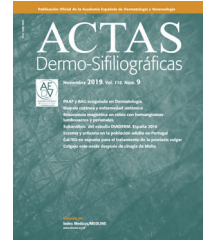




ACTAS Derma-Sifiliográficas

Full English text available at
www.actasdermo.org



PRACTICAL DERMATOLOGY

Theory and Practice of Compression Therapy for Treating and Preventing Venous Ulcers[☆]



E. Conde Montero,^{a,*} N. Serra Perrucho,^b P. de la Cueva Dobao^a

^a Servicio de Dermatología, Hospital Universitario Infanta Leonor, Madrid, Spain

^b Servicio de Cirugía Vascul, Angiogrú, Barcelona, Spain

Received 13 December 2019; accepted 21 March 2020

Available online 23 October 2020

KEYWORDS

Compressive therapy;
Therapeutic
compression;
Bandages;
Elastic stockings;
Venous ulcer

PALABRAS CLAVE

Terapia compresiva;
Compresión
terapéutica;
Vendaje;
Media de compresión;
Úlcera venosa

Abstract Compression therapy is the basis for treating the cause of venous ulcers and preventing recurrence. Various systems are currently available for applying compression, and adapting them to patients' needs can improve adherence to treatment. Understanding the principles that underlie compression therapy is essential for success. Although this paper focuses mainly on venous ulcers, compression has also proven beneficial for other conditions, such as lymphedema and wounds resulting from injury or inflammation.

© 2020 AEDV. Published by Elsevier España, S.L.U. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Principios teórico-prácticos de la terapia compresiva para el tratamiento y prevención de la úlcera venosa

Resumen La compresión terapéutica es el pilar fundamental del tratamiento etiológico y de la prevención de recidivas de la úlcera venosa. En la actualidad disponemos de diferentes sistemas y estrategias para adaptar la terapia compresiva a las necesidades de cada paciente y aumentar su adherencia al tratamiento. Es fundamental el conocimiento de los principios teórico-prácticos de este tratamiento para lograr el éxito terapéutico. A pesar de que este artículo se centre fundamentalmente en la úlcera venosa, la terapia compresiva también ha mostrado un beneficio en otras patologías como el linfedema, las heridas post-traumáticas o las de causa inflamatoria.

© 2020 AEDV. Publicado por Elsevier España, S.L.U. Este es un artículo Open Access bajo la licencia CC BY-NC-ND (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

[☆] Please cite this article as: Conde Montero E, Serra Perrucho N, de la Cueva Dobao P. Principios teórico-prácticos de la terapia compresiva para el tratamiento y prevención de la úlcera venosa. Actas Dermosifiliogr. 2020;111:829–834.

* Corresponding author.

E-mail address: elenacondemontero@gmail.com (E. Conde Montero).

Introduction

Venous ulcer is the most advanced stage of chronic venous insufficiency, that is, the result of poorly controlled venous hypertension. The prevalence of this condition is increasing alongside aging of the general population.^{1,2}

While some patients benefit from surgery or intravenous approaches for treatment of venous hypertension, compression therapy can be considered the mainstay for treatment of the underlying cause of venous ulcer. International clinical guidelines rate this type of therapy with level of evidence 1 and grade of recommendation A.³ However, despite its demonstrated effectiveness, appropriate compression therapy is not widely used for treatment of venous ulcer in Spain.⁴

Therefore, the objective of this paper is to review the theory supporting compression therapy, evidence in favor of its use, and its practical application in the treatment of venous ulcer and in the prevention of recurrence.

Compression therapy is applied to the leg mainly to increase venous and lymphatic return. The effects of compression go beyond merely reducing edema and play a role in tissue remodeling. Therefore, interest in compression therapy is not limited to the decongestion phase, but also covers maintenance treatment for venous edema, lymphedema, and phlebolympheidema.⁵

The main effects of compressive therapy are as follows⁶⁻⁹:

- Reduction in edema
- Tissue remodeling
- Reduced filtration of fluid from vessels to tissue
- Increased lymphatic drainage
- Release of anti-inflammatory mediators and reduction in inflammatory molecules and cells

Successful adherence to compression therapy requires the patient, the patient's family, and, of course, medical staff to understand the indication for treatment. However, before providing the patient with explanations or recommendations, it is important to know his/her beliefs, previous negative experience, and social and family context.¹⁰

While the main indication for compression therapy in leg injury is treatment and prevention of venous ulcer, the interest of this approach is not restricted to this type of ulcer.

The inflammatory process underlying any leg injury involves abnormal microcirculation, with greater capillary filtration and increased intravenous pressure due to the effect of gravity. Therefore, despite the absence of reflux or obstruction, the patient may develop venous hypertension that hampers healing, thus making venous return by compression therapy essential.¹¹ Irrespective of the cause (injury, surgery, vasculitis, pyoderma gangrenosum), compression therapy seems to be a good antigravity and anti-inflammatory approach for any leg injury providing there are no contraindications (see Contraindications).¹²⁻¹⁴

Properties of the Bandage

A band is known as a bandage when it is placed on a patient's leg; therefore, its properties are different. A band is more or

PRESSURE PEAKS UNDER A STIFF BANDAGE DURING MUSCLE CONTRACTION

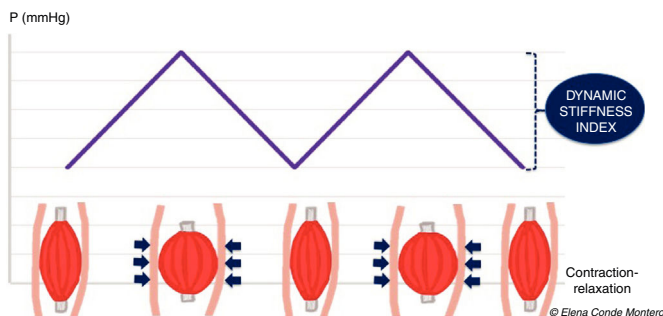


Figure 1 Pressure peaks under a stiff bandage during muscle contraction.

less elastic, whereas a bandage is stiffer or less stiff. Below, we provide the terminology used to discuss the properties of fabrics in vitro and in vivo.

Extensibility and elasticity:

Extensibility and elasticity are in vitro properties of the bandage or compression stocking.

Extensibility is the ability of the fabric to stretch in response to the tension applied. Elasticity is the ability to return to the original length when this tension is reduced. In simple terms, a stocking or bandage with considerable extensibility will also have considerable elasticity and vice versa. Bands can be classified according to their properties, and we generally refer to low and high elasticity (or short or long stretch).⁵

Multilayer and multicomponent:

The first characteristic is inherent to any type of bandage. A band applied to the leg will necessarily be a multilayered bandage, even if only 1 band is applied, since there is always some overlap between layers.

If we place 1 or more similar fabrics, the bandage is known as a monocomponent bandage. If we overlap fabrics with different physical properties, the bandage is known as a multicomponent bandage.

Stiffness

Stiffness is a property of the bandage and, therefore, an in vivo characteristic. Stiffness is defined as the resistance of the bandage to modifications in the volume of the calf muscles. The stiffer the bandage is, the more effective it will be for reducing venous hypertension while walking (ambulatory venous hypertension), since resistance to muscle contraction creates high-pressure peaks that lead to short and intermittent venous occlusions, much in the same way as the normal functioning of a valve.¹⁵ During rest, these peaks are not reached, and the pressure is lower (Fig. 1).

The concept of a "stiffer" or "less stiff" bandage should replace the current classification of a bandage as "elastic" and "inelastic". Given that all bandages are multilayer and that many are multicomponent, the mechanical characteristics of a bandage vary with respect to those of the band. In fact, friction between the layers of a bandage increases the stiffness of the bandage, especially when a cohesive component is involved.⁵ The concept of friction also explains the greater stiffness resulting from the combination of 2 stock-



Figure 2 Ensuring a consistent leg circumference.



Figure 3 Retromalleolar padding.

ings (class I and II) than the application of a single stocking (class III).

Pressure Under the Bandage

Providing there are no contraindications (see Contraindications), healing of venous ulcers can be promoted by applying strong pressure on the ankle (> 30-40 mmHg). This pressure is measured using a device that is placed on the ankle and indicates the pressure applied in the area at rest (B1, transition between the Achilles tendon and the gastrocnemius). However, the pressure differs at the various points along the leg and depends on a series of factors, all of which are covered in the well-known Laplace law⁵: the pressure under the bandage at a specific point increases as tension increases (force applied to the bandage during placement), as the number of layers increases, when the radius is lower for the circumference at the specific point (greater prominence, e.g., pretibial region), and with a narrower band. The ability to maintain this degree of tension over time depends on the properties of the components of the bandage.

Padding techniques can be explained by this physical law. The main objectives of padding are as follows⁵:

To ensure a consistent leg circumference in patients with abnormal limb morphology (Fig. 2).

To protect bony prominences and other areas that are likely to be subject to excess pressure (e.g., the pretibial region and the area of the Achilles tendon) (Fig. 3).

To increase retromalleolar pressure in the case of wounds that lie behind the malleolus in order to overcome the



Figure 4 Padding to protect areas sensitive to excessive pressure (pretibial region, lateral aspect of the foot, Achilles tendon).

“tent” effect that is usually observed in this concave area (Fig. 4).

To avoid venous congestion (erythematous-purpuric color) resulting from excess pressure on the cutaneous microcirculation and the more superficial venous system.

Contraindications and Special Situations

A review of guidelines and consensus documents, such as that performed by an expert panel in 2016,¹⁶ reveals considerable variability in the contraindications, risk factors, and complications associated with compression therapy.

Despite the heterogeneous nature of the recommendations, there is agreement on 2 absolute contraindications:

Occlusive artery disease with critical limb ischemia (ankle-brachial index [ABI], < 0.5).

Decompensated heart failure.

Given these contraindications, it is essential to suitably evaluate the wound, the leg, and the patient before prescribing any type of compression therapy. Palpation of the posterior tibial and pedal pulses is the first measure, and this is generally sufficient for application of compression therapy. If these pulses cannot be palpated, it will be necessary to measure the ABI. The ABI is the ratio of systolic arterial pressure in the ankle (measured in the posterior tibial and pedal arteries, selecting the highest value) to systolic arterial pressure in the arm. An ABI of 0.9-1.3 is considered normal. The cutoff point for critical limb ischemia is an ABI < 0.5; therefore, with a value of 0.6-0.8, despite the presence of peripheral artery disease, the patient can benefit from adapted compression therapy (stiff bandages and pressures below 30 mmHg) when indicated after evaluation by a specialist. Given that in some diabetic patients, this index may be falsely high owing to calcification of the arterial media, the patient should be referred to a vascular surgeon.⁵

Relative contraindications also vary according to the guideline. Therefore, these relative contraindications should be understood as situations where compression therapy is to be used after taking into account specific considerations so that it is safe and well tolerated by the patient. Such situations include immobility and/or some degree of arterial disease: in the case of immobile patients with peripheral arterial disease and an ABI > 0.5, a bandage

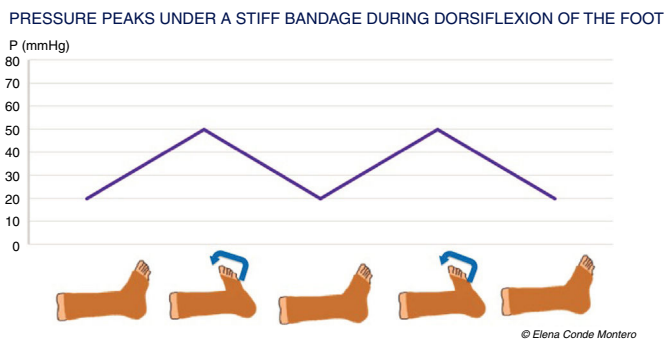


Figure 5 Pressure peaks under a stiff bandage during dorsiflexion of the foot.

with a high stiffness index at pressures lower than 30 mmHg is a safe and effective option if the patient performs dorsiflexion exercises of the foot. Moreover, there may be a double benefit, since the reduced edema can improve arterial flow (Fig. 5).¹⁷

Despite the multiple potential comorbidities, the exhaustive follow-up of these patients makes compression therapy a safe technique.

Types of Systems and Materials in Compression Therapy

Low-elasticity bandages (short stretch)

The fabrics used in low-elasticity bandages stretch very little (less than 100%) or not at all (nonelastic bandages). One example of a nonelastic bandage is the zinc bandage, which is used for the traditional Unna boot and continues to be a very interesting alternative bandage, providing a specific anti-inflammatory benefit in stasis dermatitis.¹⁸ Bandages composed of nonelastic bands are stiff, with low resting pressures, high working pressures, and considerable peak pressures associated with muscle contraction. The main drawback is that bandages composed of short-stretch bands must be changed frequently, since, pressure is quickly lost with reduced swelling.⁵

High-elasticity bandages (Long Stretch)

The components of highly elastic bandages always contain elastane fibers, which enable the bandage to stretch to twice its original length. Given that these bandages adapt to the diameter of the leg, with no resistance to muscle contraction, there is little difference between resting and working pressure; therefore, they are less effective for reducing edema. Since they exert high pressure during resting, they are more poorly tolerated by patients, especially those with some degree of arterial disease.⁵

Multicomponent bandage systems

Multicomponent systems are formed by bandages of different characteristics, on which the greater or lesser stiffness of the bandage will depend. They may be composed of 2, 3, or 4 bandages, with fixing, compression, and padding func-



Figure 6 Multicomponent bandage (2-bandage system with circular pressure indicators).

tions. Many of these systems come with pressure indicators, thus enabling them to be applied easily by nonexpert personnel (Fig. 6). These bandages can be worn continuously for up to a week without having to be changed. The frequency of changing will depend on the control of the wound exudate and maintenance of appropriate placement and subsequent pressure of the bandage.⁵

Compression stockings

The pressure exerted by compression stockings does not depend on the professional who places the bandage. In addition, this approach makes it easier to wear shoes and carry out other activities of daily living. Various fabrics and models have been marketed, although the stocking can be custom-made for patients whose measurements are outside the normal range. Depending on the type of mesh, stocking fabric is classed as circular-knit and flat-knit. The latter is stiffer and is mainly indicated in patients with phlebolymphe-dema.⁵

Compression stockings are classified according to the pressure exerted at B1. The most widely used type in Spain is the German type (Table 1).

Treatment of venous ulcer normally requires 2 overlapping stockings to reach the recommended pressure of 30-40 mmHg, thus making placement easier.

Various devices have been marketed to facilitate placement.⁵

Self-Adjusting compression systems with a Velcro closure

Self-adjusting systems include an adjustable compression device with low-elasticity fabric and Velcro closures. They are easily placed, thus enabling the patient to use the device him/herself and readjust the pressure as it gradually decreases (Fig. 7). Self-adjusting systems provide autonomy and better quality of life for patients who find it difficult to use a stocking or who do not have access to a health professional when the bandage must be changed. The stiffness achieved with these devices is very similar to that obtained with short-stretch bands, with the additional benefit that the pressure can be adjusted throughout the day.¹⁹

Table 1 Classification of Compression Stockings According to Their Degree of Compression.

Class	German Classification	British Classification	French Classification
I	10-21 mmHg	14-17 mmHg	10-15 mmHg
II	23-32 mmHg	18-24 mmHg	15-20 mmHg
III	34-46 mmHg	25-35 mmHg	20-36 mmHg
IV	> 49 mmHg	–	> 36 mmHg

**Figure 7** Self-adjusting pressure system with a Velcro closure.

Intermittent pneumatic compression

Intermittent pneumatic compression devices are formed by air chambers that surround the leg and are connected to a system that produces gradual proximal to distal pressure alternating with pressure-free intervals. Its main interest lies in its use as an adjuvant to other compression systems in immobilized patients or situations in which other types of compression therapy cannot be used.²⁰

Available Evidence

Several systematic reviews have analyzed the results of randomized controlled trials that compare the effect of compression therapy on venous ulcers with no compression, as well as the effect of the different compression therapy systems. The results of these reviews show that compression therapy is associated with faster healing than no compression.^{21–23} Comparison of the different types of compression therapy shows that multicomponent systems are associated with a more marked clinical benefit than monocomponent systems.^{21,22}

As far as the different multilayer systems are concerned, 2-layer bandages have proven to be as effective as 4-layer bandages for treatment of venous ulcer, with the advantage that they are easier to apply.²⁴

In the case of compression stockings for treatment and prevention of venous ulcers, the grade of recommendation is the same as that of bandages.²⁵

Velcro-based systems seem to be a comfortable alternative that can prevent relapse, even though the available evidence on their efficacy is scarce.²⁶

The effectiveness of compression therapy for prevention of venous ulcer is closely associated with strict adherence to treatment.²⁷ Various studies support the use of compression therapy to avoid recurrence of venous ulcers, although

studies on the most effective type of compression are clearly lacking.²⁸ Recent clinical trials conclude that recurrence is less common with class III compression stockings.²⁹ However, as previous studies have shown that patients who adhere to their compression therapy (irrespective of the class used) experience fewer recurrences, we should continue to recommend a grade of compression that is adjusted to the needs of the patient.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

References

- Berenguer Pérez M, López-Casanova P, Sarabia Lavín R, González de la Torre H, Verdú-Soriano J. Epidemiology of venous leg ulcers in primary health care: Incidence and prevalence in a health centre-A time series study (2010-2014). *Int Wound J*. 2019;16:256–65.
- Purwins S, Herberger K, Debus ES, Rustenbach SJ, Pelzer P, Rabe E, et al. Cost-of-illness of chronic leg ulcers in Germany. *Int Wound J*. 2010;7:97–102.
- Wittens C, Davies AH, Bækgaard N, Broholm R, Cavezzi A, Chastanet S, et al. Management of Chronic Venous Disease: Clinical Practice Guidelines of the European Society for Vascular Surgery (ESVS). *Eur J Vasc Endovasc Surg*. 2015;49:678–737.
- Soldevilla J, Torra JE, Verdú J, Rueda J, Martínez F, Roche E. Epidemiology of Chronic Wounds in Spain: Results of the First National Studies on Pressure and Leg Ulcer Prevalence. *Wounds*. 2006;18:213–26.
- Dissemond J, Assenheimer B, Bültemann A, Gerber V, Gretener S, Kohler-von Siebenthal E, et al. Compression therapy in patients with venous leg ulcers. *J Dtsch Dermatol Ges*. 2016;14:1072–87.
- Konschake W, Valesky E, Stege H, Jünger M. Evidence of compression therapy. *Hautarzt*. 2017;68:625–31.
- Altintas AA, Gehl B, Aust MC, Meyer-Marcotty M, Altintas MA. Impact of compression therapy on local microcirculation and histomorphology in venous leg ulcers. *Phlebologie*. 2011;40:9–14.
- Beidler SK, Douillet CD, Berndt DF, Keagy BA, Rich PB, Marston WA. Inflammatory cytokine levels in chronic venous insufficiency ulcer tissue before and after compression therapy. *J Vasc Surg*. 2009;49:1013–20.
- Beidler SK, Douillet CD, Berndt DF, Keagy BA, Rich PB, Marston WA. Multiplexed analysis of matrix metalloproteinases in leg ulcer tissue of patients with chronic venous insufficiency before and after compression therapy. *Wound Repair Regen*. 2008;16:642–8.
- Mudge E, Holloway S, Simmonds W, Price P. Living with venous leg ulceration: issues concerning adherence. *Br J Nurs*. 2006;15:1166–71.
- Partsch H, Mortimer P. Compression for leg wounds. *Br J Dermatol*. 2015;173:359–69.

12. Conde-Montero E, Silvente-San Nicasio C, Velázquez-Tarjuelo D, De la Cueva-Dobao P. La terapia compresiva tras cirugía dermatológica en la pierna. *Dermatol Rev Mex*. 2019;63:235–6.
13. Isoherranen K, O'Brien JJ, Barker J, Dissemond J, Hafner J, Jemec GBE, et al. Atypical wounds. Best clinical practice and challenges. *J Wound Care*. 2019;28(Sup6):S1–92.
14. Shavit E, Alavi A. Compression therapy for non-venous leg ulcers: Current viewpoint. *Int Wound J*. 2019;16:1581–6.
15. Partsch H, Schuren J, Mosti G, Benigni JP. The Static Stiffness Index: an important parameter to characterise compression therapy in vivo. *J Wound Care*. 2016;25 Suppl 9:S4–10.
16. Andriessen A, Apelqvist J, Mosti G, Partsch H, Gonska C, Abel M. Compression therapy for venous leg ulcers: risk factors for adverse events and complications, contraindications — a review of present guidelines. *J Eur Acad Dermatol Venereol*. 2017;31:1562–8.
17. Stansal A, Tella E, Yannoutsos A, Keita I, Attal R, Gautier V, et al. Supervised short-stretch compression therapy in mixed leg ulcers. *J Med Vasc*. 2018;43:225–30.
18. Rubin JR, Alexander J, Plecha EJ, Marman C. Unna's boot vs polyurethane foam dressings for the treatment of venous ulceration: a randomized prospective study. *Arch Surg*. 1990;489–90.
19. Partsch H. Reliable self-application of short stretch leg compression: Pressure measurements under self-applied, adjustable compression wraps. *Phlebology*. 2019;34:208–13.
20. Berliner E, Ozbilgin B, Zarín DA. A systematic review of pneumatic compression for treatment of chronic venous insufficiency and venous ulcers. *J Vasc Surg*. 2003;37:539–44.
21. O'Meara S, Cullum N, Nelson EA, Dumville JC. Compression for venous leg ulcers. *Cochrane Database Syst Rev*. 2012;11. CD000265.
22. Mauck KF, Asi N, Elraiyah TA, Undavalli C, Nabhan M, Altayar O, et al. Comparative systematic review and meta-analysis of compression modalities for the promotion of venous ulcer healing and reducing ulcer recurrence. *J Vasc Surg*. 2014;60:715–90S.
23. Wong IKY, Andriessen A, Charles HE, Thompson D, Lee DTF, So WKW, et al. Randomized controlled trial comparing treatment outcome of two compression bandaging systems and standard care without compression in patients with venous leg ulcers. *J Eur Acad Dermatol Venereol*. 2012;26:102–10.
24. Lazareth I, Moffatt C, Dissemond J, Lesne Padiou AS, Truchetet F, Beissert S, et al. Efficacy of two compression systems in the management of VLU: results of a European RCT. *J Wound Care*. 2012;21:553–4, 556, 558 passim.
25. Rabe E, Partsch H, Hafner J, Lattimer C, Mosti G, Neumann M, et al. Indications for medical compression stockings in venous and lymphatic disorders: An evidence-based consensus statement. *Phlebology*. 2018;33:163–84.
26. Stather PW, Petty C, Howard AQ. Review of adjustable velcro wrap devices for venous ulceration. *Int Wound J*. 2019;16:903–8, <http://dx.doi.org/10.1111/iwj.13116>.
27. Moffatt C, Kommala D, Dourdin N, Choe Y. Venous leg ulcers: patient concordance with compression therapy and its impact on healing and prevention of recurrence. *Int Wound J*. 2009;6:386–93.
28. Nelson EA, Bell-Syer SE. Compression for preventing recurrence of venous ulcers. *Cochrane Database Syst Rev*. 2014:CD002303.
29. Milic DJ, Zivic SS, Bogdanovic DC, Golubovic MD, Lazarevic MV, Lazarevic KK. A randomized trial of class 2 and class 3 elastic compression in the prevention of recurrence of venous ulceration. *J Vasc Surg Venous Lymphat Disord*. 2018;6:717–23.