

## Original Article

# Compression therapy for ulcers: The science and the art

**Shashi B. Gogia, Arun R. Gogia**

Sanwari Bai Surgical Centre, New Delhi, India

**Address for correspondence:** Dr. Shashi Bhushan Gogia, Sanwari Bai Surgical Centre, 28/31 Old Rajinder Nagar, New Delhi, India.  
E-mail: gogia7@gmail.com

### ABSTRACT

**Introduction:** Chronic ulcers are characterized by being resistant to all forms of treatment. Recent improvement in compression techniques, notably use of multilayer bandaging has created a need for a re-look into its use. **Materials and Methods:** The authors present two case reports of successful management of chronic ulcers using compression through bandaging where all other forms of treatment had failed. This is followed by a review of literature based on previous articles as well as more recent ones found through Pubmed. **Conclusion:** It is suggested that, at least in India, compression through proper multilayer bandaging, should be a choice far higher in the treatment ladder than so previously. However, if the technique is improper, it may be harmful so the option is to be exercised with care and only by those who have received adequate training. The need of a team approach, and alongside, wider introduction of more and better training facilities for therapists and nurses is underlined.

### KEY WORDS

Chronic ulcers; compression therapy; lymphoedema; multilayer bandaging

### INTRODUCTION

The range of options for management of ulcers and wounds has widened considerably of late. However, most options, notably negative pressure wound therapy (NPWT) concentrate on ulcers in the acute or intermediate phase. Obviously, better outcomes will mean fewer ulcers will end up in the chronic phase. However, once faced with a chronic ulcer, the choices beyond flap surgery seem restricted. Most patients, by this stage would have exhausted all available options. But we have come to understand that compression

therapy, though not new, has not been possible or shown appropriate outcomes in most centres in India, due possibly, to lack of proper technique. We hereby present two cases of successful outcomes in chronic ulcers following use of compression therapy. This became possible following the availability of a trained person. The rest of the article attempts to justify the need for trained personnel, for creating a workforce as well as the acceptance of a therapist in the team which manages ulcers. They can offload plastic surgeons to concentrate on doing what they do best, which is to operate.

### MATERIALS AND METHODS

Two cases of chronic recalcitrant ulcers with history of over 12-year duration are discussed. Both were seen at the lymphoedema clinic run by the authors, one of whom is a surgeon. The other, although a non-medico, became a therapist following continuous exposure to patients and later undergoing certificate courses in India

#### Access this article online

Quick Response Code:



Website:

[www.ijps.org](http://www.ijps.org)

DOI:

10.4103/0970-0358.101296

and the U.S. The lymphoedema team also includes nurses and specially trained assistants who take measurements and photographs, operate the compression pumps as well as do the bandaging. Although admission facilities exist, most of the care is on an ambulatory basis, lasting upto 2 hours a day. At the end of the treatment course, counseling for home care is given and stockings and customized pressure garments are provided. For the purpose of this review article, a search for the literature was done through books, previously referred articles, along with a Medline as well as Pubmed search

## CASE I

SA, a 27 years old morbidly obese male with weight above 180 Kg had been showing at our clinic with recurrent lymphangitis since 1997. In 2000, during an attack of cellulitis of the leg, he developed a large gangrenous patch on the posterior and dependent side of the right calf. Following debridement, he persisted with a nonhealing ulcer which reached a size of 13 × 9 cms [Figure 1]. He later developed two secondary ulcers, one near the ankle which was 4 × 3 cm and one anteriorly which was 6 × 4 cm. These ulcers did not heal with antibiotics and various other forms of ancillary therapy. He did purchase a compression pump in 2001 which helped the associated oedema but the ulcer kept waxing and waning and never completely disappeared. Skin grafting was tried four times. [Figure 2]. In between he required three visits to the ICU for septicemia, with adult respiratory distress syndrome (ARDS). He was put on a Bi PAP machine following the first attack. Surgery for morbid obesity was not an option as the risks were stated to be too high. The presence of the ulcers was declared to be adding to the risk.

In early 2010, he was started on multilayer lymphoedema bandaging (MLLB) [Box 1] – this was done a few times at the clinic where the process was taught so that after learning and purchasing a set of bandages and related consumables he could continue the same at home. Benzathine penicillin injections (Pencom 12<sup>®</sup>) were continued every 3 weeks as before. When he came back to us around 3 months later, all the ulcers had miraculously healed [Figure 3]. During his last follow-up a year later, he was still ulcer free and continued using a compression pump as well as penicillin. Thus, in summary, MLLB resulted in healing of more than one large recalcitrant ulcer (s) in a morbidly obese individual.

### Box 1: Our technique of compression bandaging (MLLB)

#### Effects

It increases the effectiveness of the muscle pump mechanism It increases the overall tension in the affected extremity and therefore reducing ultrafiltration It supports the skin while it is reducing in size

#### Materials

The lymphoedema compression bandage is a multilayered low-compression bandage. The compression is achieved by the thickness of the bandage, not by the tightness. The bandage will easily consist of 8-10 layers, especially more toward the periphery. The layers may consist of different materials, each with their own distinct function. They can be distinguished in three basic layers. These are the absorption, equalization and the compression layers.

#### Absorption layer

The absorption layer is in direct contact with the skin. Its main function is to absorb perspiration and to be a barrier between the skin and the layers of the bandage and thus minimizing irritation and increasing the comfort. Materials of the absorption layer are preferably cotton-based and washable. Frequently used materials include Stockinette, tubular or flat bandages without significant compression or Tubigrip tubular bandages with some compression. The advantage of tubular bandages is the ease of donning/doffing, but the fit may not always be optimal. The advantage of flat, single layer material is the more custom fit, but it requires about two layers for optimal coverage and it is slightly more complex to apply, especially with self-bandaging. Most of this material is washable and reusable.

#### Equalization layer

Placed over the absorption layer, it consists of materials that aide in pressure distribution. Needed to equalize, focus or relieve pressure at certain areas within the bandage. This material can be foam, cast padding or a combination of both.

#### Compression layer

This layer is giving the actual compression on the extremity. It consists of several layers of short-stretch bandage material. Short-stretch bandages have only about 20% stretch, as against upto 100% with a long-stretch bandage. Higher pressures are generated by short-stretch bandages which mean better hold,<sup>[36]</sup> better effect,<sup>[37]</sup> as well as concordance<sup>[38]</sup> Tape - To secure the bandage in place, tape is recommended as against the elastic clips often supplied with the bandages. Since clips have sharp points, these may cause injury. Taping is used for fixation in all the layers. With normal use, one strip of paper tape for each layer and 4-5 strips for the final layer will be sufficient. If no paper tape is available, masking tape can be used. Avoid using silk tape, since the heat of the bandage will soften the glue and make for a very sticky bandage during later reuse.

## CASE II

MJ, a 45-year-old male, a resident of Lucknow had suffered fractures of the right leg 12 years back following a road traffic accident. He had been given a plaster cast initially along with external fixators. After the cast was removed, he was found to have multiple ulcers in the leg. Since then, the ulcers have persisted with occasional attacks of cellulitis. Various treatment methods including four surgeries (split skin grafting) did not result in long-lasting wound closure. He was referred to our clinic and seen first time on 17<sup>th</sup> May 2012. After cleaning the leg, and a single shot of benzathine penicillin, he was given compression therapy using a



Figure 1: Case 1 - Ulcer in the year 2001



Figure 2: Case 1 the ulcer was its smallest size a few weeks after SSG in 2006. However, the size increased again and he also developed secondary ulcers in two more places



Figure 3: Same patient seen 3 months after initiating multilayer bandaging

multichambered pump. This was followed by multilayer bandaging after local application of commercially available micronized Silver in the form of cream as well as dressing. Foam packing ensured uniformity of the pressure across the pressure points like the malleoli. The bandaging process is shown in Figure 4.

The dressing was opened every 3 -4 days and then reapplied after washing and following the same protocol as above. After the fourth session, he wanted to go back with a promise of applying the bandage and dressing himself and regular follow-up. When he came back on 7<sup>th</sup> of June 2012, all the original ulcers had healed completely. However, there was a small fresh superficial ulcer higher up at the shin, which he attributed to a small injury caused by a local graze. It was also noticed that his self application had the problem of using knots to tie the bandages which caused pressure points. We suspect



Figure 4: Case 2 - Multilayer bandaging in progress, This was done by the patient himself to enable photographs after the ulcers had largely healed

an imperfect self-bandaging technique to be the possible cause for the abrasion in the shin.

A final course of pumping, followed by bandaging was done [Figure 4]. Only a very light dressing was required. His leg circumference measured at various points showed that the concomitant oedema also improved alongside [Table 1]. A repeat follow-up visit after another month showed continued healing with only a mild scar breakdown at one place [Figures 5 and 6]. In summary,



**Figure 5:** Case 2 Leg views datewise at various stages of healing. Bandaging was initiated on 17/05/2012. When he came for follow-up after 10 days of home care (3 weeks from day 1), a small superficial ulcer (photo no 5) was found on the shin which was attributed to a minor injury by the patient. However, one contribution could be using knots instead of tapes during self bandaging. Healing has been accompanied by a fall in the leg circumference.

his ulcers healed completely in less than 3 weeks with the use of compression therapy and multilayer bandaging. Figure 5 shows the leg date wise at various stages of healing. Table 1 shows how healing was parallel to decrease in limb oedema

**DISCUSSION**

Both the cases had chronic leg ulcers, but not due to the commonest cause correlated with leg ulcers viz venous disease which has been stated to be upto 70%<sup>[1]</sup> of the causes of leg ulcers. However, in developing countries, additional factors like malnutrition and problems of access to proper medical care make the scenario more complicated.<sup>[2]</sup> While compression bandaging for venous ulcers is textbook knowledge,<sup>[3]</sup> its use for other reasons, especially post traumatic ulcers alone is not so popular, especially with the proliferation of many newer therapies like NPWT<sup>[4]</sup>, hyperbaric oxygen,<sup>[5,6]</sup> etc.

**BACKGROUND AND HISTORY**

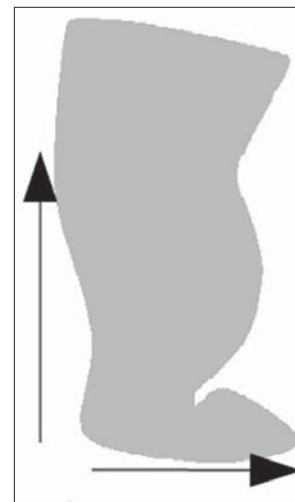
In 1948, Joseph Conrad E, who happened to be a patient with venous oedema noticed that swimming resulted in improvement of his oedema.<sup>[7]</sup> This he correlated with



**Figure 6:** Case 2 At follow-up visit at 7 weeks

**Table 1:** Case II- circumference of the foot and leg at various levels. The slight increase in circumference on the last visit, while done in the evening, do indicate the need for better maintenance at home Figure 8 shows the method of measurement

| Level in the lower limb | Limb circumference on Zero day | limb circumference on 21 <sup>st</sup> day follow-up | limb circumference on 57 <sup>th</sup> day follow-up |
|-------------------------|--------------------------------|--|--|
| -15 cm                  | 28                             | 27   | 27   |
| -10 cm                  | 31                             | 29   | 29   |
| 0 (across heel)         | 43                             | 38   | 39   |
| 10 cm                   | 34                             | 27   | 28   |
| 15 cm                   | 32                             | 27   | 28   |
| 20 cm                   | 33                             | 30   | 31   |
| 25 cm                   | 37                             | 33   | 35   |
| 30 cm                   | 40                             | 37   | 37.5   |
| 35 cm                   | 41                             | 39   | 40   |
| 40 cm                   | 41                             | 39.5   | 40   |
| 45 cm                   | 41                             | 38   | 39   |
| 50 cm                   | 45                             | 42   |  |



**Explanation to measurements as shown in Table 1, 0 is heel point. Negative points are distal to the heel and positive points go upward similarly.**

uniform pressure application in the entire limb rather than bundling of pressure and creation of a ring effect which had made conventional Ace stockings in use till then less popular.<sup>[8]</sup> Thus, the concept of a customized stocking was borne i.e., which would cater to the natural folds and curves of the limb. Later a pneumatic pump was invented by him which would could apply higher pressures than could be possible with a stocking. A system of timers allowed the circulation to be restored intermittently and the term IPC – short for Intermittent Pneumatic Compression- entered the medical lexicon. This method of treatment was popular in the U.S. for its effects on venous and lymphatic oedemas.<sup>[7,8]</sup> However, even before this, in the 1930s manual lymph drainage (MLD) came into prevalence in Europe.<sup>[9]</sup> Incidentally Emil Vodder, to whom the concept of MLD is attributed could not complete his medical graduation due to a temporary illness. This loss to medicine resulted in the gain of a new field which came to be known as lymphoedema therapy and later generalized to therapy. Compression was added to the therapy protocols with a dramatic improvement in the results and the term CPT (Combined Decongestive Therapy - in variance the C may stand for, Complex, Complete or Comprehensive) was born. While therapists have been focusing on oedema reductions, most researchers agree that the main component of CPT that helps oedema reduction is bandaging.<sup>[10]</sup>

At around the same time the Unna's boot came into being as a treatment for venous ulcers.<sup>[11,12]</sup> This was a special gauze impregnated with zinc oxide as well as calamine. However, most agree the beneficial effects are, again, related to compression.

CDT is a set of four therapeutic measures consisting of two phases of management:<sup>[13]</sup>

Phase 1 is used for initiation of therapy and is called intensive therapy. This is best done in a hospital setting, although there do exist stand alone facilities for such care e.g., Foldi Clinic in Germany.<sup>[14]</sup> The components of phase I are 1) MLD, 2) MLLB, 3) skin care and 4) remedial exercises

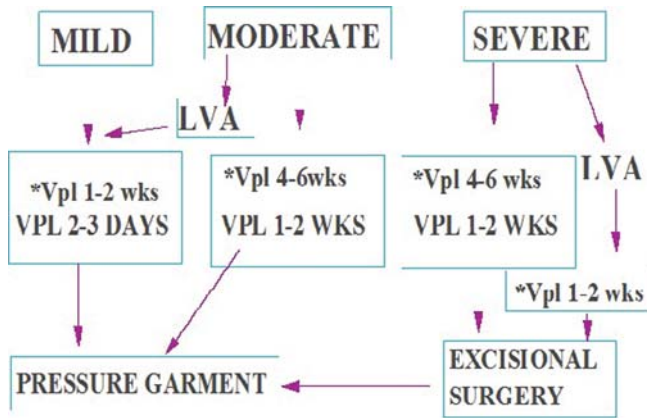
Phase 2 is for maintenance of reduction and is done at home. It consists of compression garments, skin care, regular exercise with the addition of MLD, simple lymph drainage (SLD) and nocturnal bandaging as appropriate.

## PHYSIOLOGICAL BASIS FOR COMPRESSION THERAPY

Ulcers and oedema have a complex relationship, even if both may have a common cause e.g., in venous disorders. It is believed that oedema decreases the available tissue oxygen and nutrients.<sup>[13,15]</sup> This is related to a decreased difference of osmotic pressure and also the nutrients need to travel a greater average distance from the capillary wall. For ulcers, a wider circumference of the limb means an increase in the distance between the epithelial ends, thus adding to the ulcer size. Also, an open ulcer invites infection and inflammation leading to further oedema. Similarly, an increase in scarring and fibrosis impede venous and lymphatic return. The role of ulcer in causing venous oedema is well described.<sup>[15]</sup> Several studies have shown an impressive reduction in swelling as a result of compression.<sup>[16-18]</sup> The following mechanisms may explain how compression reduces volume in a lymphoedematous limb:<sup>[19]</sup>

- Reduction in capillary filtration
- Shift of fluid into noncompressed parts of the body
- Increase in lymphatic reabsorption and stimulation of lymphatic transport
- Improvement in the venous pump in patients with venolymphatic dysfunction
- Breakdown of fibrosclerotic tissue

Compression not only decreases oedema, but also assists the microcirculation. While its beneficial effect in lymphoedema patients is well described, results have also been described in venous diseases, notably those who have accompanying oedema.<sup>[16,20]</sup> The main technical factor to consider, is to ensure, that circulation is not impeded.<sup>[15,21]</sup> The lymphatic system is part of the body's immune-surveillance system and plays a vital role in the healing process.<sup>[15]</sup> It is to be expected that improvement in lymphatic circulation will decrease infection. It is believed that persistent Gram-positive infections notably, *Streptococci* and *Staphylococci* have a significant role to play in of the pathophysiology of lymphoedema.<sup>[10,15]</sup> To control infection, besides long-term penicillin, ancillary preventive aspects of infection control like leg washing, treatment for dryness, taking care of fungal infections are important. Oedema reduction helps prevent infection too by shoring up the lymphatic circulation as well as removing a static body fluid which could be a potent culture medium. Better lymphatic circulation also implies access to the body's natural infection control mechanism i.e., the lymph nodes.



**Figure 7:** Protocol followed before introduction of MLLB<sup>®</sup>. Legends: Vpl – Compression therapy on an ambulatory basis VPL - Compression therapy on 24/7 basis after admission LVA -Lympho-nodo venous shunt surgery In between compression sessions, we would be using SLB. Introduction of MLLB has made the protocol similar to VPL, but on an ambulatory basis.

## OUR EXPERIENCE

Compression therapy was initiated by us for lymphoedema patients.<sup>[22]</sup> Till 2008, it was largely dependent on Pumps and Pressure garments. We were using single layer bandaging (SLB) with occasionally another layer as a stop gap adjunct to pump therapy, i.e till further decrease in swelling by pumping stopped. Once the maximum reduction was achieved, the limb was considered ready for a properly fitting stocking. [Figure 7] As described above for CDT, by this time the patient could be considered to be in the maintenance phase. Despite overall fair results,<sup>[22,23]</sup> our patients showed less preference for our SLB protocol, viz a viz pressure garments, although many were not happy with the pressure garments too, opting for use of pumps alone. While use of garments were limited by cost, inappropriate sizing and inability to hold it in place once it went above the knee, bandaging was difficult to maintain and, if left to the patient to tie on his/her own, uncomfortable. Even though training was imparted, there would inevitably be folding, slippage and an occasional ring effect resulting in pain. These problems were more around the knee. To circumvent this, we almost stopped prescribing above knee garments and suggested bandaging as a combination, if required. MLLB usage was introduced in late 2009, but more as a component of CDT. Alongside better patient satisfaction and compliance to a wider range of treatment protocols being offered, there has been concomitant improvement in ulcer healing rates. Out of the 109 patients managed with our new protocol, we have treated 9 patients in which the presence of an ulcer has been recorded. All the ulcers have healed but only the two patients currently

being described, had chronic ulcers, and due to the long history of undergoing various therapies previously, have been felt to be worth reporting. There were some more patients who had pinhole sinuses from which lymph would ooze out. Such oozing also stopped with the initial treatment course. Occasional recurrences have occurred but managed easily with repeat courses.

The main shift in our treatment protocol has been in introduction to MLLB alongside use of gradient pumps. Although we did have fair results<sup>[8,22,23]</sup> earlier, these have improved further. Intolerance of the garment was reported from areas of high humidity previously but it has decreased with proper multilayer bandaging and also use of better quality stockings Case I was being managed by us throughout his clinical course – even the initial ulcer occurrence took place during a lymphangitis attack while under our care. Hence, we are very certain that a change to multilayer compression bandaging brought about the cure.

For case II, however, such a conclusion i.e., bandaging was the only factor resulting in a cure is difficult to draw. While the patient had been under treatment for 12 long years including that from a plastic surgeon, the exact protocols followed are not fully known. Since we gave him penicillin, administered micronized silver locally and also gave him machine-based compression in addition to bandaging, any of these may have been the key factor which resulted in a cure. Nevertheless, since he had not received multilayer bandaging before and also based on the discussions in the rest of this article, we are inclined to attribute bandaging to be the key reason. We plan to continue penicillin and compression through bandaging or stocking for a long time.

## COMPARISON OF VARIOUS FORMS OF COMPRESSION

O'Meara *et al.*<sup>[24]</sup> did a Cochrane Review of 47 trials of various kinds of compression therapy for ulcers and found, in general, that there were no clear differences between treatment groups. Smaller subsets, however, showed a) Venous ulcers heal more rapidly with compression than without (based on 7 trials). b) Single-component compression was less effective than multicomponent compression (6 trials). c) Among multilayer bandaging trials, outcomes were better when an elastic component was included. (8 trials total - 2 used two layers, 3 used three layers and another 3 used four layers). d) Four-layer

bandage comparison with paste bandage was uncertain (5 trials). e) Cost-effectiveness analysis was rigorous enough for reporting in only one which suggested that four-layer bandage was more cost-effective than multicomponent compression comprising a short-stretch bandage.<sup>[25]</sup> Many trials reported adverse events and leading to withdrawals. One trial indicated that there was less pain with use of stockings as apposed to bandaging. Adding a compression stocking on to the bandage layer improved results further.<sup>[20]</sup> For venous leg ulcers, at least, it has been found that a) compression is better than no compression, and b) multilayered high compression is more effective than single-layer compression.<sup>[26]</sup> High-pressure hosiery helped in preventing ulcer recurrence.<sup>[27]</sup>

Indian reports do mention the role of compression in venous ulcers.<sup>[28]</sup> However, the method of compression is largely through compression garments.<sup>[29]</sup> It is largely agreed that both bandaging as well as pumps, are agents of compression with a difference in degree.<sup>[13]</sup> Even while bandaging is an essential component of compression, the role of pumps in improving healing of venous ulcers in the absence of oedema has been deemed as controversial although studies do show it adds to the effectiveness of bandage-based compression.<sup>[30]</sup> Where bandaging scores over pumps is that it becomes effective even in a mobile patient. However, there is much user variation, and technique does matter. It may even be harmful in the absence of adequate skill.<sup>[17,21]</sup> For pumps, on the other hand, the patient has to be immobilized during the treatment session. Also, its effect may be short lasting. Overall, it is our belief that, especially for patients with higher grades of oedema as well as fibrosis, pumps can be of immense help in initiating treatment, even more so than MLD.

Proponents of MLD find pump usage for lymphoedema itself to be controversial. Foldi and Clodius,<sup>[21,31]</sup> among others, have been vehemently against the use of pumps. On the other hand, benefits have been found even in single chambered systems.<sup>[7,23]</sup> Our view is that, as in bandaging, wherein there are many variations leading to varied results,<sup>[15,24]</sup> there are many variations of pumps too. Definitely, there are pumps which can cause harm. More than this would be beyond the scope of the current article.

Most of the proponents of pumps agree that gradient compression using multiple chambers is more beneficial as compared to a single chambered pump.<sup>[13]</sup> Furthermore, they also discuss the need for care for the abdominal

component of the lymphatic flow. As a consequence, some pumps catering to such a demand have appeared in the market.

## THE BANDAGING TEAM

The role of a team in providing ulcer care has been emphasized.<sup>[15,32]</sup> Dressings are low-brow components of clinical care, often relegated to the nurse, compounder or dresser. As discussed above, bandage therapy started separately, not for ulcers, but rather for the management of oedema. Even with the Unna boot,<sup>[10,11]</sup> that compression was the main contributor to ulcer healing was understood much later. So a merger of these components of ulcer care requires the creation of a trained team, which need to be working under the surgeon incharge. MLLB is a very specific technique which has to be learned. This was supposed to be the domain of the Therapist – although most articles on this, from the NHS, UK at least, appear in Nursing Journals.<sup>[17,33,34]</sup> In India, however, and especially in the outpatient setting, the use of teams to treat simple problems is lacking. Also the term, ‘Therapist’, at least for oedema care is virtually unknown in India

Probably, specialized clinics catering to minor limb problems are the way out. While such clinics<sup>[14]</sup> exist in the developed world, such a project titled “*Legs To Stand On*” has been initiated<sup>[35]</sup> with WHO support.<sup>[2]</sup> A similar effort, in India, is being planned by us.

## CONCLUSIONS

Compression, especially via multilayer bandaging is effective in managing even recalcitrant and chronic ulcers. However, more has to be invested in orientation and training of healthcare personnel before it can become routine and first line.

## ACKNOWLEDGMENTS

The authors wish to thank Dr. Ankur Bhatnagar, Prof of Plastic Surgery at SGPGI, Lucknow, for referring case no II to us and sharing all his previous clinical details to enable us to present the case.

## REFERENCES

1. Briggs M, Closs SJ. The prevalence of leg ulceration: A review of the literature. *Eur Wound Management Assoc J* 2003;3:14-20.
2. Ryan TM. Wound healing in the developing world. In: Macdonald JM, Geyer MJ, editors. *Wound and Lymphoedema Management*. World Health Organization; 2010. p. 3-7.
3. Bailey and Love's Short Practice of Surgery. 25<sup>th</sup> ed. In:

- Williams NH, Bulstrode CJ, O'Connell P, editors. Publisher Hodder Arnold; 2008. p. 935.
4. Blume PA, Walters J, Payne W, Ayala J, Lantis J. Comparison of negative pressure wound therapy using vacuum-assisted closure with advanced moist wound therapy in the treatment of diabetic foot ulcers: A multicenter randomized controlled trial. *Diabetes Care* 2008;31:631-6.
  5. O'Meara S, Cullum N, Majid M, Sheldon T. Systematic reviews of wound care management: (3) antimicrobial agents for chronic wounds; (4) diabetic foot ulceration. *Health Technol Assess* 2000;4:1-237.
  6. Shaw J, Hughes CM, Lagan KM, Bell PM. The clinical effect of topical phenytoin on wound healing: A systematic review. *Br J Dermatol* 2007;157:997-1004.
  7. Brush BE, Wylie JH, Beninson J. Some devices for lymphoedema of the extremities. *Surg Clin North Am* 1959;39:1493-8.
  8. Gogia SB. VPL therapy for filarial lymphoedema in India. New Delhi, India: Interprint; 1996. Available from: <http://openmed.nic.in/1809/>.
  9. Manual Lymph Drainage History (MLD®) [Internet]. Available from: <http://www.isisboston.com/assets/PDF-Files/Vodder-History-of-MLD.pdf>.
  10. Bihari I, Meleg M. Conservative management of lymphedema of the limbs. *Orv Hetil* 1991;132:1705-8. [Article in Hungarian].
  11. Polignano R, Bonadeo P, Gasbarro S, Allegra C. A randomised controlled study of four-layer compression versus Unna's Boot for venous ulcers. *J Wound Care* 2004;13:21-4.
  12. Barr DM. The Unna's boot as a treatment for venous ulcers. *Nurse Pract* 1996;21:55-6, 61-4, 71-2 passim; quiz 76-7.
  13. NLN Medical Advisory Committee. Position statement of the National Lymphedema Network 6. 2011.
  14. History of Foldi Clinic. Available from: <http://www.foeldiklinik.de/englisch/historie.php>.
  15. Macdonald JM. Lymphedema and the chronic wound: The role of compression and other factors. In: Macdonald JM, Geyer MJ, editors. *Wound and Lymphoedema Management*. Geneva: World Health Organization; 2010. p. 73.
  16. O'Meara S, Tierney J, Cullum N, Bland JM, Franks PJ, Mole T, *et al*. Four layer bandage compared with short stretch bandage for venous leg ulcers: Systematic review and meta-analysis of randomised controlled trials with data from individual patients. *BMJ* 2009;338:b1344.
  17. Harrison MB, Vandenberg EG, Hopman WM, Graham ID, Carley ME, Nelson EA. The Canadian bandaging trial: Evidence-informed leg ulcer care and the effectiveness of two compression technologies. *BMC Nurs* 2011;10:20.
  18. O'Brien J, Grace P, Perry I, Hannigan A, Clarke Moloney M, Burke PE. Randomized clinical trial and economic analysis of four-layer compression bandaging for venous ulcers. *Br J Surg* 2003;90:794-8.
  19. Parstch M. Understanding the pathophysiological effects of compression. In: *Understanding Compression Therapy: EWMA Position Document*. Medical Education Partnership Ltd; 2003. p. 2-5.
  20. Milic DJ, Zivic SS, Bogdanovic DC, Perisic ZD, Milosevic ZD, Jankovic RJ, *et al*. A randomized trial of the tubulcus multilayer bandaging system in the treatment of extensive venous ulcers. *J Vasc Surg* 2007;46:750-5.
  21. Foldi E, Junger H, MP. The science of Lymphoedema Bandaging. In: *Lymphoedema Bandaging in Practice*. London: Medical Education Partnership Ltd; 2003. p. 3.
  22. Gogia SB. Evaluation of intermittent pneumatic external compression in filarial lymphoedema of the extremities. (Thesis) All India Institute of Medical Sciences; 1981.
  23. Gogia SB, Appavoo NC, Jeykumar S, Burney K. Comparative results of non-operative multi-modal therapy for filarial lymphoedema. *Indian J Plast Surg* 2009;42:22-30.
  24. O'Meara S, Cullum S, Nelson E. Compression for venous leg ulcers. In: *The Cochrane Library*. Chichester UK: Wiley; 2009.
  25. Franks PJ. European wound management association cost effectiveness panel. *Eur Wound Management Assoc J* 2003;3:31.
  26. Cullum N, Nelson EA, Flemming K, Sheldon T. Systematic reviews of wound care management: (5) beds; (6) compression; (7) laser therapy, therapeutic ultrasound, electrotherapy and electromagnetic therapy. *Health Technol Assess* 2001;5:1-221.
  27. Milic DJ, Zivic SS, Bogdanovic DC, Perisic ZD, Milosevic ZD, Jankovic RJ, *et al*. A randomized trial of the tubulcus multilayer bandaging system in the treatment of extensive venous ulcers. *J Vasc Surg* 2007;46:750-5.
  28. Kanjoor JR. Venous ulcer: Current concepts. *Indian J Plast Surg* 2011;44:109-11.
  29. Alamelu V. Is chronic venous ulcer curable? A sample survey of a plastic surgeon. *Indian J Plast Surg* 2011;44:104-9.
  30. Parstch M. Understanding the pathophysiological effects of compression. In: *Understanding Compression Therapy: EWMA Position Document*. Medical Education Partnership Ltd; 2003. p. 2-5.
  31. Clodius L, Földi E, Földi M. On non operative management of chronic lymphedema. *Lymphology* 1990;23:2-3.
  32. Marsten K, Vowden M. Compression therapy: A guide to safe practice. In: *Understanding Compression Therapy: EWMA Position Document*. 2003. p. 11-5.
  33. Hopkins A. A community nursing guide: Multilayer lymphoedema bandaging. *Br J Community Nurs* 2008;13:S18, S20-4.
  34. Rose K, Taylor H, Twycross R. Volume reduction of arm lymphoedema. *Nurs Stand* 1987;7:29-32.
  35. Legs to Stand On™ [Internet]. Available from: <http://legstostandon.org>. [Last accessed on 2012 July 14].
  36. Ghosh S, Mukhopadhyay A, Sikka M, Nagla KS. Pressure mapping and performance of the compression bandage/garment for venous leg ulcer treatment. *J Tissue Viability* 2008;17:82-94.
  37. Damstra RJ, Brouwer ER, Partsch H. Controlled, comparative study of relation between volume changes and interface pressure under short-stretch bandages in leg lymphedema patients. *Dermatol Surg* 2008;34:773-8; discussion 778-9.
  38. Miller C, Kapp S, Newall N, Lewin G, Carville K, Santamaria N, *et al*. Predicting concordance with multilayer compression bandaging. *J Wound Care* 2011;20:101-2, 104, 106 Passim.

**How to cite this article:** Gogia SB, Gogia AR. Compression therapy for ulcers: The science and the art. *Indian J Plast Surg* 2012;45:275-82.

**Source of Support:** Nil, **Conflict of Interest:** Some of the material (Compression pumps only, not the others) mentioned as part of the treatment provided in the case reports are sold through a company owned by one author (ARG).