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Demystifying mild, moderate and high compression systems – when and how to introduce "lighter" compression

Unravelling the history of compression

Clarifying "lighter" compression

Compression tips for practical application

Wounds International

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Compression therapy remains the treatment of choice for venous leg ulcers and, in mixed ulcer aetiology, mild compression has an important role in treatment, increasing both venous return and improving arterial perfusion. However, data would indicate that the tools required to assess patients before the application of compression, such as the Ankle Brachial Pressure Index (ABPI) calculation are often either delayed or not performed in many patients with lower limb ulceration.[1,2] It is unclear whether this relates to skill, equipment availability, available time or patient preference.[2]

In the UK, the draft lower limb recommendations from the National Wound Care Strategy Programme Group (2019) focus on improving the uptake of compression therapy and propose new recommendations for lower limb wounds to avoid delayed treatment[3]. Initial discussions suggest that the group favours the early introduction of first-line, mild graduated compression (up to 20mmHg) prior to full assessment of a patient with a lower limb wound providing "red" flag conditions are excluded (e.g. severe peripheral arterial disease, a suspected new or acute deep vein thrombosis (DVT), a skin cancer or an acute infection).

It has been suggested that mild compression may only be suitable for less than 10% of a caseload and can be used inappropriately, especially when full compression is clinically indicated.[4] The recommendation may also shift focus away from the aim of getting the majority of patients with venous ulceration into moderate-to-strong compression as early as possible.[5] This provides an opportunity to revisit the principles of compression therapy and provide clarity in relation to understanding factors that influence sub-bandage compression levels and how to safely deliver effective compression.

This position document aims to challenge the tradition of pressure level categorisation for compression and aims to present a better understanding of how to select and deliver safe and effective compression for lower leg wounds, in particular in patients with mixed arterial disease. The goal is to move towards a more holistic and individualised patient-centered approach.

The first article provides a brief history of compression, the terminology used to describe compression therapy and the current challenges around how much pressure is delivered in practice. This includes a call for better understanding of what different compression systems offer, outlining the challenges to using arbitrary figures for sub-bandage pressure and ABPI and an understanding of the factors that affect pressure delivery.

The second article focuses on the introduction of the term — 'lighter' compression — as a safe way to introduce compression early in presentation. Lighter compression describes compression that is less than 40mmHg, and so combines the categories of mild (<20mmHg) and moderate (20–40mmHg) compression. Lighter compression is indicated in several clinical situations, such as in the initial stages of venous disease, when a venous ulcer is healed and recurrence prevention is necessary, in mixed aetiology disease and in the lymphoedema maintenance phase.

The final article offers a practical focus for using lighter compression (<40 mmHg) with helpful tips and tricks, and case studies to illustrate best practice when using 'lighter' compression.

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Unravelling the history of compression, understanding compression levels and what compression offers

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Compression therapy is one of the most important therapeutic procedures in chronic venous disease and it is indicated in all symptomatic stages. Compression may be applied by different devices: elastic and inelastic bandages, elastic stockings, adjustable compression wraps and pneumatic pumps. Different compression options may be suitable for different patients, depending on the clinical challenges present – in this article we will focus on compression bandaging.

Reports of the use of bandages and other simple forms of compression therapy by Hippocrates date back to the 4th Century BC.[1] Early bandages were made of non-extensible fabrics and were not suitable for the application of sustained graduated compression.[2] The introduction of elasticated bandages in the middle of the 19th Century allowed greater functionality to be introduced into bandages and, in 1878, Callender reported their use in the management of ulcers and varicose veins.[3] One of the earliest forms of "modern" compression therapy developed was Unna Boot, an inelastic compression system developed in 1896.[4,5] Even now compression remains the gold standard of conservative treatment for venous leg ulcers (VLU)[6] with high compression (40mmHg) systems remaining the treatment of choice.

MODE OF ACTION OF COMPRESSION

As our understanding of the mode of action of compression has developed and new materials have been introduced so too has the effectiveness of compression as a treatment method for lower limb venous disease improved. Blair *et al* published a comparison of a four-layer bandage system with traditional bandaging and demonstrated improved sustained compression and ulcer healing.[7] Since then numerous studies have been published demonstrating the effectiveness of alternative multi-layer compression systems.[8-11] The clinical effectiveness of these systems is similar and choice is often based on cost effectiveness, nursing preference, clinical status of the wound such as exudate levels and patient acceptability.[9,12] One thing that is clear is that healing outcomes are better with compression than without,[6] although even this fact which underpins modern therapy for venous ulceration has been challenged.[13] In this paper, the authors found that the healing rate of non-healing VLUs of >3 months' duration in the no-compression groups was double that of VLUs in the compression groups[13] questioning the effectiveness of application of compression in these patients.

Regulating and maintaining a graduated sub-bandage (interface) pressure is critical if compression is to be successful in treating venous leg ulceration although even this is being challenged by the concept of progressive compression.[14] The two laws of physics that apply to the application of compression therapy are outlined in Box 1.[15,16] Much of the work supporting the use of graduated compression was based on theoretical mathematical equations and this has not been supported by experimental studies.[15,17]

A variety of methods exist for measuring interface pressure (the pressure between the compression system and the limb) but there is no agreement as to the best or most clinically relevant measurement protocol.[18]

Box 1: Pascal's and LaPlace's Law[15,16]

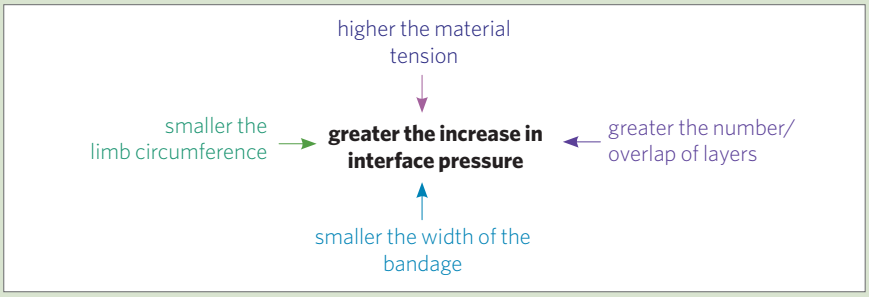
Two physical laws apply to the application of compression therapy:

1. **Pascal's Law[16]:** external static pressure exerted on a confined fluid (the limb) is distributed evenly.
2. **LaPlace's Law[15]:** Pressure applied by compression is proportional to the tension at the interface with skin and inversely proportional with limb radius: Pressure (mmHg) = (Tension [KgF] x number of layers x 4620) / (Circumference [cm] x Bandage width [cm]).

These laws have several implications that are the basis of modern compression therapy:

1. Each additional layer increases the interface pressure. Increased applied pressure reduces vessel radius increasing flow rate and potentially decreasing reflux by restoring valvular competency.
2. The normal limb shape, often described as an inverted cone, has an increasing radius from ankle to knee, which means that the same tension applied at the ankle will generate more pressure than if applied at the calf.

How bandage and limb factors interact to affect the pressure produced by a compression system:



For example, although sub-bandage pressure may be varied by the application of a bandage, such as adjusting the stretch or the number of layers[19], the relationship is complex. Sub-bandage pressure is influenced by bandage material, tension, radius, number of layers and surface hardness of the leg, which varies between bone with minimal soft tissue covering over the shin to soft muscle in a relaxed calf.[20]

Compression dosage (mmHg) is only one factor influencing the haemodynamic efficacy of compression therapy. In addition to dose, the bandage type has to be selected to match the disease pathology and level of activity of the patient.[21-22]

COMPRESSION CLASSIFICATIONS AND PRESSURE

When describing the level of compression applied to a limb, whether by hosiery or bandages, the following terminology should be used:[23,24]

- Mild (less than 20mmHg)
- Moderate (20–40mmHg)
- Strong (40–60mmHg)
- Very strong (greater than 60mmHg).

In general, strong compression (>40mmHg) is recommended for the treatment of venous leg ulceration. For some patients however, factors such as mild arterial disease, neuropathy or cardiac failure render strong compression potentially harmful or painful and mild or moderate compression may be required (Box 2).

Compression bandages are further categorised according to their ability to generate and maintain a predetermined level of compression at the ankle on an "average" leg i.e. the limb of a person of normal height and weight without overt disease present[31] (Table 1).

Box 2: Mild compression indications

Mild compression is recommended for a range of lower limb wounds (e.g. skin tears[25-27]) and is recommended in the yet to be published draft leg ulcer guidelines produced by the National Wound Care Strategy Group in the UK.[28] The National Wound Care Strategy Group favours the early introduction of mild compression (up to 20 mmHg) prior to full assessment of a patient with a lower limb wound providing "red" flag conditions are first excluded such as severe peripheral arterial disease, a suspected deep vein thrombosis (DVT), a skin cancer or an acute infection.[28] Following a DVT, once a patient is mobilised and stable on anticoagulant therapy compression therapy can be safely instigated.[29-30]

Table 1. Classification of bandages

Class	Bandage type	Bandage function
1	Lightweight conforming	Generates very low levels of sub-bandage pressure – used for dressing retention
2	Light support	Generates moderate levels of compression
3a	Light compression	Exerts a pressure range of 14–17 mmHg at the ankle
3b	Moderate compression	Exerts a pressure range of 18–24 mmHg at the ankle
3c	High compression	Exerts a pressure range of 25–35 mmHg at the ankle
3d	Extra high compression	Exerts a pressure of up to 60 mmHg at the ankle

There are two main types of bandage, inelastic/short-stretch bandages and elastic/long-stretch bandages. Bandages are often used in combination to form a compression system. The resulting multi-layer bandage system may consist of elastic bandages but performs as an inelastic system forming a "stiff" container for the limb, such as the four-layer bandage and other multi-layer bandaging systems.[32] The practical aspects of bandage classification and description have been outlined elsewhere.[23]

A short-stretch 2-layer compression system (3M™ Coban™ 2 Lite Two-Layer Compression System) has been demonstrated to be safe and well-tolerated in patients with moderate peripheral arterial disease as defined by an Ankle Brachial Pressure Index (ABPI) of 0.5–0.8.[10] Patients with more severe arterial disease should not receive compression.[33] Ongoing research (see below) challenges the present recommendations in relation to ABPI, shifting some contraindications into a list of potential indications for compression therapy.[34]

- **Patients with severe arterial disease should not receive compression.[33]**
- **Strong compression (>40mmHg) is contraindicated for patients with mild arterial disease, neuropathy or cardiac failure.**
- **Mild or moderate compression may be suitable for these patients and has been supported in the literature.[10,34-36]**

GUIDELINES AND ANKLE BRACHIAL PRESSURE INDEX

Current guidelines recommend that a patient assessment be undertaken including an ABPI to exclude significant peripheral arterial disease before considering introducing compression therapy.[37-38] Despite these recommendations, data would indicate that ABPI is either delayed (In the UK, NICE stipulates that the ABPI should be undertaken within 2 weeks to avoid treatment delay), not recorded accurately or not performed in many patients with lower limb ulceration, including those receiving compression.[39-40] It is unclear whether this relates to skill, equipment availability, available time or patient preference.[40] Automated ABPI equipment may overcome some of these problems, providing correct methodologies are followed and absolute ankle pressure as well as the ABPI are available to clinicians to assess treatment suitability.[41]

The methodology for undertaking ABPI calculation and the rationale for the use of ABPI in defining compression levels for patients with lower limb ulceration have been outlined elsewhere.[42-43] The role of ABPI as an assessment tool has been debated and the relationship between a defined level of ABPI and an exact cut-off for the level of compression likely to be tolerated has been questioned.[41] There is also disagreement within the global clinical practice guidelines in relation to absolute levels of ABPI and compression.[44] However ABPI remains the gold standard against which other methodologies are judged.

ABPI is the main way to exclude significant peripheral arterial disease before considering introducing compression therapy.[37-38] However, there is debate on the role of ABPI as an assessment tool and disagreement within the global clinical practice guidelines in relation to the levels of ABPI and compression.[44] Systolic pressure at the ankle and differences in systolic pressure between vessels at the ankle may be of more relevance when predicting which patients may be at risk from compression therapy.[35,42]

SHIFTING COMPRESSION CONTRAINDICATIONS IN RELATION TO ARTERIAL DISEASE

Rabe *et al* have published an international consensus statement outlining the risks and contraindications of a wide range of lower limb medical compression systems and provides clear guidance as to when to avoid applying any form of compression therapy.[30] A range of physiological parameters (ankle pressure <60mmHg; toe pressure <30mmHg) exclude patients with severe peripheral arterial disease from receiving any form of compression therapy other than intermittent pneumatic compression therapy. Rabe *et al* also emphasise that patients with peripheral arterial disease and higher ankle or toe pressures than those listed above may be suitable to receive compression therapy with a low resting pressure.[30] Such bandaging may actually improve leg pulsatile blood flow rather than diminish perfusion.[30,45]

Patients with peripheral arterial disease and ankle pressures >60 mmHg or toe pressures >30 mmHg may be suitable to receive compression therapy with a lower resting pressure.

COMPRESSION, STIFFNESS AND FUNCTION

When compression is applied to the lower leg, it must be taken into account that the leg is a dynamic system and the lower limb shape changes with muscle contraction. When this occurs within a "stiff" compression system distinct resting (constant) pressures and working (intermittent) elevated interface pressures are generated.[46]

The Static Stiffness Index (SSI) is the difference between the working (standing, walking and exercise) and resting (supine) pressures. For example, if the supine pressure is 40 mmHg and the standing pressure increases to 55 mmHg the SSI is 15 mmHg. This is measured by recording the pressure at the interface between the compression therapy system and the skin (the interface pressure):

- **Supine pressure**: Measurement is taken on the leg when level with the heart, preferably with the person lying down and the knee and ankle joint relaxed.
- **Standing pressure**: Measurement is taken 2-3 minutes after standing allowing the leg veins to fill.

Whereas the SSI looks at how the compression system reacts to muscular activity (lying to standing) the Dynamic Stiffness Index (DSI) demonstrates a system's ability to resist calf muscle expansion and generate intermittent pressure increases. The DSI is defined as the change in pressure when a person activates their calf muscle through movement, such as walking or exercise.

The more elastic or extensible a bandage or bandage system, the lower the pressure peaks during exercise. Inelastic bandages and multi-layer bandage systems generally have a higher SSI when compared to compression hosiery. Figures 1 and 2 provide a diagrammatic representation of working and resting pressures and SSI.[46-47]

Research does however suggest that achieving high pressure over the calf muscles alone may be an alternative and effective approach to improving venous pump function,[48-50] particularly as true graduated compression is difficult to obtain in practice.[51] To achieve high calf pressures would require very high ankle pressures if graduated compression were used, which increase the risk of pressure

damage over the bony prominences of the foot and ankles. It has therefore been suggested that lower ankle than calf pressures might be used — this is known as progressive compression. To date, few studies have focused on the use of progressive compression, either with bandaging or hosiery, in the treatment of venous ulceration.[14] Work by Couzan *et al* would however indicate that this form of compression is well tolerated in the presence of peripheral arterial disease.[52]

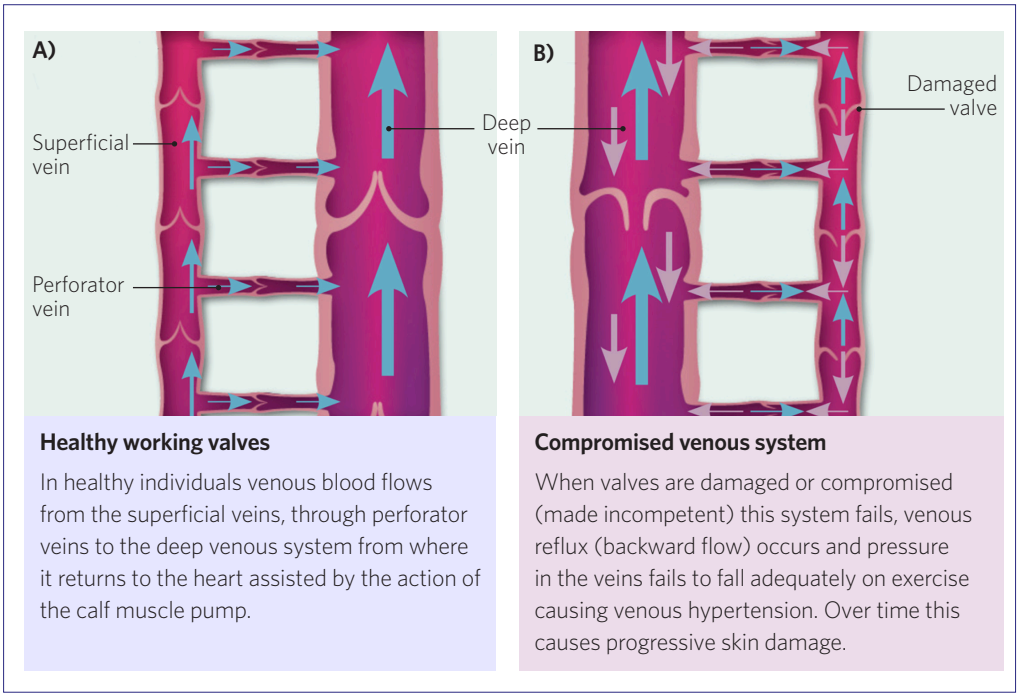


Figure 1: Venous reflux and the mechanism of action of compression bandages and hosiery. (A) Venous return in normal individuals and (B) in patients with incompetent venous valves (adapted from [47]).

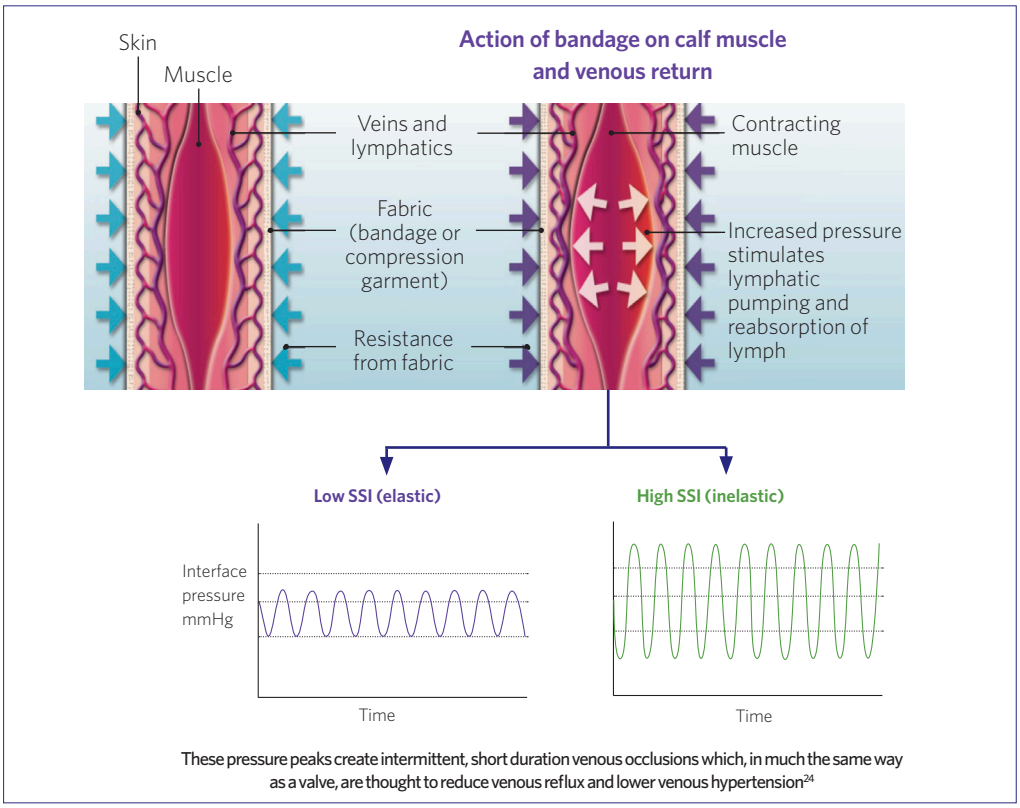


Figure 2: Action of bandage on calf muscle function and venous return (adapted from [22])

- At rest, the bandage system applies a constant pressure to the skin (resting pressure).
- When muscles contract (e.g. during walking), they expand, increasing the sub-bandage pressure temporarily (working pressure).[46]

When using compression to manage venous disease, the bandage system, hosiery or adjustable wrap is designed to enhance venous function and improve venous return by providing an inelastic barrier against which muscle pump action can work to aid venous return even in the presence of incompetent venous valves. In a normal individual the hydrostatic pressure within the veins at the ankle vary according to position and level of activity as outlined in Figure 3. In the presence of venous reflux, the expected fall in venous pressure at the ankle does not occur and gives rise to venous hypertension, the primary causative factor in gaiter region skin changes and ulceration.

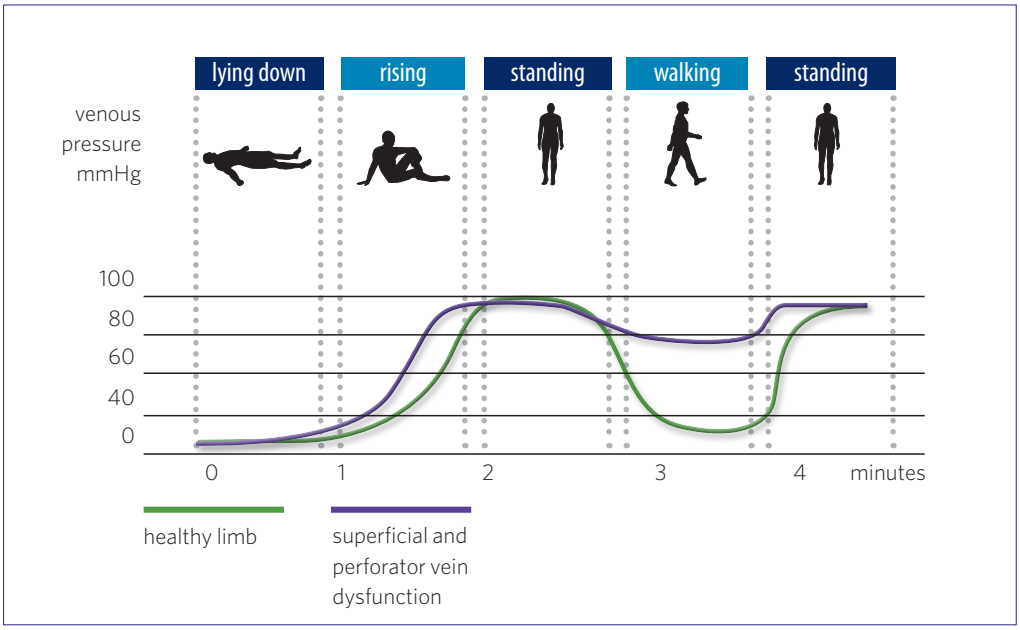


Figure 3: Changes in pressure (measured at the ankle) in the venous system in legs with healthy and defective venous valves during lying, rising, standing and exercise. (adapted from [22])

APPLICATION TO PRACTICE

Compression systems generating >10 mmHg difference between supine and standing pressures are classified as having higher stiffness (inelastic), whereas <10mmHg indicate low stiffness typically observed with elastic materials.[53] When clinical or psychological intolerance prevents the use of strong compression, stiff, moderate compression systems such as Coban 2 Lite compression system can provide a safe and effective compression for patients with an ABPI >0.5.[10,54-56] Systems such as Coban 2 Lite compression system can provide tolerable compression during rest, counteract the gravitational effect of standing and generate high-pressure peaks during exercise narrowing leg veins and reducing oedema safely (Figure 4).

TRAINING AND SUB-BANDAGE PRESSURES

For compression bandaging to function successfully the individual components of any bandage system must be correctly selected, must match the limb size and shape, and must be correctly applied. The importance of good bandaging technique was described in 600 BC by Sushruta who suggested that practitioners should practice on life-sized mannikins made of stuffed linen.[2] It has since been confirmed that training and markers on a bandage could aid correct application[57] and improve the sub-bandage pressure generated.[58] Sub-bandage (interface) pressure monitors should also be available as part of quality assurance for treatment, training of care providers and education.[59-60]

It is well known that the sub-bandage pressures of compression bandages drop over time due to oedema reduction, material fatigue and slippage, so the selected compression bandage may not provide the prescribed compression over time.[61]

Despite awareness of these training and competency issues, bandage application and training in compression bandaging remains a problem.[62] Poorly applied compression bandaging (and hosiery) increases the risk of skin damage by slippage and results in worse outcomes in terms of healing, concordance and complications[63] and users need to be fully informed of these risks.[34]

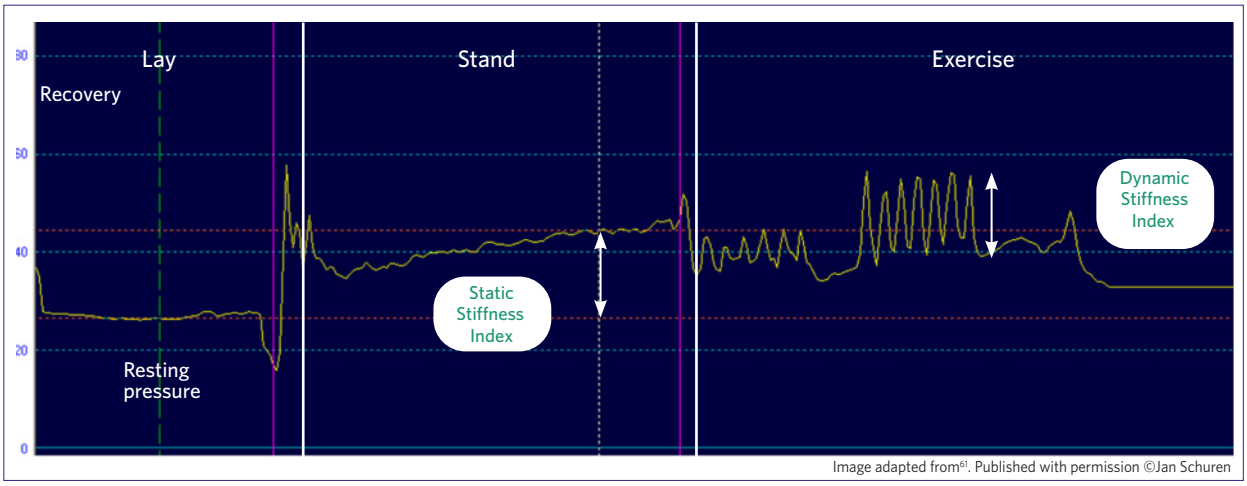


Figure 4: Changes in pressure with Coban 2 Lite compression system

Lay: Resting pressure; **Stand:** Standing pressure; **Exercise:** Working pressure
Static Stiffness Index is the difference between resting and standing pressures; Dynamic Stiffness Index is the difference in pressures when a person activates their calf muscle through movement, such as walking or exercise.

COMPRESSION HOSIERY

Bandage systems are not the only way of delivering compression. Conrad Jobst observed that external hydrostatic pressure relieved symptoms of venous insufficiency and in the 1950's developed compression hosiery to emulate those pressure effects.[64] Table 2 lists the current hosiery classification systems.

Table 2. Classification of hosiery

Class	British Standard	German RAL Standard	European Class
I	14-17 mmHg	18-21 mmHg	18-21 mmHg
II	18-24 mmHg	23-32 mmHg	23-32 mmHg
III	25-35 mmHg	34-46 mmHg	34-46 mmHg
IV		>49 mmHg	

In the UK the draft guidelines for leg ulcer management support the use of compression hosiery therapy. These guidelines favour the use of 40 mmHg two-layer compression hosiery kits as one of the primary methods of management in suitable patients, basing their conclusions on the results of the VenUS IV study.[65-66] Hosiery kits are available off-the-shelf, using a two-to-three point measurement process. However, when a limb shape does not fit within this criteria, there will be a need to apply a seven-point measuring method to produce a made-to-measure compression garment. If fitting is not accurate, hosiery will fail to prevent oedema, maximise ulcer healing or prevent recurrence whilst increasing the risk of skin damage complications.[67]

CONCLUSION

Despite being one of the oldest and most widely practiced forms of treatment it is only recently that advances in material technology and our understanding of the pathophysiology of venous disease has provided clinicians with the necessary equipment and understanding to apply safe and effective compression therapy. These developments are ongoing; even established dogmas such as the importance of graduated compression and sub-bandage pressure measurements are being challenged by new theories and devices.

Advances have provided clinicians with a wide range of alternative compression devices and systems which now allow clinicians to offer safe compression therapy even in the presence of moderate

peripheral arterial disease. Each compression system has unique characteristics, advantages and disadvantages. The current challenge is to apply the right treatment to the right patient in a timely, safe and cost-effective way to optimise outcomes.

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Clarifying "lighter" compression: Identifying its role in clinical practice

Compression therapy is a mainstay of the conservative treatment of chronic venous disease. It can be exerted by different compression devices but must be applied with a proper pressure depending on the clinical situation. In some clinical scenarios, i.e. acute stages of venous and lymphatic disease, compression must be strong (>40 mmHg) or very strong (>60 mmHg) according to the World Union of Wound Healing Societies (WUWHS) classification, as reported in the previous paper (pages 4–12). However, many clinical situations require a lower pressure, and, for consistency, this will be referred to as "lighter" compression throughout the rest of this article. Lighter compression refers to pressure <40 mmHg and encompasses the terms of mild and moderate compression (<20 mmHg and <40 mmHg respectively). Lighter compression is adequate in several clinical situations, such as in the initial stages of venous disease, in the prevention of recurrence for a healed venous ulcer, in the presence of mixed venous/arterial aetiology, and in the maintenance phase of lymphoedema. Beyond these indications, a lighter compression can help support patient compliance and adherence to compression when strong pressure is indicated but the patient cannot tolerate strong compression. Lighter compression can act as a 'first step' for these patients so that they can ultimately tolerate a stronger therapeutic pressure.

AVAILABLE COMPRESSION SYSTEMS

Compression therapy is one of the most important therapeutic procedures in chronic venous disease and it is indicated in all symptomatic stages.[1] Compression may be applied by different devices: elastic and inelastic bandages, elastic stockings, adjustable compression wraps and pneumatic pumps. Compression devices can be divided into two main categories depending on the material used: elastic and inelastic. Elastic material tends to return to its original length when extended and the "return force" is directly related to the stretch of the bandage: the more it is stretched, the greater the return force. When extensively stretched, the elastic material compression system will exert a "squeezing" effect. This squeezing effect explains why, when applied with a strong compression pressure >40-45 mmHg, compression therapy may be painful or less tolerated. As described in the first article, elastic material allows for calf muscle expansion during exercise and has a lower Static Stiffness Index (SSI)[3] compared to inelastic material. Inelastic material exerts its effect by resisting the increase of muscle volume during standing and exercise. Inelastic materials alone, or a combination of elastic materials or both inelastic and elastic materials as in a multi-layer system can perform as an inelastic sleeve to form a semi-rigid sleeve around the lower leg, which produces a significant pressure increase during standing and exercise, overcoming the intravenous pressure and exerting a strong haemodynamic effect.

Bandage materials have different elastic and inelastic properties and as a result produce different haemodynamic effects. Compression generated by a single-layer elastic material will have a less significant haemodynamic effect than either inelastic materials or a multi-layer compression system.

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ROLE OF INELASTIC MATERIAL

Inelastic material is more effective compared to elastic material in countering the haemodynamic

impairment of venous disease. In particular it has been demonstrated that inelastic material is more effective in reducing both superficial and deep venous reflux[4,5], improving venous pumping function[6] and, as a consequence, in reducing ambulatory venous hypertension.[7]

Inelastic material systems, which offer a high SSI, are often reported as being more comfortable as they offer a lower resting pressure than a low stiffness compression system.[8-11]

When a haemodynamic effect is required for a patient (e.g. in the case of venous leg ulcers or lymphoedema treatment phase), strong compression is more effective than mild or moderate compression.[12-18] Typical clinical scenarios that require strong compression (40-60 mmHg) by inelastic systems are venous leg ulcers (C6 and C6r according to the CEAP [Clinical-Etiology-Anatomy-Pathophysiology] classification [Box 1[48]]) and during the lymphoedema treatment phase. Indeed strong compression for these indications is recommended in all recent guidelines and consensus documents.[19-28] It is necessary to be aware that failure to correctly apply strong compression may even delay the ulcer healing.[28,29]

Box 1: The 2020 update of the CEAP classification system[30-46] (underlined and italics descriptions have been added in the 2020 update)[48]

C class Description
C0 No visible or palpable signs of venous disease
C1 Telangiectasias or reticular veins
C2 Varicose veins
C2r *Recurrent varicose veins*
C3 Edema
C4 Changes in skin and subcutaneous tissue secondary to CVD
C4a Pigmentation or eczema
C4b Lipodermatosclerosis or atrophie blanche
C4c *Corona phlebectatica**
C5 Healed
C6 Active venous ulcer
C6r *Recurrent active venous ulcer*

E class Description
Ep Primary
Es Secondary
Esi *Secondary – intravenous*
Ese *Secondary – extravenous*
Ec Congenital
En *No cause identified*

A class Description
As Superficial
Ad Deep
Ap Perforator
An *No venous anatomic location identified*

P class Description
Pr Reflux
Po Obstruction
Pr,o Reflux and obstruction
Pn *No pathophysiology identified*

**fan-shaped intradermal telangiectases on the medial or lateral aspects of the foot*

In other clinical conditions, as in the case of leg oedema or symptomatic varicose vein, a 'mild to moderate' compression pressure of <40 mmHg is sufficient to reduce or resolve clinical symptoms and signs. From this definition, 'lighter' compression, meaning compression lower than 40 mmHg, corresponds to 'mild to moderate' compression according to the WUWHS[30] classification (Figure 1).

Lighter compression is a new and important term that encompasses mild to moderate compression. It can be indicated in the majority of cases of chronic venous disease: in CEAP grading C0s to C5 (i.e. telangiectasia [spider veins], varicose veins, oedema prevention and treatment, lipodermatosclerosis, healed ulcer) after vein procedures, in post-thrombotic syndrome and in lymphoedema maintenance phase.[31-47] Lighter compression is not suitable for venous disease CEAP grades C6 and C6r (active or recurrent active venous ulcer).

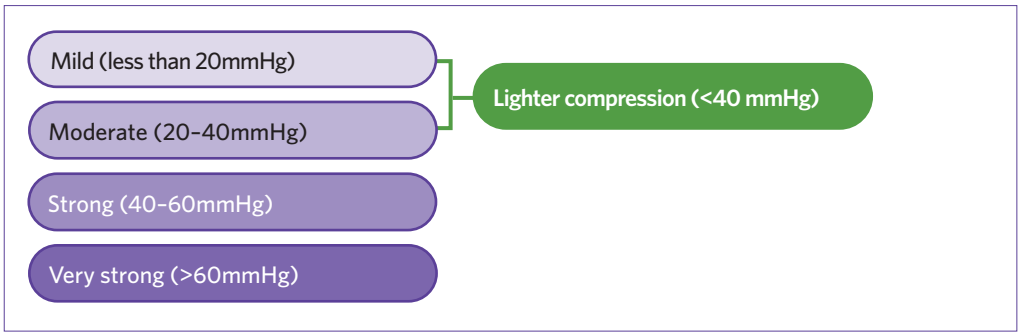

Figure 1: 'Lighter' compression, meaning compression lower than 40 mmHg, corresponds to 'mild to moderate' compression according to the WUWHS[30] classification

Lighter compression (<40 mmHg) is a new and important term that encompasses mild to moderate compression using the WUWHS[30] classification. It can be indicated in the majority of cases of chronic venous disease (apart from active or recurrent active venous ulceration), and is considered safe for patients with an ABPI >0.5, or for patients less tolerant of strong compression.

CLINICAL CHALLENGE: SUB-BANDAGE PRESSURE RANGES

The WUWHS sub-bandage pressures were developed to provide consistency in care, to improve communication between clinicians and to support patient understanding, but it is important to remember that the ranges were based on generalised figures, and no absolute guideline exists. In addition, these schematic values are valid only at bandage application time, and there is no way of knowing the sub-bandage pressure over time. After a few hours or during standing and walking, the compression pressure to the limb decreases whatever compression device was applied, and compression may become less effective than at application.

There is potential concern that the incorrect use of mild compression (<20 mmHg at application) may become ineffective after some time. A stronger compression at application is necessary taking into account the pressure drop over time.

CLINICAL CHALLENGE: CO-EXISTENT VENOUS AND ARTERIAL DISEASE

One of the major clinical challenges of compression therapy is when strong compression is indicated but it cannot be prescribed because of co-morbidities and/or low tolerance of the patient. A classic example is when venous and arterial disease co-exist, defined as a mixed ulcer. The definition of a "true" mixed ulcer is not easy as it strongly depends on the degree of arterial disease involvement. One of the most clinically used parameters to define the severity of arterial disease is the Ankle-Brachial Pressure Index (ABPI), the ratio between ankle and brachial systolic pressure. In patients with no arterial disease the ABPI is usually ≥1 and the ABPI usually decreases progressively* as the severity of arterial disease increases:

- An ABPI >0.8 defines mild arterial disease
- An ABPI of 0.5-0.8 defines moderate arterial disease
- An ABPI <0.5 defines severe arterial disease.

When venous incompetence co-exists with mild arterial disease (ABPI >0.8), the venous disease can be considered the main pathophysiological component of the leg ulcer. This describes a venous ulcer with minimal arterial involvement, and compression therapy can be applied safely.

When a patient has an ABPI of <0.5, severe arterial disease is the main pathophysiology of the leg ulcer. The ulcer must be considered an arterial ulcer with an accompanying venous involvement. If the patient also has venous disease, the ulcer needs to be referred to a vascular surgeon for arterial vascular or endovascular procedure. In this situation, sustained compression is contraindicated until successful revascularisation is performed and the arterial circulation is restored.

*The ABPI may be falsely elevated in some patients such as those with vascular calcification, diabetes or renal disease

It therefore seems appropriate to reserve the term "mixed" aetiology leg ulcer for when venous incompetence occurs simultaneously with moderate arterial disease (ABPI 0.5-0.8). In other words, a mixed ulcer has clinical features that are very similar to a venous ulcer but is complicated by coexisting moderate arterial disease (Table 1).

A mixed ulcer results from simultaneous venous incompetence and moderate arterial disease (ABPI 0.5-0.8). A mixed ulcer has similar clinical features to that of a venous ulcer , but is complicated by coexisting moderate arterial disease.

Selecting the most appropriate compression system in this situation is not easy as venous incompetence requires compression, but compression could cause local skin damage due to a reduction in arterial perfusion. For this reason, the term "reduced" compression system was arbitrarily proposed without a clear definition of what reduced compression actually means.[49-50]

Table 1. Common features of venous, arterial and mixed aetiology leg ulcers

Class	Venous	Arterial	Mixed aetiology
History	Varicose veins; deep vein thrombosis; other venous disease; trauma; surgery	■ Intermittent claudication, rest pain ■ Cardiac or cerebrovascular disease	History of both venous and arterial disease
Location	Gaiter region of the leg; most commonly around the medial malleolus	Toes, feet or lateral or pretibial aspects of the lower leg	Ankle both in the medial and lateral aspect
Wound bed	Fibrinous, granulating base and slough	Slough and necrosis	Slough
Exudate level	High	Dry/low	High
Pain	Not severe unless complicated by infection/ inflammation	Painful, independently of infection/ inflammation	Not severe unless complicated by infection/ inflammation
Peri-wound skin	Venous eczema, lipodermatosclerosis, atrophie blanche, haemosiderosis, oedema	■ Trophic changes, possibly gangrene ■ Surrounding skin is often dry and shiny with loss of hair ■ Weak or absent foot pulses	Mixed skin features but no gangrene
Treatment	■ Strong/very strong compression therapy ■ Superficial venous ablation when venous reflux occurs in the superficial veins	■ Arterial surgery (bypass, angioplasty/ stenting)	■ Lighter compression therapy ■ Superficial venous ablation when venous reflux occurs in the superficial veins ■ Arterial surgery only in case of unsuccessful treatment

Lighter compression (<40 mmHg) could be a safe way to introduce compression early in presentation, and is suitable for patients with mixed aetiology ulcers.

DEFINING SAFE AND EFFECTIVE COMPRESSION FOR MIXED AETIOLOGY ULCERS

There have been attempts to define the level of compression that is both effective and safe for patients with mixed aetiology ulcers.[52] In 25 patients with simultaneous arterial and venous disease, inelastic compression with progressively increasing pressures was applied: 20–30 mmHg, 30–40 mmHg and 40–50 mmHg. Peri-wound blood flow, toe pressure, transcutaneous oxygen pressure ($TcPO_2$) and the venous ejection fraction (which gives precise information on the venous pumping function) were assessed. The peri-wound flow, toe pressure and $TcPO_2$ were increased by compression therapy up to a pressure of 40 mmHg. The authors reported that for the patients with mixed aetiology ulcers, pressures of 40 mmHg significantly improved the venous pumping function, increased the arterial perfusion, and remained safe in the presence of arterial disease.

The study also highlighted the importance of the perfusion pressure (the ankle systolic pressure) as a more useful indicator than the ABPI to identify the type or level of compression. The ABPI is very effective in defining the severity of arterial disease, but it should not be solely relied upon when deciding the type or level of compression (Box 2).

Box 2: Challenges of interpreting ABPI

An ABPI of 0.5 is the result of an ankle pressure of 50 mmHg and a brachial pressure of 100 mmHg, but also of an ankle pressure of 90 mmHg and a brachial pressure of 180 mmHg. A compression pressure of 40 mmHg would be very dangerous in the first example, but completely safe in the second case. Hence, ABPI alone should not be relied upon to decide the type or level of compression.

ABPI should not be used as the sole measure when deciding the type or level of compression (Box 2). Other indicators, such as visible clinical signs and symptoms presented by the patient and their wound(s), and the perfusion pressure, should also be reviewed.

By analysing the data, the study authors[52] established that an inelastic compression pressure of 40 mmHg is safe for people with mixed ulceration when the ABPI is >0.5, and the perfusion pressure (i.e. the ankle systolic pressure) is >60 mmHg, highlighting the higher importance of the perfusion pressure compared to the ABPI.

The effect of lighter compression on the microcirculation was confirmed subsequently by other authors using another compression device specifically designed for patients with impairment of the arterial flow.[53] In another publication it was possible to verify the hypothesis that inelastic compression up to 40 mmHg is effective and safe in mixed ulceration with moderate arterial involvement in the 'real-world' outpatient setting.[54] The clinical outcomes of strong compression therapy (>60 mmHg) in patients with venous leg ulcers and lighter compression therapy (<40 mmHg) in patients with mixed ulceration were retrospectively compared. Patients with mixed ulceration healed as well as patients with venous leg ulcers but in a longer time frame due to the arterial disease. Lighter compression was demonstrated to be safe by the absence of any adverse effects. This study confirmed previous observations performed without measuring the compression pressure[49-51], and its results are confirmed by more recent studies in terms of both effectiveness and safety.[55-57]

Lighter compression (<40 mmHg) used in patients with mixed aetiology ulcers (ABPI >0.5) leads to healing, albeit in a longer time frame than in patients with venous leg ulcers.[54] Lighter compression (<40 mmHg) is safe in patients with mixed ulceration.[55-57]

PATIENT CONCORDANCE AND TOLERANCE

Poor patient concordance is another reason to choose to reduce compression pressure even in cases where strong compression would be more appropriate[10]. In these cases, starting from a lower compression pressure and progressively increasing the pressure could help increase patient concordance. There are no current data, guidelines or consensus on this subject but starting with a lower pressure and gradually progressing to a more appropriate pressure could be considered good practice. Remember that compression (whatever pressure it exerts) is always more effective than no compression[21] but also that the stronger the compression the higher the healing rate.[58] After ulcer healing, maintenance of compression is necessary to manage venous disease and prevent ulcer recurrences.[43-44]

CONCLUSION

In some clinical scenarios, like in venous leg ulceration, compression therapy is necessary and must be applied with a compression pressure strong enough to overcome the intravenous pressure and to exert a haemodynamic effect. The incorrect use of reduced, mild compression may lead to healing delays in patients who should be receiving strong therapeutic compression. Lighter compression (<40 mmHg) therapy with inelastic material for patients with mixed ulcers can be effective in promoting ulcer healing, although with some delay compared to venous leg ulcers treated by strong compression. It is safe and does not increase the risk of skin damage, but actually improves the skin condition.[55-56] Lighter compression may also be considered indicated for some patients with low tolerance to strong compression at the beginning of treatment. In this case, the compression pressure can be lowered to increase patient concordance and then progressively increased to reach the target pressure as and when the patient becomes more tolerant.

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Compression tips for practical application

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Despite technological advances in compression product design and availability, and frequently updated clinical evidence, it can still be a challenge to select and use the right product with the correct pressure profile, for the right patient, at the right time. It is important for a health care professional to understand how varying compression systems, different materials and application techniques can be suitable for different patient scenarios. However, there can be many challenging factors to consider in order to ensure patient safety and clinical potential.[1-3] These range across pathophysiology, lack of knowledge and confidence, unclear referral pathways and complex patient expectations and acceptance of compression therapy.[4]

SELECTING THE RIGHT PRODUCT, FOR THE RIGHT PATIENT, AT THE RIGHT TIME

Choosing a compression system solely on the compression pressures 'stated on the box' is not the ideal way to drive selection. The process to select the correct compression system must consider the underlying causes of ulceration, patient tolerance, and the evidence supporting the various options. Selection pathways and navigation tools, such as the example in Appendix 1, can help form the foundation behind evidence-based best practice and treatment continuity.

Safety first: Obtaining an Ankle-Brachial Pressure Index (ABPI) is still considered best practice within a lower limb assessment to determine a patient's arterial status,[2,5,6] but it should not be used in isolation.

Diagnostic support: A comprehensive assessment should be carried out including past medical and surgical history, history of limb trauma, infection, medication, a family history of venous disease or limb swelling, and ankle mobility. The practitioner should assess the skin and lower limb circulation (including pedal pulses) to help diagnose the underlying disease process.

Intact sensation: Peripheral neuropathy is nerve damage caused by a number of conditions. Causes of neuropathies include unstable diabetes, alcoholism, vitamin deficiencies and some autoimmune diseases such as rheumatoid arthritis and lupus. All patients with diabetes should have their feet tested to ensure sensation is intact prior to compression therapy. This may involve input from the skin and wound, vascular, diabetes and podiatry specialities.

Palpable foot pulses: To palpate the Dorsalis Pedis pulse, place fingers just lateral to the extensor tendon of the great toe. If you cannot feel a pulse, move fingers more laterally. To palpate the Posterior Tibial pulse, place fingers behind and slightly below the medial malleolus of the ankle. In an obese or oedematous ankle, the pulse may be more difficult to feel.

Moisture management: It is recommended that exudate should be maintained and managed within the primary dressing prior to application of a compression hosiery. When exudate is excessive consider possible causes, such as infection or heart failure.

No signs of lower limb ischaemia: The symptoms of arterial disease may include claudication pain in the calf muscle on exercise that is alleviated with rest. It is important to remember that claudication pain may be absent in a largely immobile patient. Other symptoms include hair loss on the legs and feet, numbness or weakness in the legs, brittle or slow-growing toenails, changing skin colour on the legs such as turning pale or blue and shiny, frail and thin skin.

Suitable limb shape: The anatomical shape and size of the limb impacts the choice of a compression system. For example, despite compression hosiery being a first-line option for many clinical scenarios, a distorted limb shape and skin folds make compression hosiery inappropriate until the limb has been normalised, usually through compression bandaging.[3,7]

THEORY INTO PRACTICE: PATIENT ACCEPTANCE AND COMMUNICATION

Although the use of clinical pathways and product development have improved clinical outcomes including long-term, self-care management, a patient's understanding and willingness to accept care will always be at the centre of any treatment success. Successful patient empowerment requires the health care professional to have a competent skill set relevant for the condition and associated comorbidities, alongside a clear understanding of different compression systems available. Furthermore, managing and sustaining this condition long term requires excellent communication skills, compassion and empathy.[8]

It is universally recognised that 40 mmHg at the ankle is needed to optimise venous return and improve wound healing, therefore much focus has been given to ensuring patients quickly and safely receive strong compression (>40 mmHg). More recently, there has been attention towards getting patients into mild compression (<20 mmHg) prior to full assessment providing "red" flag conditions are first excluded, such as severe peripheral arterial disease, a suspected deep vein thrombosis, a skin cancer or an acute infection.[9] Since studies by Mosti *et al* [10-12] have shown that reduced compression pressure not higher than 40 mmHg can be safely used in mixed aetiology ulcers, we propose to use the terminology "lighter compression", defined as <40 mmHg, and recommend this as a more efficacious treatment for these patients than" mild compression" (<20 mmHg). In addition, there has been concern expressed as long-term use of mild compression may be suitable for less than 10% of a caseload and can be used inappropriately, especially when full compression is clinically indicated.[13] The recommendation may also shift focus away from the aim of getting the majority of patients with venous ulceration into moderate-to-strong compression as early as possible.[14]

LIGHTER COMPRESSION

Lighter compression (<40 mmHg) is a term described in detail in the previous article (pages 13–19) that encompasses mild to moderate compression based on the definitions proposed by the World Union of Wound Healing Societies.[15,16] It can be considered in the majority of cases of chronic venous disease (apart from active or recurrent active venous ulceration), and considered safe for patients with an ABPI >0.5 or for patients less tolerant of strong compression.

When clinically appropriate, challenges including psychological tolerance, pain, mixed aetiology ulceration and chronic oedema can be managed using moderate or 'lighter' compression (<40 mmHg).[3,10] Utilising lighter compression, with an appreciation of how materials can affect intermittent pressure peaks, can help overcome clinical and psychological intolerance.

WHEN TO APPROPRIATELY USE LIGHTER COMPRESSION

To understand when lighter compression is appropriate, there needs to be clear guidance. There are many clinical, practical and psychological factors that can challenge a clinical decision to use strong compression in isolation.

Underlying clinical conditions and comorbidities

Comorbidities including peripheral arterial disease, chronic kidney disease, congestive heart failure and obesity can contraindicate the use of strong compression. Cardiac insufficiency is also widely regarded as a contraindication for compression therapy. However, a review of recent guidelines by Andriessen *et al* states that the only true contraindications to compression therapy are critical limb ischaemia defined by an ABPI lower than 0.5 and pulmonary oedema, and some other classical contraindications such as heart failure may be suitable for modified forms of compression.[17] Based on the available evidence and expert recommendations for cardiac insufficiency and compression therapy, the experts concluded that[18]:

1. Cardiac insufficiency in itself does not constitute a contraindication for compression therapy.
2. In the disease stages New York Heart Association Functional Classification (NYHA) I and NYHA II, appropriate compression is possible. See Box 1 for NYHA Classification.
3. In the disease stages NYHA III and IV, careful use of compression therapy is possible to a limited extent alongside clinical and haemodynamic monitoring.

Box 1: New York Heart Association (NYHA) Classification

1. **Class I:** No symptoms and no limitation in ordinary physical activity, e.g. shortness of breath when walking, climbing stairs.
2. **Class II:** Mild symptoms (mild shortness of breath and/or angina) and slight limitation during ordinary activity.
3. **Class III:** Marked limitation in activity due to symptoms, even during less-than-ordinary activity, e.g. walking short distances (20—100 m). Comfortable only at rest.
4. **Class IV:** Severe limitations. Experiences symptoms even while at rest. Mostly bedbound patients.
5. No NYHA class listed or unable to determine.

4. In patients with oedema and cardiac insufficiency, it is recommended to start compression therapy with reduced/lighter pressure on one lower leg and slowly progress to stronger pressure applied on both legs.

Before selecting a suitable compression system, a holistic clinical assessment should be undertaken, including evaluation of the arterial, venous and lymphatic systems.[3,19] Clinicians also need to refer to individual manufacturer's instructions for use for complete safety information, indications and contraindications, and instructions on the use of specific compression therapy systems. If heart failure is asymptomatic and patients are not in the acute stage, reduced compression can be applied one leg at a time, and with caution. Communication with the multi-disciplinary team is advisable, and where heart failure is uncontrolled, extreme caution is recommended.[20]

Tolerance factors including pain

Pain is commonly poorly managed in patients with a VLU.[21] For compression to be tolerated, pain needs to be effectively managed in the early outset to allow healing to progress. Patients who experience pain should receive an assessment of the compression type, and the application technique used to optimise concordance.[22] If pain using strong compression is preventing adherence, start with the application of a lighter compression system which may be associated with less pain ensuring a gradual increase in compression as pain levels improve.[3]

Size, shape and presentation of the lower limb and foot

Oedematous limbs can lead to dysmorphic limb shapes and skin folds.[3] Primary treatment to normalise the limb or to treat toe swelling should include specialist bandaging techniques using inelastic compression. The aim is to compress beyond the oedema to ensure fluid distribution and avoid adjacent areas of oedema across the knee, thigh and toes.[23] In patients with, or in those developing forefoot or toe oedema when wearing compression, forefoot and toe bandaging, or forefoot and toe compression pieces in addition to leg compression should be considered.[18] When managing lower limb oedema and where oedema rises above the knee, consider the need to apply a full leg system to manage this effectively. A thorough skin care and hygiene regimen should also be a priority, as these patients present with an increased risk of infection.

Cellulitis

When cellulitis is confirmed and managed, compression therapy can be continued if tolerated by the patient. Lighter compression can be used to improve patient tolerance and ease pain, and then the compression can be gradually increased when discomfort has been managed.[3,24]

Long-term wheelchair use

Long-term wheelchair users such as people with paralysis or spina bifida may experience muscle wastage, leading to an abnormal limb size and shape. Lighter compression can be useful to control dependent oedema in immobile patients, which can be sufficient to maintain skin integrity. Elevation, passive exercise and frequent re-positioning should also be considered based on an individual's ability.[3] Any compression should be used with caution if a significant sensory neuropathy is present, as noted above.

There are clinical scenarios where lighter compression (<40 mmHg) may be appropriate, such as when the patient cannot tolerate strong compression due to pain, when strong compression is contraindicated or to control dependent oedema.

THEORY INTO PRACTICE

Although there are many patient, practitioner and health system-related factors influencing choice, attributes of a compression system should also be considered. An ideal compression system allows clinicians to implement effective, safe and consistent compression therapy with a low risk of complication (Box 2).

As highlighted within this Position Document, there are patient, clinical and practical indications that drive choice of compression. The three main compression systems available are bandages, hosiery and adjustable compression wraps.[3] It is important to assess the patient holistically to determine the correct and most effective form of therapy. Clinical skill set, patient concordance alongside clinical indicators, such as oedema and exudate level, also play a key role in determining choice.[3] Although product innovation has led to an expansion in compression therapy options, it is important to choose the right product without the mindset of '*I have always used...*' or other ritualistic influence.

Box 2: Properties of an ideal compression system (adapted from [4])

- Proven clinical effectiveness
- Delivers tolerable sustained compression during rest and high-pressure peaks during walking
- Enhances calf muscle pump function
- Easy application encourages safe, accurate and consistent application
- Non-slip and likely to stay in place until next bandage application
- Conformable and can be adapted to cope with limb distortion
- Comfortable and allows the patient to mobilise and to wear appropriate footwear and clothing.
- Non-sensitising
- Durable (i.e. can be worn for up to 7 days)

TIPS USING A 2-LAYER COMPRESSION SYSTEM

Compression systems (kits) commonly combine either 2 or 4 layers with a combination of either inelastic/short stretch and elastic/long stretch components, some of which are cohesive. The inelastic, cohesive multi-layer systems function utilising a comfortable resting pressure with a high stiffness factor.[4] These align with the attributes of an ideal compression system, are versatile across many clinical indications and use a consistent application technique for reproducibility.[25] The 3M™ Coban™ 2 Two-Layer Compression System and 3M™ Coban™ 2 Lite Two-Layer Compression System are 2-layer cohesive compression systems consisting of a comfort foam layer with a cohesive backing, alongside a compression layer that has similar cohesive properties. Due to these dual cohesive layers, both layers cohere to each other resulting in a low profile, semi rigid and inelastic sleeve. The cohesive properties of the two layers also makes it a versatile solution with numerous clinical applications (e.g. toe bandaging) without the natural limitations of traditional textile-based or other non-dual cohesive compression bandages.

When using a 2-layer cohesive compression system for "normal" compression or "lighter" compression, there are some general tips to consider:

☑ **Tip 1:** There are no "standard" legs, and every patient has their own morphology. Therefore, the aim should be to achieve the best anatomical fit to ensure clinical effectiveness. Due to the cohesive properties of the bandage, if there are difficulties in application, the bandage can be simply be cut, realigned and stuck down. Application of the bandage can then continue ensuring conformability without compromising effectiveness.

☑ **Tip 2:** Whenever possible apply the comfort layer with minimum overlap but still keep in mind the anatomical fit. Small folds or 'bumps' that occur when bandaging will be pressed down with the compression layer and will not cause any harm or reduce the effectiveness of compression. Again, the versatility of the cohesive property means that the bandage can be simply cut and pressed down if there are minor errors in application.

☑ **Tip 3:** During application, keep both the comfort and compression layer rolls close to the skin for easier handling, manoeuvring and consistent pressure delivery. The comfort layer is applied with enough tension to aid its conformability, with a minimal overlap to ensure a low-profile protective layer is achieved. A minimum force is required to achieve a full stretch application with the compression layer. Again, in case the layers do not "roll" as desired, the layers can be cut, stretched and pressed down to conform.

☑ **Tip 4:** When applying the bandage, starting from the foot, begin in line with the 5th metatarsal head (little toe) in the direction of the 1st metatarsal head (big toe). This ensures that the bandage supports the usual anatomical positioning of the foot, keeping the bandage close to the digit line.

☑ **Tip 5:** Muscle activity is essential to achieve venous and lymphatic return. When applying any compression bandage, avoid having too many layers around articulating areas such as the ankle or knee joint (or even the wrist and elbow in case of arm lymphoedema). It is not recommended to cover the plantar (heel pad) with the first layer/comfort layer as this uses three to four layers of extra material covering the ankle joint, limiting functionality (movement) and compromising muscle activity. The plantar fascia is naturally well protected so additional protection under the compression layer is not necessary.

LIGHTER COMPRESSION SYSTEM: COBAN 2 LITE COMPRESSION SYSTEM

To demonstrate the use of lighter compression, Coban 2 Lite compression system has been chosen to highlight how an inelastic, 2-layer, semi-rigid sleeve with a reduced level of resting pressure can be effective when used with an appropriate clinical and patient-focused rationale. Coban 2 Lite compression system achieves a lower resting pressure than Coban 2 compression system and as a result can be more comfortable for patients less tolerant of compression therapy. This includes those patients with a mixed aetiology ulcer or with an ABPI >0.5, those who have known intolerance for compression therapy or are needing a comfortable but effective solution for foot and toe oedema.[26,27]

To ensure safety, Ladwig *et al* undertook a prospective clinical study with the primary objective to assess safety and tolerability of Coban 2 Lite compression system in patients with impaired arterial circulation (ABPI 0.5–0.8)[28]. The study demonstrated that Coban 2 Lite compression system:

- Is safe and well tolerated by patients with an ABPI between 0.5-0.8
- Achieves an average supine sub-bandage pressure of 28 mmHg immediately after bandage application
- Is not associated with any pressure-related skin damage, or pain related to tissue hypoxia
- Has beneficial effects on the microcirculation.

Although guidance states strong compression should be implemented when appropriate, lighter compression systems such as Coban 2 Lite compression system offer a low risk of pressure-related skin damage in patients with ABPIs above or equal to 0.5.[29] When needed and due to a variety of bandage widths available, Coban 2 Lite compression system can also interlock with both full leg and toe boot application methods.

The Coban 2 Lite compression system is an inelastic, 2-layer, semi-rigid sleeve that provides lighter compression. It can be effective for patients with mixed aetiology ulceration or with an ABPI >0.5, have known intolerance for compression therapy or are needing a comfortable but effective solution for foot and toe oedema.

CASE SCENARIOS

The case scenarios presented in this article highlight the use of the Coban 2 Lite compression system. Box 3 includes an example of using Coban 2 Lite compression system for a patient with a mixed aetiology ulcer,[30] while Box 4 explores the clinical need to address compression intolerance and toe oedema using the Coban 2 Lite compression system.[31]*

CONCLUSION

Although compression materials have evolved and educational theory has advanced the question remains, has healthcare embraced this shift? There is often a need for alternative solutions to ensure we provide a choice of treatment that both addresses the patient need and delivers effective and appropriate compression. For patients for whom strong compression is inappropriate or who have

*Note, all products widths may not be available in all markets

toe and foot oedema to be treated correctly, it is important that practitioners are able to implement evidence-based solutions.[32]

Successful compression therapy includes more than the stated compression dosage 'written on the box'. Other factors to consider are the aetiology of the underlying disease, the patient's presentation, and their ability to tolerate and use compression effectively as part of their daily routine, thereby promoting adherence.[19] The effects and safety of compression materials also need to be incorporated.

Furthermore, the application of lighter compression incorporating innovative techniques can offer a safe, reproducible, comfortable and easy-to-learn option to address the issue of compression intolerance and toe oedema.[20,25,28,33]

Box 3. CASE SCENARIO: MIXED AETIOLOGY ULCER (COURTESY OF NIA JONES AND NICOLA IVINS[30])

A 62-year-old man presented with a medical history of hypertension, type 2 diabetes and recurrent leg ulcers for 8 years. Duplex imaging confirmed that the current ulcer on the right leg was of mixed aetiology, and it had been present for over 12 months (Figure A). There was granulation tissue at the wound bed of the ulcer, but the ulcer had not progressed over the previous 4 weeks. The wound measured 16.24 cm^2 and had a depth of 0.2 cm, with moderate levels of exudate. Compression therapy had been a problem for this patient because he had been unable to tolerate reduced compression systems and compression hosiery kits, and he was using a two-layer support bandage.

The bandage and dressing changes were repeated weekly. Initially, the patient continued to experience pain in the lower leg; however, by week 4 of using Coban 2 Lite compression system, the pain had reduced, and by week 6, he was no longer experiencing any pain. At week 15, the wound measured 0.56 cm^2 (Figure B). Compression therapy with Coban 2 Lite compression system was continued after this evaluation, and the wound healed 4 weeks later.

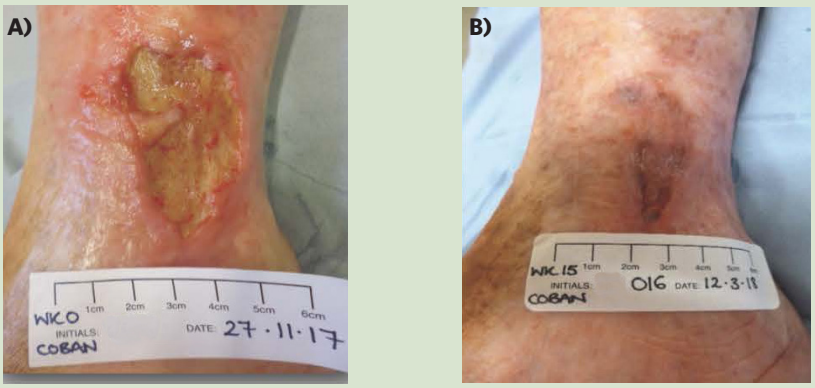


Figure A. Mixed aetiology ulcer on the leg of a 62-year-old man with type 2 diabetes and hypertension
Figure B. Mixed aetiology ulcer after 15 weeks of compression therapy with Coban 2 Lite compression system

Box 4. CASE SCENARIO: FOOT AND TOE OEDEMA[31]

Although toe and foot oedema are commonly associated with lymphoedema, this can also be problematic for patients with chronic venous insufficiency and subsequent lymphovenous oedema.[34] Many practitioners do not routinely undertake individual toe bandaging, possibly as a result of a lack in regular contact with patients with toe and foot oedema and so lack competency and confidence. Toe bandaging can also be time consuming for practitioners to implement, often needing daily reapplication, and is also not always tolerated well by patients.[35]

A 76-year-old lady presented with bilateral lower limb ulceration and toe oedema, alongside a history of hypertension, chronic venous insufficiency and varicose eczema (Figure A). This had previously been managed using compression hosiery alongside a hygiene and skin care regimen; however patient concordance was poor, and leg and foot oedema had progressed. Following several episodes of cellulitis requiring antibiotic treatment, strong compression bandaging with conventional short stretch bandage and the application of a foot glove was commenced to reduce oedema and normalise the limb to enable review and re-measurement of hosiery.

However, due to strong compression discomfort, bandage slippage and failure to manage toe oedema the treatment was stopped and Coban 2 Lite compression system was applied below the knee and Coban 2 compression system was used to apply a toe boot (Figures B & C). The toe boot application technique was developed to be a more comfortable option to support and reduce oedema in the foot and toes (Figure E). This plan of care aimed to reduce resting compression levels by 25% to improve tolerance, use static stiffness to exert a haemodynamic effect and control toe oedema using a comfortable toe boot application.

Prior to removal there was no bandage slippage or visible exudate strikethrough noted and the patient had found it comfortable (Figure D). After 3 weeks of treatment with Coban 2 Lite compression system below the knee plus the toe boot application using Coban 2 compression system and only three dressing and bandage changes, the patient was measured for a below-knee, flat-knit, made-to-measure, closed-toe stocking.

Figure A. Erythematous, oedematous and painful left foot

Figure B. Pieces of double-folded comfort foam layer are fitted in each web space

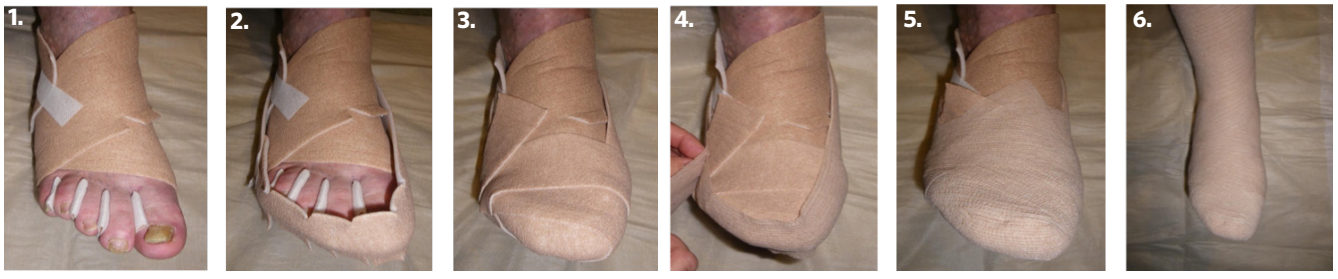
Figure C. Coban 2 Lite compression system below the knee plus the toe boot application using Coban 2 compression system

Figure D. After 3 weeks of treatment, there was reduction in oedema and pain, and improved skin integrity. The limbs were ready for prophylaxis hosiery and toe cap.

Figure E. The toe boot application method

1. Apply comfort foam layer to foot prior to filling the web spaces. Fill each web space with pieces of double-folded comfort foam layer with the foam side out and trimmed to shape.
2. With a 5 cm wide comfort foam layer, make a circular turn without tension over the toes and the heel with an overlap over the 5th metatarsal head. Make a few slits to ease conformability over the toes.
3. Cover all open areas over and under the toes. Trim to fit and mould to conform.
4. Using a 5 cm compression layer roll and without tension, apply a circular winding from toes to heel starting from the little toe.
5. Cover the dorsal and plantar toe areas with the compression layer at full stretch in a fan-fold technique with semi-circular windings. To prevent a tourniquet effect, avoid circumferential windings around the foot.
6. Mould the layer to the anatomy of the forefoot. After toe wrapping, overlap the compression layer and apply to lower limb and mould to conform. Complete application of Coban 2 compression system below the knee.

This application may not be applicable to those patients with vascular impairment, peripheral neuropathy or unstable diabetes as the toe boot system is only available in the Coban 2 compression system format and it would not be possible to visually assess the toes.



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APPENDIX 1. Example clinical pathway

Managing conditions of the lower limb

Patient presents with a lower limb condition, i.e. wound, skin tear, oedema, varicose eczema, skin changes

Complete a full leg and foot assessment, vascular assessment (ABPI) and wound assessment as suggested below

If a vascular assessment has not been performed at first contact, consider application of light compression subject to the following:

Diagnosis

Intact sensation

Palpable foot pulses

Minimal exudate

No signs of ischaemia on leg or foot

Suitable leg shape and size

Start

Obtain Ankle Brachial Pressure Index (ABPI)

- When a patient presents with clinical challenges, consider using a manual, handheld Doppler
- When using a handheld Doppler, this must be performed by a trained health care professional

Complex clinical challenges
- Patients with hypotension
- Long standing diabetes or known calcification
- Circumferential ulcers (due to pain)
- Significant chronic oedema
- Static or deteriorating ulcers

0–2 weeks

ABPI	Level of arterial disease	Suitability for compression
<0.5	Severe arterial insufficiency	Refer urgently to vascular service
≥0.5	Mixed aetiology – Moderate to mild arterial insufficiency	Light compression (3M™ Coban™ 2 Lite Two-Layer Compression System) Refer to vascular services
≥0.8	Normal	Standard compression (3M™ Coban™ 2 Two-Layer Compression System)
>1.3	Arterial calcification or inaccurate in the presence of chronic oedema	This may suggest a rigid artery. Seek specialist advice prior to compression

Diagnosis

ABPI ≥0.8 to 1.3
Plus oedema and/or exudate
- Wound requires management of exudate
- Limb requires normalising
- First line Coban 2 compression system
- Consider toe boot or thigh-high bandaging (foot and thigh oedema)

Requires appropriately trained nursing input

ABPI ≥0.8 to 1.3
No oedema and/or exudate
- Minimally exuding wound and/or no limb shape distortion
- First line Coban 2 Lite compression system
- Consider toe and/or thigh-high bandaging (foot and thigh oedema)

or

Leg ulcer hosiery kit when measurements fit into stock size hosiery or consider adjustable wraps

Requires appropriately trained nursing input

ABPI ≥0.5
Light compression
- Mild arterial insufficiency or for patients who are less tolerant of standard compression
- First line Coban 2 Lite compression system
- Consider toe and/or thigh-high bandaging (foot and thigh oedema)

Requires appropriately trained nursing input

If a patient cannot tolerate any bandaging, seek advice and consider adjustable wraps (Not suitable for patients with high exudate and/or skin folds)

Treatment

Patients should be reassessed every 6 weeks whilst an ulcer is present

When patient achieves total wound closure move onto ongoing maintenance pathway

At 4–6 weeks if less than 20-30% healing refer to link Nurse or TVN for advice

Evaluation/ outcomes

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WOUNDS INTERNATIONAL

POSITION DOCUMENT