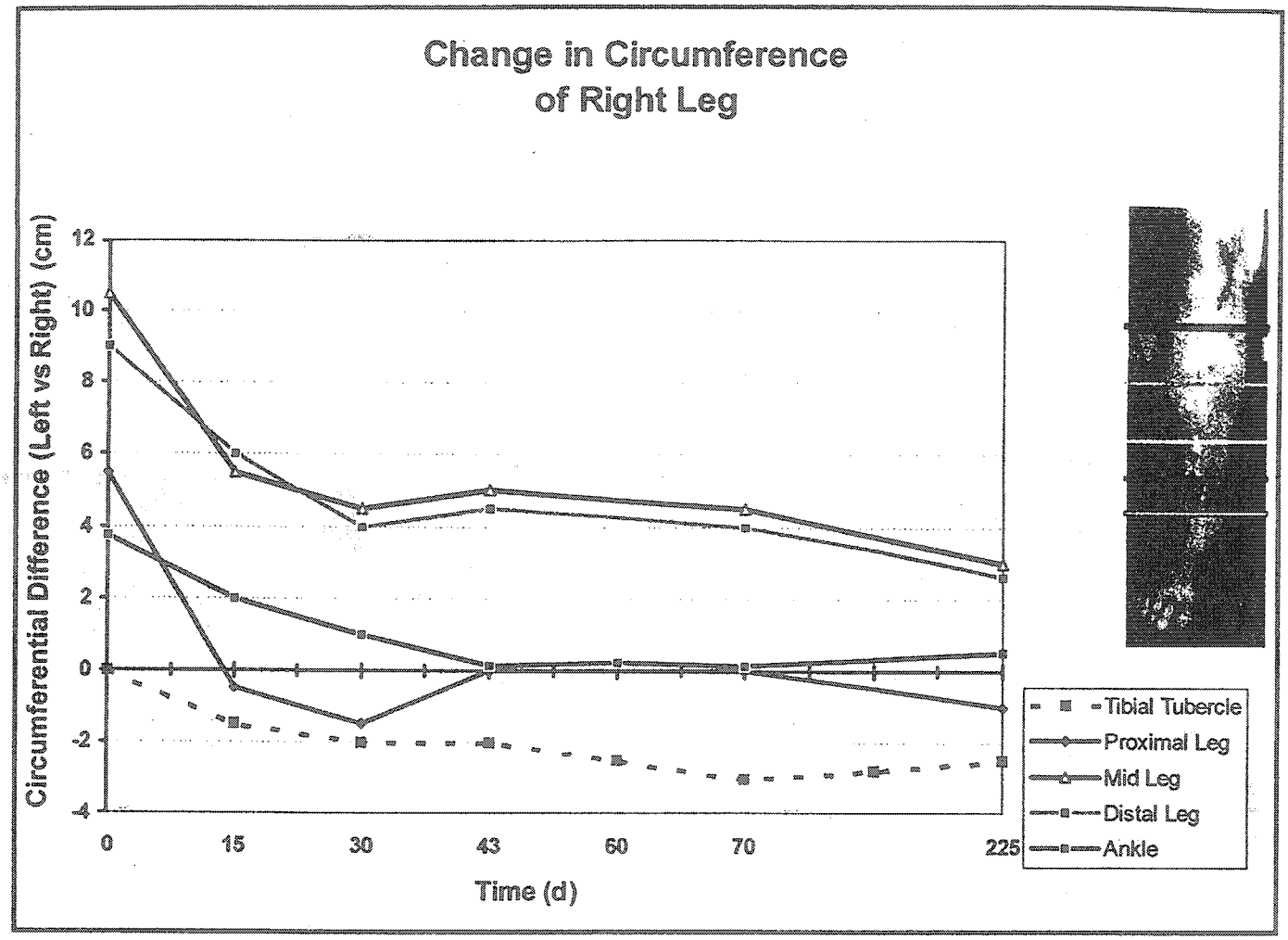

Figure 3.
Line graph illustrating the changes in circumference of the right leg compared with the uninvolved leg at each of the sites of measurement. Ankle=9 cm proximal to the heel, distal leg=15 cm proximal to the heel, mid leg=20 cm proximal to the heel, proximal leg=30 cm proximal to the heel, tibial tubercle=40 cm proximal to the heel.

Table 3.
Wound Area Measurements (in Square Centimeters) for Proximal and Distal Tibial Wounds

	Beginning of Treatment	15 d After Start of Treatment	24 d After Start of Treatment	End of Treatment	4 wk Postdischarge	6 mo Postdischarge
Proximal tibial wound	7	5.25	3.75	0.75	0.5	0
Distal tibial wound	13.5	8.75	7	1.5	0	0

Treatment

Manual lymph drainage treatments were initiated 1 year after the injury. Twenty-three treatments were administered over a 7-week period, normally 3 times per week. The lymph drainage was performed with the patient positioned supine or prone with the legs elevated 45.7 cm (18 in) on a leg-support cushion, from 45 minutes to 1 hour each treatment session. The majority of treatment time was devoted to massage of the right foot and leg in a caudal to cephalad direction, routing edema around skin-grafted or open wound areas where lymphatic vessels would be absent or damaged. To prevent skin infection, a sterile 10.2- × 10.2-cm (4- × 4-in) dressing without topical medication was applied to the wound, and low-pH skin lotion (Eucerin*) was used for the remainder of the leg. The initial 2 weeks of treatment included lymph drainage treatments without compression bandages because the therapist was awaiting shipment of supplies that were unavailable locally. The

* Beiersdorf Inc, PO Box 5529, Norwalk, CT 06856-5529.

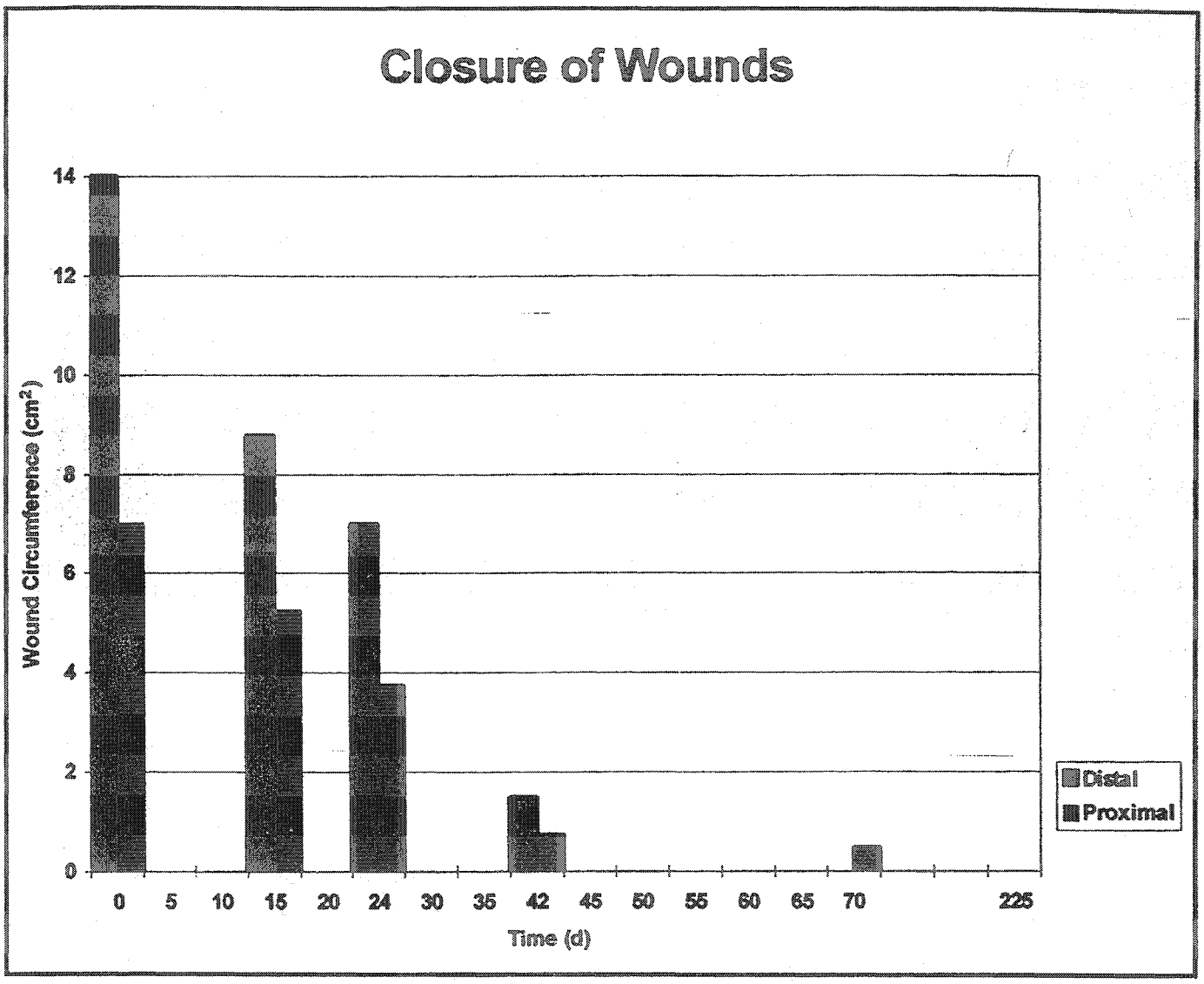

Figure 4.
Change in wound area of proximal (black bars) and distal (gray bars) leg wounds.

patient demonstrated a palpable softening of tissues, decreased edema, and diminished redness of the leg during treatment, but these improvements were not maintained between treatment sessions.

Compression bandaging of the patient's right foot, ankle, and leg was initiated during the third week of treatment and was continued until he received his compression stocking 3 weeks later. The bandaging consisted of soft Artiflex padding* overwrapped with multiple layers of low-stretch, elastic bandages (Rosidal K short stretch bandages†). A 6-cm bandage, a 8-cm bandage, and two 10-cm bandages were used to wrap the foot, ankle, and leg. The therapist formed a pressure gradient with the bandages such that the highest pressures were exerted at the ankle, with pressure gradually decreasing toward the knee. The bandages were applied following the manual lymph drainage treatments and remained on between treatment sessions, except for the patient's wound care at home. The patient had been instructed in self-bandaging, so he was able to reapply the bandages following his wound care. To further assist in lymph drainage, the patient exercised the leg in the physical therapy clinic after being bandaged. The exercises, which the patient performed 3 times a week for 7 weeks, are summarized in Table 1. The patient also was instructed on home exercises of ankle stretching and strengthening.

A Juzo below-knee, 30- to 40-mm Hg compressive stocking‡ was issued to the patient after 6 weeks of treatment when reduction of edema was noted and further weekly

† Lohmann GbgH and Co KG, Postfach 23 43, D-56513 Neuwied, Germany.

‡ Julius Zorn Inc, 80 Chart Rd, PO Box 1088, Cuyahoga Falls, OH 44223.

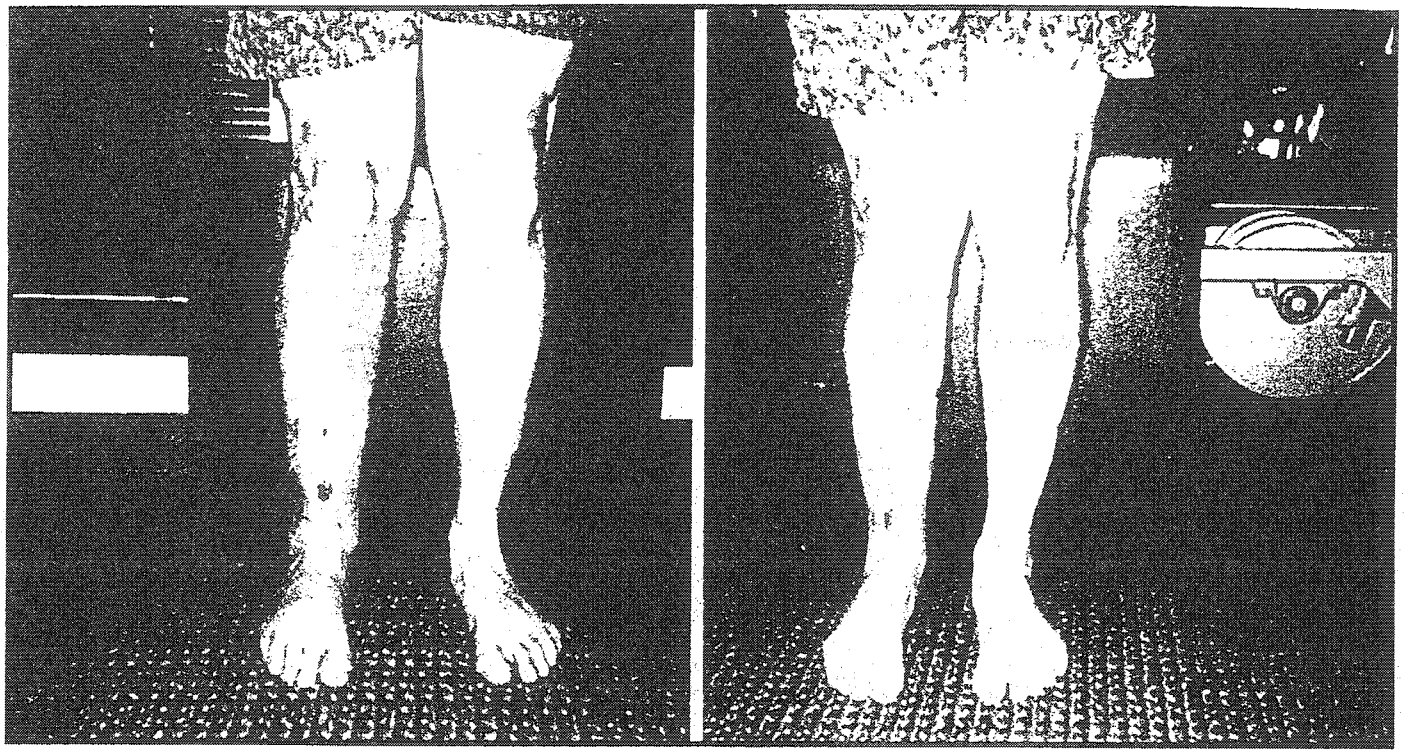

Figure 5.
Images of the right leg 26 days after the start of treatment (left) and 27 days after discharge (right).

improvements were less than 1 cm smaller than measurements obtained previously at the sites measured. He discontinued use of the bandages, and he wore the stocking daily and removed it at night. It was at this time that he began wearing a shoe.

Outcomes

Circumferential and wound healing data indicated a decrease in leg circumference (Tab. 2, Figs. 2 and 3) and wound size (Tab. 3, Fig. 4) during the initial 4 weeks of treatment. Although pain had not been a major complaint, the patient remarked frequently during this period that the discomfort associated with the swelling was being eliminated. He said he was pleased to be able to wear his shoe after receiving the compression stocking, because this enabled him to walk without hip pain at work and during recreational activities. Although the decrease in edema slowed after 4 weeks, wound healing continued to progress. At the last regular follow-up, 10 weeks after the start of treatment and 4 weeks after discharge, the distal wound had healed and only a 0.5-cm^2 proximal wound site remained open (Tab. 3). This was a 93% improvement in wound area, compared with initial measurements for the proximal wound. Surrounding skin color was almost normal (Fig. 5), and an 80.9% circumferential reduction in edema was noted, compared with initial circumference data (Tab. 2). The patient's final follow-up visit was conducted 7½ months after the start of treatment, when he needed to order new compression stockings. He had excellent tissue

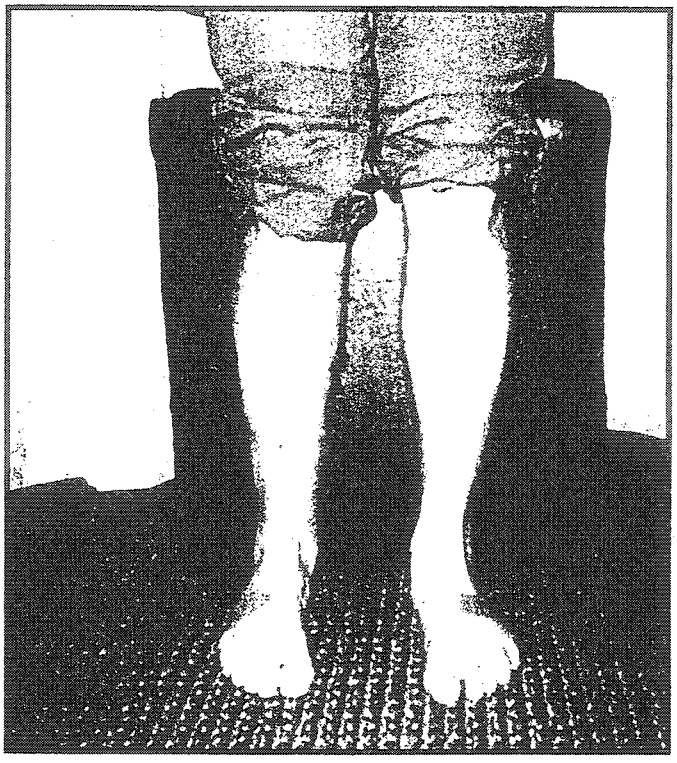

Figure 6.
Image of the right leg at final follow-up visit, 6 months after discharge.

repair, good skin color, and no evidence of pitting or indurated edema (Fig. 6). The distal 20 cm of the leg remained up to 3 cm greater than the same sites on the uninvolved leg.

At discharge, the patient's ankle range of motion had improved to 10 degrees of dorsiflexion and 24 degrees of plantar flexion. His ankle MMT grade had increased one half of a muscle grade to 4+/5, and all hip and knee MMT grades were 5/5, but these grades were within the error range for these measures. He had resumed walking in preparation for future hiking activity.

Discussion

This patient's leg edema may have been caused by the inflammatory process inherent in wound healing, and it may have been exacerbated by damage to the superficial lymphatic vessels resulting from the initial severe trauma, multiple surgeries, and persistent infection. The persistence of edema may have hindered wound healing because of stress on the wound sites and interference with good tissue nutrition and oxygenation. Complete decongestive physiotherapy was chosen for treatment because it has been shown to decrease edema[18] and wound healing might be expedited if edema were reduced.

Following the initiation of treatment, leg edema and limb circumference decreased and tissue healing progressed in direct relation to the decrease in edema (Figs. 2 and 4). The first 30 to 40 days of treatment resulted in the greatest improvements. Because massage is thought to influence lymph flow,[15,22] it is likely that the damaged lymphatic vessels were assisted in draining by the techniques used. As excessive edema was removed, the periphery of the wounds no longer had adverse tension to hinder wound closure, and the improved local tissue nutrition and oxygenation optimized an environment for healing.[1,15] Improvements in edema control and wound healing continued after discontinuing active treatment. Adherence with daily wearing of a compression stocking probably further reduced edema, and complete wound healing occurred. Similar posttreatment edema reduction was reported by Boris et al,[15] who found that initial reduction of lymphedema by 80% improved to 86% at a 12-month follow-up.

The compression bandaging compensates for the elastic insufficiency of the connective tissue and assists in preventing reaccumulation of fluid in evacuated tissues by increasing tissue pressure.[16] This was found to be true during the initial 2 weeks of treatment, when bandaging supplies were unavailable. Softening and improved color of tissues were noted with treatment, but this improvement was poorly maintained between sessions. It was not until the leg was bandaged that steady improvements were noted.

Severe musculoskeletal injuries are frequently accompanied by open wounds and soft tissue edema. These complications are challenging for the patient and health care providers because they often prolong the rehabilitation period, vastly increase health care costs, cost the patient time and lost wages, and interfere with the patient's quality of life. The patient described in this case report had edema of the leg since his initial trauma, which was exacerbated with each of his surgeries. Concomitant with the edema was delayed wound healing. For a year, he dressed the wounds, received antibiotics for a persistent infection, and was unable to wear his shoe with the lift to compensate for the right leg-length discrepancy. These factors alone contributed to excessive cost and prolongation of his care. This case provides insight into the role that CDP may play in the care of injuries that are complicated by prolonged edema.

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