Principles of compression in venous disease:

A practitioner's guide to treatment and prevention of venous leg ulcers

FOREWORD

Compression therapy is the recognised treatment of choice for recurrent venous leg ulcers. Compression therapy systems include hosiery, tubular bandages and bandage systems comprising two or more components. These systems aim to provide graduated compression to the lower limb in order to improve venous return and to reduce oedema. The aim of this document is to enhance practitioners' knowledge of compression bandaging in the management of venous disease and to explain the scientific principles of compression for safe and effective application.

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INTRODUCTION

Chronic venous insufficiency affects up to 50% of the adult population and it is estimated that 1% of individuals will suffer from venous leg ulceration during their lifetime[1,2]. Correctly applied compression therapy is the cornerstone of treatment and has been demonstrated to improve healing rates in patients with existing venous leg ulcers (VLUs) and to reduce ulcer recurrence[3,4].

Compression therapy is often used sub-optimally in practice because of a lack of knowledge and confidence in relation to assessing patients using Doppler ankle brachial pressure index (ABPI) measurement and applying compression bandaging[5]. As a result, patients may not always receive the full benefits of the treatment.

This document describes how venous drainage occurs in the healthy leg and the changes that occur with progressive venous disease (chronic venous insufficiency). It then describes current understanding of the mechanisms by which compression therapy works and also explains the principles underlying how compression therapy systems deliver pressure to a limb. The document then goes on to demonstrate how this understanding can be used to achieve safe and effective compression in clinical practice.

PRINCIPLES OF COMPRESSION THERAPY

Treatment is aimed at correcting, as much as possible, the long-term complications of chronic venous insufficiency. Compression therapy systems applied externally to the lower leg increase pressure on the skin and underlying structures to counteract the force of gravity. This can help to relieve the symptoms in the lower limb by acting on the venous and lymphatic systems to improve removal of fluid (blood and lymph) from the limb.

The most commonly used compression therapy systems come in two forms:

- Bandage components or layers wrapped around the leg (either full leg or below knee)
- Compression hosiery, eg compression stockings.

In general, bandages are most commonly used for the treatment of active VLUs; compression stockings are generally used to prevent recurrence once the ulcer has healed. Compression stockings may also be used in the early stages of chronic venous disease, including thrombotic disease (eg deep vein thrombosis [DVT]) to help prevent disease progression. Box 1 (page 2) explains some of the terminology used in relation to compression therapy.

KEY PRINCIPLES

- Compression aims to counteract the force of gravity and promote the normal flow of venous blood up the leg
- Compression acts on the venous and lymphatic systems to improve venous and lymph return and reduce oedema

Box 1: Unravelling the terminology

There are several types and forms of compression therapy and the terminology used can be confusing. This document will consider compression bandages and compression hosiery (stockings).

Compression bandages

Long strips of fabric that are wrapped around the leg to form a continuous covering. The bandages are applied so that the long edges overlap to prevent gaps. Bandages may be applied in layers usually with additional materials such as padding: these are known as multi-layer systems (eg four-layer and two-layer bandaging systems).

Note: the terminology surrounding layers is problematic as there will always be some overlap when applying bandages, giving at least two layers of material at any point on the bandaged leg. As such a single-layer bandage cannot exist. The term component may therefore be a better way to describe individual products that are used to create a compression system[6].

Compression hosiery

Knitted garments that have anatomical shaping and are applied like a piece of clothing.

Elastic/inelastic (long-/short-stretch) compression

A compression system may contain elastic or inelastic materials or a combination of both:

- Elastic materials (also known as long-stretch) contain elastic (elastomeric) fibres that can be stretched to increase the overall length of the material by over 100%. When the tension is released the elastic fibres return almost to their original length.
- Inelastic materials (also known as short-stretch) contain few or no elastic fibres and increase in length by often considerably less than 100% when stretched[7].

Pressures

Compression therapy systems may be categorised according to the pressure produced on a model limb at the ankle during laboratory testing. There is variation between countries in the pressures used to define each category and so care should be used when comparing categories by name. An international consensus group has recommended a system for categorising compression bandage systems (Table 1)[6].

Table 1: Recommended categorisation of compression bandage systems (from ref[6])

Category	Pressure
Mild	<20mmHg
Moderate	≥20-40mmHg
Strong	≥40-60mmHg
Very strong	≥60mmHg

The classification of compression hosiery is also variable between countries. Compression hosiery that delivers at least 18–24mmHg and up to 35mmHg at the ankle has been recommended for the prevention of VLUs[8].

Interface (sub-bandage) pressure

Measuring the pressure produced by a compression therapy system inside a limb is invasive and so measurement of the interface pressure — the pressure between the compression therapy system and the skin — is often used as a proxy for internal pressure. However, interface pressure, also known as sub-bandage pressure, is rarely measured in clinical practice.

VENOUS DRAINAGE IN THE LEG

NORMAL MECHANISM OF VENOUS DRAINAGE IN THE LEG

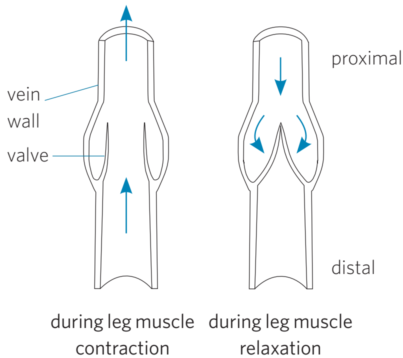
Unless a patient is lying flat, drainage of venous blood from the legs to the heart needs to overcome gravity. Blood in the lower limb veins is squeezed upwards by the contraction of the surrounding thigh, calf and foot muscles. In addition, there is a network of veins on the plantar surface of the foot that is compressed on standing to aid venous return.

Valves in the veins prevent backward flow of blood when the muscles relax (Figure 1)[9]. About 90% of venous return from the legs is through the action of the muscle pumps; in addition, the negative pressure produced in the thorax during inhalation aids venous return to the heart[10].

The calf muscle pump is the most important muscle pump in the leg and is active during walking and ankle movement[11]. As a result, the effectiveness of the calf muscle pump depends on normal calf muscle activity. This itself requires good ankle mobility, a normal gait and lack of neurological deficit[12]. Calf muscle function decreases with increasing age, at least partly as a result of reduced muscle bulk[13].

Figure 1: Mechanism of action of venous valves

The valves in the veins comprise two thin flaps of tissue attached to the vein walls. When the leg muscles contract blood is pushed along the vein from distal to proximal, ie from the leg towards the heart, and the flow of blood pushes the flaps to the side and opens the valve. When the leg muscles relax, gravity causes the blood to flow backwards down the vein. This closes the valve and prevents the blood moving back into the next section of vein. When the leg muscles contract again, the pressure on the blood in the vein opens the valves to allow blood to flow towards the heart.



KEY PRINCIPLES

- When standing, venous blood flow in the leg needs to overcome gravity to return to the heart
- Valves in the leg prevent backward flow of blood when the calf muscles relax
- The calf muscle pump depends on normal calf muscle activity to ensure effective venous return

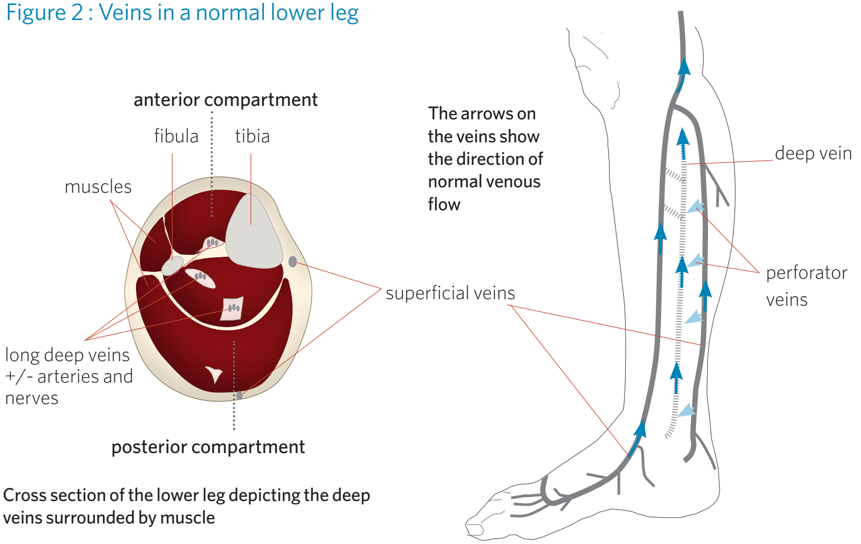
WHAT CAUSES IMPAIRED VENOUS DRAINAGE?

The veins in the lower leg are divided into superficial, perforator and deep veins (Figure 2). The superficial veins are found just below the skin and are connected to the deep veins by perforator veins. The deep veins are found between the muscle groups and comprise the long deep veins that carry most of the blood leaving the leg and the blood collecting networks within the calf muscles (also known as the sinusoidal veins).

Valves are found in the long deep veins, in the superficial veins and in the perforator veins. In the calf, the valves in the perforator veins normally allow blood flow from the superficial veins into the deep veins[14].

Chronic venous insufficiency occurs when the valves of the veins do not function correctly and venous drainage is impaired. Valve failure may occur due to a weakening of the valves as a result of varicose veins, or damage to the deep veins secondary to venous thrombosis, trauma or venous obstruction. In both cases, the failure of the valves allows the blood to flow back down (reflux) into the section of vein below (Figure 3 opposite). This prevents the reduction in venous pressure that normally occurs during exercise resulting in **venous hypertension**. In addition, poor function or failure of the calf muscle pump due to inactivity, immobility or abnormal gait may contribute to venous hypertension[2,15].

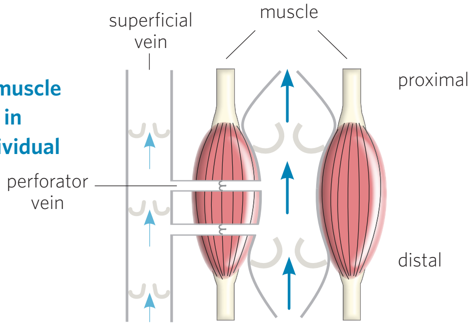
Figure 2 : Veins in a normal lower leg



Cross section of the lower leg depicting the deep veins surrounded by muscle

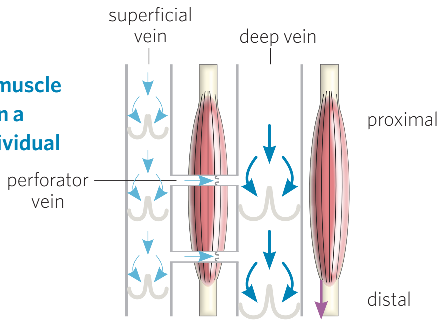
Figure 3: Effect of valve failure on blood flow in the venous system

During leg muscle contraction in healthy individual



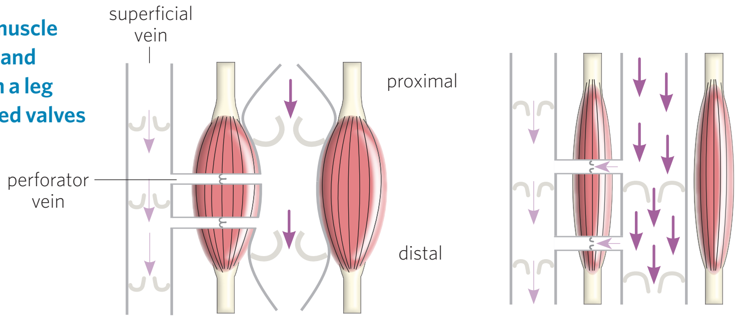
Normal valve function and blood flow during calf muscle contraction. In a healthy individual there is no flow from the superficial to the deep venous system

During leg muscle relaxation in a healthy individual



During calf muscle relaxation, normal valves close to prevent back flow of blood

During leg muscle contraction and relaxation in a leg with damaged valves



Failure of the valves in the lower leg causes the blood to flow back down into the section of the vein below, reducing venous return to the heart. Perforator valve incompetence results in reflux into the superficial system. This prevents the normal fall in venous pressure that occurs during exercise, resulting in venous hypertension

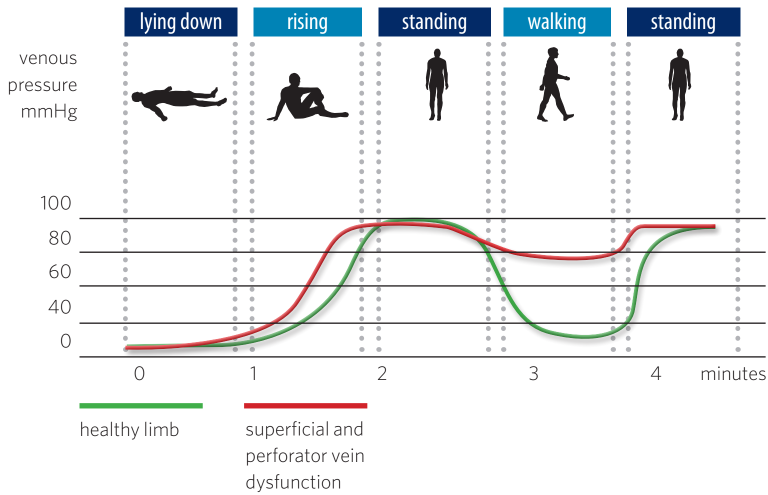
Venous pressure changes with posture

As a person rises to a standing position from lying down, the pressure within the venous system increases considerably (Figure 4). This is due to gravity, which causes blood to accumulate in the lower extremities. As the person moves during exercise, the pumping effect of the calf muscles in a healthy leg considerably reduces the pressure in the venous system by encouraging blood flow out of the legs. When the person stops walking, the pressure rises again.

During exercise in a healthy individual, venous pressure will fall to about 30mmHg — this is the ambulatory venous pressure. When venous disease is present and/or the calf muscle pump is not working properly, the reduction in venous pressure associated with exercise is much less marked (Figure 4) and returns to the high standing pressure more quickly[9]. These effects are relieved by rest and on elevation of the leg.

In a person at rest, venous pressure in the lower limb is mainly determined by the vertical distance between the ankle and heart. For all individuals of the same height, irrespective of the presence of venous disease (other than those with a severe venous outflow obstruction as may occur in venous thrombosis), the resting pressure within the venous system will be the same. For a standing person who is 1.8m tall, the venous pressure in the ankle region will be approximately 100mmHg[16].

Figure 4: Changes in pressure (measured at the ankle) in the venous system in legs with healthy and defective venous valves during lying, rising, standing and exercise



Adapted from ref[2]

The term venous hypertension relates to the maintenance of a high mean ankle venous pressure either due to a failure of venous pressure to fall normally during exercise, a lack of a fall in pressure due to prolonged inactivity with the legs dependent or due to venous outflow obstruction, such as a deep vein thrombosis.

Effects of venous hypertension

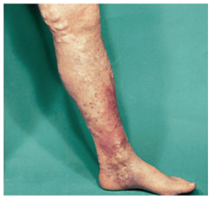
Chronic venous hypertension causes abnormalities in the capillaries in the leg tissues that make them more permeable. This allows fluid, proteins and blood cells to leak into the tissues. Venous hypertension may also be associated with an increased inflammatory response, changes in the structure of the microvasculature and reduced skin and tissue oxygenation.

Overall, these effects cause changes in the skin and subcutaneous tissues such as oedema, hyperpigmentation, lipodermatosclerosis, atrophe blanche and varicose eczema (Figure 5), and contribute to greater skin fragility and increased risk of leg ulceration and delayed healing[1,17].

Figure 5: Skin changes as a result of venous hypertension

Ankle flare

Hyperpigmentation



Varicose eczema

KEY PRINCIPLES

- In healthy individuals, the calf muscle pump/venous valves in the leg regulate the increase in venous pressure exerted at the ankle that occurs when standing
- Failure of the calf muscle pump/venous valves in the leg will cause the venous pressure at the ankle to remain high during exercise — this is known as venous hypertension
- Prolonged raised venous pressure leads to an increase in capillary permeability with the leaking of fluid and protein into the surrounding tissues. This can cause hardening of the tissues and changes in skin appearance

DIFFERENCES BETWEEN INELASTIC AND ELASTIC COMPRESSION SYSTEMS

Compression systems may contain both inelastic and elastic materials. Most multi-layer systems (two- and four-layer) function as an inelastic system even if they contain mainly elastic components.

An inelastic bandage has high stiffness compared to an elastic bandage. The stiffness of a compression therapy system can be assessed by measuring the static stiffness index (SSI). This is measured by recording the pressure at the interface between the compression therapy system and the skin (the interface pressure) when the patient is lying down and when they are standing[18]. The SSI is the difference between the two measurements.

Compression therapy systems with a high SSI (inelastic or multi-layer bandage system) will produce higher pressures during standing and lower pressures when lying down than systems with a lower SSI (an elastic system).

Effective compression is achieved by accurate application of the bandage system, which should provide some compression at rest, but work effectively during exercise. All compression therapy systems achieve this to some extent and the choice of bandage or hosiery system requires selection on an individual basis.

HOW DOES COMPRESSION THERAPY WORK?

The two main principles underpinning how compression therapy works are:

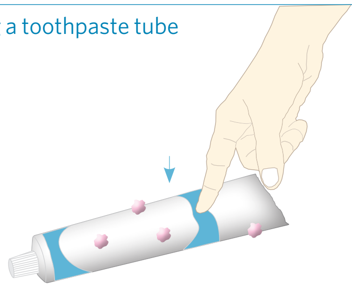
- Creation of an enclosed system that allows internal pressures to be evenly distributed in the leg
- Variation of interface pressures according to limb shape and tension of bandage applied. This will be influenced by bandage/hosiery characteristics and the skill and technique of the person applying the compression.

Pressure redistribution under compression

Compression bandages with a high SSI create an unyielding (rigid) but flexible cast or cylinder when applied to the lower limb. This acts like a closed system whereby external pressure applied to the leg is transmitted equally in all directions within the contained area[18]. **The principle involved is known as Pascal's Law** (Figure 6).

Figure 6: A demonstration of Pascal's Law using a toothpaste tube

Pascal's Law states that pressure applied to an enclosed system of an incompressible fluid is distributed evenly. This can be demonstrated using a capped tube of toothpaste in which several equally sized-holes have been punched. When pressure is applied to the tube at one point, toothpaste will extrude from all of the holes at the same rate no matter how far they are from the point of applied pressure.

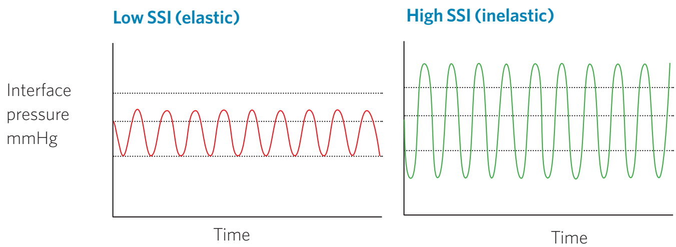


The rigid container provided by the compression therapy system maximises the effect of muscle movement. During exercise (active or passive), the muscles in the leg contract, which results in a localised increase in the calf circumference. When compression with a high SSI is applied externally to the limb, muscles in the leg work against the rigid tube and any increase in the circumference of the calf is prevented. The muscle movement creates a pressure wave that is distributed evenly throughout the lower limb, according to Pascal's Law. This has a compressive effect, reducing the diameter of the veins within the lower leg and, due to the positioning of the valves in the veins, forcing the venous blood to return to the heart[19]. This results in a decrease in the volume of blood held locally and helps to produce a more normal venous pressure profile in the leg (Figure 4, page 6). In addition, the rate of blood flow through the veins increases.

Oedema is reduced because the applied pressure allows less fluid to leak out of the capillaries and encourages more fluid to be reabsorbed into the vascular and lymphatic systems. Together these actions may prevent or reverse some of the mechanisms that may contribute to the development and delayed healing of VLUs.

It is generally acknowledged that movement and exercise are positive predictors of outcome in VLUs[20]. By working against the leg muscles and containing the pressure created within the limb, compression systems with a high SSI are able to demonstrate more pronounced effects during exercise (the pressure peaks are higher and the troughs are lower) than with elastic materials, ie the working pressures are higher and the resting pressures are lower (Figure 7).

Figure 7: Interface pressure variations during walking with elastic and inelastic materials



The peaks and troughs relate to muscle activity in the leg[2]. Note: the pressure range depends on application tension

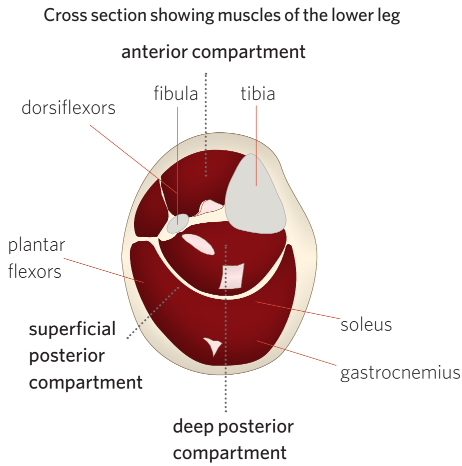
KEY PRINCIPLES

- Compression therapy has two mechanisms of action: a static effect or resting pressure and a dynamic effect due to the changing circumference of the leg during walking
- Applying external pressure will increase pressure in the limb. This will be distributed evenly, according to Pascal's Law
- The greater the pressure increase in the lower limb, the greater the force that pushes the fluid out of the limb

Figure 8: Muscle activity and changes in pressure

Each pressure peak during exercise relates to contraction of the calf muscles (gastrocnemius and soleus) during plantar flexion.

The dorsiflexor muscles are smaller so their increase in bulk during contraction is not as great as the muscles used during plantar flexion, hence the drop in pressure at that point in the walking cycle.



Common terms explained
Plantar flexion: movement of the foot that increases the angle at the front of the ankle
Dorsiflexion: movement of the foot that decreases the angle at the front of the ankle

In clinical practice, the higher standing and working pressures of inelastic systems may mean that oedema resolves more quickly and the bandage(s) will become loose more quickly as the leg circumference reduces. In addition, there are no elastomeric fibres in the system to maintain bandage position. This loosening might be expected to mean that the system loses efficacy in improving venous return. However, when compared with elastic materials, inelastic compression bandages continue to provide haemodynamic benefits over a week despite a significant reduction in the pressure produced[21].

KEY PRINCIPLES

- Bandages with a high SSI (inelastic) are able to remain rigid due to their lack of extensibility. This allows them to generate intermittent high working pressures and low resting pressures (improving both comfort and effectiveness of calf muscle pump)
- Bandages with a low SSI provide constant pressure, maintaining a therapeutic level of compression at rest, but with less marked changes in pressure during exercise

Factors affecting the interface pressure

It is widely stated that compression therapy should be applied so that the pressure at the ankle is higher than that over the calf[6]. In theory, if the compression bandage is applied at the same tension all the way up the lower leg, a gradual reduction in pressure from ankle to knee (known as graduated compression) will occur automatically. This is because the circumference of the limb is larger at the calf (producing a lower pressure) than at the ankle (higher pressure). The impact of these variables is defined by the principle known as Laplace's Law.

This law can help us to understand how the interface pressures will vary according to the limb size (radius of curvature) at the ankle and calf, characteristics of the compression materials used, bandage width, the degree of overlap/number of bandage layers and degree of tension applied[2] (Figure 9).

It is possible to predict the effect of changes in one of the variables that affect pressure beneath a compression therapy system if it is assumed that all the other variables stay the same. For example, if the same width of bandage, using the same number of layers or overlap of bandage is applied to a limb of the same circumferences with increased tension, we can predict that the interface pressure will increase.

Figure 9: The interaction of factors that affect the pressure produced by a compression therapy system — Laplace's Law

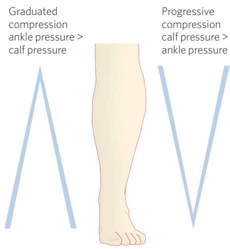
higher the bandage tension ↓

smaller the limb circumference → **greater the increase in interface pressure** ← greater the number/ overlap of bandage layers

↑ smaller the width of the bandage

Time to rethink compression?

In clinical practice, because interface pressures are rarely measured, graduated compression has not often been demonstrated. Recently, there has been research to suggest that achieving high pressure over the calf muscles alone may be a more effective approach to improving venous pump function than ensuring graduation of pressure[22,23]. However, to achieve high calf pressures would require very high ankle pressures if graduated compression were used, which may cause pressure damage over the bony prominences of the ankles. It has therefore been suggested that lower ankle than calf pressures might be used — this is known as progressive compression[24]. More research is required to evaluate such an approach with regards to efficacy in VLU healing, oedema reduction and adverse events[23].



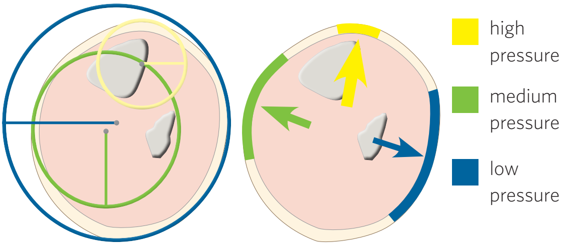
Pressure damage and limb circumference

Compression bandages can cause tissue damage if applied incorrectly. The relationship between limb circumference and pressure can help to explain the occurrence of pressure damage over bony or tendinous prominences in the lower limb, as described by Laplace. Limbs are irregularly shaped in cross section. The curves that make up the irregular shape can be thought of as being parts of a series of imaginary circles (Figure 10)[25]. For the areas of the limb corresponding to the smaller circles, the pressure produced by the compression therapy system will increase.

This explains why the tibial crest, the prominent anterior edge of the tibia that runs the length of the lower leg, is particularly vulnerable to pressure damage. The tibial crest is more sharply curved than the muscles at the back of the leg (which have a flatter curve) and so the pressure is higher over the tibial crest. Similarly, because the lateral aspect of the medial malleolus has a small radius of curvature, the bandage would apply high pressure at this point, but none to the tissues immediately behind (Figure 11).

Application of padding to areas at risk of pressure damage can help to flatten out the curve and decrease the amount of pressure applied by the compression therapy system.

Figure 10: Cross sections through the lower right leg showing how different pressures may be generated according to the radius of curvature of the leg



The radius of curvature is the distance from the centre of the circle to its surface (shorter the distance the smaller the radius of curvature)

Figure 11: Medial malleolus and gap

Without padding around the medial malleolus, a bandage would apply high pressure to the bony prominence and no pressure to the tissues immediately posterior

KEY PRINCIPLES

- When bandages are applied with the same tension to the lower leg, the pressure will be highest at the ankle and gradually decrease up the leg — this is known as graduated compression
- The circumference of the limb inversely affects the pressure under the bandage (interface pressure). The smaller the radius of curvature of the area (bony prominence), the greater the likelihood of pressure damage
- Applying a compression bandage to a large leg needs high tension. Care is needed when applying bandages to a slim leg to avoid pressure damage

DEFINING THE IDEAL COMPRESSION THERAPY SYSTEM

Understanding the principles of how compression therapy works allows the most important properties of the ideal compression therapy system to be described (Box 2).

Box 2: Properties of the ideal compression therapy system (adapted from ref[26])

- Incorporates inelastic component
- Conformable, ie produces a good anatomical fit
- Allows full functionality and movement
- Comfortable at rest
- Easy to apply and adapt to a range of limb sizes and shapes
- Non-allergenic and durable

Inelastic component

Compression therapy systems that incorporate an inelastic component have a high SSI that provides an unyielding, but flexible cast around the limb. Such systems produce the greatest variations in interface pressure during walking — the so called massaging effect — and are thought to be more effective at aiding venous return than elastic systems[27]. However, the variations in pressure are reliant on calf muscle movement, eg during walking or dorsi-/plantar flexion (see Figure 8, page 10).

In patients with reduced motor function in the lower leg, passive movement will to some extent mimic the changes in calf width (and hence interface pressure changes) that occur during walking and can be incorporated into the care plan. For patients with restricted ankle mobility, walking may still be encouraged and exercises to improve range of movement at the ankle may also be useful[12].

Conformable

Compression therapy systems need to be conformable to be applied effectively to a range of limb sizes and shapes, while offering therapeutic levels of compression without the risk of damage. For example, a two-layer cohesive system can be used even on highly misshapen limbs. This is because the cohesive properties allow the bandage to be shaped to the limb by cutting during application, restarting anywhere on the limb, and filling any gaps in the application afterwards.

Allows full functionality and movement

The effectiveness of inelastic compression therapy systems in improving venous return are highly reliant on volume changes in the calf muscles during movement of the lower leg, eg through walking. Compression therapy systems therefore need to be as adaptable and thin as possible to facilitate movement, and to minimise impact on quality of life by allowing continuation of exercise and usual activities, and the wearing of normal clothes and shoes[2].

Comfortable at rest

Concordance with compression therapy is important in improving outcomes in patients with VLUs[28]. Although patients are often able to tolerate high pressures during movement, when at rest, high pressures may be uncomfortable and even unsafe. Poor tolerability may contribute to reduced concordance, which reduces healing rates and may double the time to complete healing[8,29].

Non-allergenic and durable

Ease of use and adaptability to a range of limb sizes and shapes will aid application of the compression therapy system for maximum efficacy and minimal risk of adverse events. Some patients may develop skin allergies while wearing a compression therapy system made with latex. Latex-free versions should be offered to individuals at risk.

The compression system needs to be durable and allow patients to perform their daily activities. Any slippage in the bandage system will result in a loss of tension and fit, reducing its effectiveness. In addition, there is a risk of damage to fragile skin. Various factors may increase slippage including the composition of the compression materials used, the application technique, the lifestyle of the patient and the shape of the limb itself. Avoidance of slippage will itself enhance concordance and efficacy, while helping to avoid adverse events from ridges in the bandages pinching the skin or by gaps allowing the skin to 'balloon' through. Specialist techniques for application should be considered or made-to-measure hosiery selected if slippage is a particular problem.

TIPS FOR USING COMPRESSION THERAPY

Successful compression therapy is dependent on a number of patient- and practitioner-related factors. For example, patients must be prepared and able to wear compression therapy. This requires that they understand the importance of the treatment, that it is tolerable and does not impinge significantly on their daily lives.

It is important that practitioners understand how a bandage works, which product to select for which patient, how to apply it correctly and adapt it when necessary. Any bandage — even a simple retention bandage — if applied incorrectly is unsafe.

Local protocols regarding assessment, application and review of compression therapy should be followed. The tips below, while not a comprehensive list, provide general guidance intended to highlight some important issues.

Conduct a full assessment

Before application of compression therapy, patients should receive a full, documented assessment that includes evaluating peripheral blood supply by measuring Doppler ABPI[30,31]. In addition, a full assessment of the patient's neurological status, cardiac status, skin condition, extent of oedema, limb shape, level of mobility and allergies will inform the treatment plan [8,26,31]. Recent guidelines that focus on the importance of treating the underlying disease suggest early referral for a vascular opinion in all patients with CEAP C_4 disease and above (ie changes in skin and subcutaneous tissue prior to development and following development of an ulcer)[32].

Be clear on the indications for specialist referral

Patients with an ABPI <0.8, diabetic foot ischaemia/neuropathy or cardiac failure require specialist referral for further assessment before compression therapy can be considered[6]. Additional bandaging skills will be needed when managing patients with abnormal limb shape, abnormal peripheral circulation, skin problems and previous bandage-related problems.

Follow the manufacturer's instructions for use

Indications/contraindications, method of application and care of compression therapy systems may vary between manufacturers. Bandages should be applied with maximum dorsiflexion of the ankle (toe towards the nose).

Ensure compression over the calf muscles

It is tempting to slacken the bandage when ascending the leg to achieve graduated compression. However, this is not necessary as the pressure will naturally be lower because of the increased circumference of the calf. As the calf muscle pump is responsible for a significant proportion of venous return from the leg, it is important to ensure that sufficient pressure is applied over the calf muscles.

Use padding if required

Additional padding may be required beneath a compression therapy system to adjust shape and protect an area at risk of pressure damage or to manage excessive exudate. Although sufficient padding should be used to prevent damage/absorb exudate, it is important to be aware that the padding will increase limb circumference and so reduce the level of compression and SSI, resulting in a decline in the working pressures (and so efficacy of) the compression therapy system. This may also increase exudate production, resulting in problems with tissue protection.

New two-layer compression systems now incorporate bandage textiles that reduce the need for additional padding. This allows for a less bulky system which will aid patient mobility.

Figure 12: Applying padding to tibial crest

The purpose of additional padding over a bony prominence is to reduce pressure to that area. This is best achieved by using the padding to 'round off' the prominence, ie the padding should be used mainly to pad around the prominence, not just over it. This will mean that the bony prominence becomes a smoother shape and protrudes less. The effect of this change in shape will be to reduce the pressure applied to it by a compression therapy system.

Padding around a bony prominence will change the shape of the prominence and reduce the pressure exerted on it by a compression therapy system.

Use compression hosiery to prevent recurrence

Compression hosiery remains the mainstay of preventing recurrent VLUs. Accurate measurement of the limbs according to the manufacturer's instructions will ensure selection of the correct size of hosiery[2]. It is also important to provide effective aids for application where appropriate to increase patient concordance and effectiveness. Patients need to be encouraged to exercise for improved ankle mobility and calf muscle function and/or be referred for vascular surgery to restore blood flow[32].

Referral to vascular specialist

Referral to vascular services for lower limb revascularisation is recommended for patients with peripheral artery disease (eg low ABPI). Patients with VLUs may also benefit from correction of venous reflux using surgical or minimally invasive procedures (eg foam sclerotherapy), which may assist healing and help prevent recurrence.

Document compression

The type and manufacturer of the compression therapy system should be documented, along with notes on any modifications made or difficulties encountered during application.

Reassess regularly

Patients should be reassessed regularly for suitability and tolerability of the current compression therapy system and concordance with treatment. This should identify any potential problems that may affect healing or recurrence such as pain, signs of pressure damage or impact on circulation and slippage.

Reassessment provides the opportunity for the clinician to review the safety and efficacy of the treatment, and to make adjustments as appropriate. For example, if lower leg swelling or oedema is not diminishing, but there are no adverse effects on the circulation or skin and the patient is concordant with treatment, it may be appropriate to consider reapplying the compression system with a higher pressure. Conversely, if the skin, circulation or concordance are compromised, consideration of a reduction in pressure or change in type of compression therapy system may be required.

Patients using hosiery should be advised to examine their legs for skin breaks, swelling and other changes and report these to their healthcare practitioner (see Appendix A).

Ensure good skin care

Although compression therapy is the mainstay of treatment and prevention of VLUs, it should be combined with good lower limb skin care and advice regarding limb elevation.

Optimise concordance

Adherence to compression therapy will be influenced by numerous factors including the patient's understanding of the rationale for compression therapy, control of symptoms such as pain or wound leakage, psychosocial issues, disruption to daily living and aesthetic issues[29,33,34]. Involvement of patients in treatment planning and type of compression used, provision of information and regular review will help to avoid issues that might compromise concordance.

When choosing a compression system, it is important to discuss the options with patients and understand their preferences. In addition, training of staff in the methods of application are important in applying effective levels of compression — providing a balance between exerting too little pressure, which is ineffective, and too much which the patient is not able to tolerate.

COMPRESSION THERAPY MYTHS

Myth: Compression therapy is required only directly over the VLU

The pathology underlying VLUs is high pressure within the venous system (venous hypertension). The high pressure is therefore not just present in and immediately around the VLU, and treatment to reduce venous hypertension is needed more widely over the lower leg, especially the calf muscle area.

Myth: Compression therapy is not needed once the VLU has healed

Even when a VLU has healed, the underlying problem that gave rise to the wound — high pressure in the venous system — remains. Ongoing compression therapy to reduce venous pressure is therefore required to prevent recurrence of the VLU and development of further wounds.

Myth: All patients with even mild arterial disease should not have compression therapy applied

The decision about whether or not to apply compression therapy in patients with peripheral arterial disease is related to the degree of arterial compromise. Most guidelines use ABPI as a measure of severity: compression therapy with bandages or hosiery is contraindicated in patients with ABPI <0.5 (critical ischaemia) and used with caution or at reduced pressures (modified compression) in patients with ABPI 0.5–0.8 [26]. Recent research has found that inelastic bandages with compression pressures of up to 40mmHg are able to increase arterial flow and venous pump function in patients with mixed ulcers and ABPI 0.6–0.8[35]. However, local protocols on the application of compression to patients with peripheral arterial disease and when to refer for specialist assessment should be followed[24].

Myth: Compression bandages should always be applied so that the pressure at the ankle is higher than over the calf, ie pressure is graduated

Ensuring graduation of pressure, so that the pressure produced by a compression therapy system is higher at the ankle than over the calf, has been an underlying principle of compression therapy for many years. Clinical observation may indicate that it is pressure over the calf muscle that delivers the efficacy of compression therapy and that ensuring sufficient calf pressure is more important than achieving graduated compression[35]. However, further research is needed.

Myth: Inelastic bandages produce lower pressures than elastic bandages

Inelastic bandages produce high working pressures and low resting pressures. The application technique will affect the level of compression applied to the limb. Inelastic bandages should be applied with a higher resting pressure than elastic bandages to allow for the initial decrease in limb size and to maintain haemodynamic benefits (see page 10).

Myth: Patients with reduced ankle mobility should only be bandaged with elastic bandages because inelastic bandages will be ineffective

The action of inelastic bandages is related to peaks in pressure within the calf muscles achieved when the muscles contract during ankle movement. It has therefore been suggested that patients with reduced ankle mobility should receive only elastic bandages that provide a constant level of pressure even in the absence of calf muscle contraction. However, when an inelastic system is used, it is still possible to achieve periods of pressure change through passive movement of the ankle.

CONCLUSION

Compression therapy undoubtedly improves outcomes for patients with current and healed VLUs[8]. By understanding how compression therapy works and how it can be used most effectively to achieve sufficient compression over the calf muscles while avoiding adverse events, practitioners can maximise the benefits their patients receive. This document has explained why it is important to ensure adequate pressure over the calf muscles and why inelastic compression therapy systems are thought to be more effective at improving venous return than elastic systems.

Questions for research

Although venous disease has been studied since Hippocrates, we still do not have all the answers. Compression therapy systems are still evolving as is our understanding on how to manage patients with venous disease. Current uncertainty around the ability to demonstrate graduated compression and improved understanding of the principles of compression have given rise to the following questions that may be addressed by future research:

1. Is compression over a VLU itself necessary for healing?
2. How do VLU healing rates and adverse event rates compare between progressive compression and graduated compression systems?
3. If the calf muscle is the most important area for compression therapy systems to apply pressure, is compression over the ankle and foot necessary?
4. How can practitioners quickly and easily measure interface pressure in routine practice and what is the optimal interface pressure (supine, standing, exercise) to achieve maximum efficacy and tolerability

APPENDIX A: COMPRESSION PRINCIPLES FOR PATIENTS

These principles can be used by practitioners when discussing the role of compression in the management of venous disease to help improve concordance and outcomes.

- Wearing compression therapy bandages or stockings will help your venous leg ulcer to heal or if already healed will help prevent another one occurring.
- If you have any problems with the bandages or stockings, report the problem to the person who applied the bandage or to your doctor or nurse as soon as possible.
- If you experience any of the following, take the bandage/stocking off and report the problem to the person who applied the bandage or to your doctor or nurse as soon as possible:

  – the skin is pinched or made sore by the bandage or stocking
  – you lose sensation in any part of your leg or foot
  – your toes go pale and cold or dusky coloured.
- If you have been experiencing pain whilst wearing your compression therapy or the level of pain increases suddenly, report the problem to the person who applied the bandage or to your doctor or nurse as soon as possible.
- Movement, in particular walking, is very good for you when wearing compression bandages or stockings and helps them to work at their best. When you are sitting, flexing your ankles and wriggling your toes will help too. If you are unable to move your ankles, it can be helpful to ask someone else to flex your ankle gently several times daily.
- When sitting, put your legs up to help any swelling go down and to aid healing. This should be done when wearing compression bandages or stockings.
- If you have compression stockings and have been advised to take them off at night time, it is best to put them back on before you get out of bed in the morning to help prevent swelling.
- If you have compression stockings and are finding them difficult to put on, report the problem to the person who prescribed them and they will be able to give advice and provide any aids that are appropriate.
- If you are wearing compression stockings, check the skin on your legs, feet and heels whenever you take your stockings off.
- When you first start treatment with bandages, you might notice that they become looser after a few days. This is because some of the swelling has gone down and is to be expected. If the bandage becomes very loose, report the problem to the person who applied the bandage as soon as possible.
- Your compression bandages or stockings need to be kept dry. Devices to help with this during bathing/showering are available from your practitioner.

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