

## ORIGINAL ARTICLE

# Compression therapy for venous leg ulcers: risk factors for adverse events and complications, contraindications – a review of present guidelines

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## Abstract

**Introduction** The adequate use of compression in venous leg ulcer treatment is equally important to patients as well as clinicians. Currently, there is a lack of clarity on contraindications, risk factors, adverse events and complications, when applying compression therapy for venous leg ulcer patients.

**Methods** The project aimed to optimize prevention, treatment and maintenance approaches by recognizing contraindications, risk factors, adverse events and complications, when applying compression therapy for venous leg ulcer patients. A literature review was conducted of current guidelines on venous leg ulcer prevention, management and maintenance.

**Results** Searches took place from 29th February 2016 to 30th April 2016 and were prospectively limited to publications in the English and German languages and publication dates were between January 2009 and April 2016. Twenty Guidelines, clinical pathways and consensus papers on compression therapy for venous leg ulcer treatment and for venous disease, were included. Guidelines agreed on the following absolute contraindications: Arterial occlusive disease, heart failure and ankle brachial pressure index (ABPI) <0.5, but gave conflicting recommendations on relative contraindications, risks and adverse events. Moreover definitions were unclear and not consistent.

**Conclusions** Evidence-based guidance is needed to inform clinicians on risk factor, adverse effects, complications and contraindications. ABPI values need to be specified and details should be given on the type of compression that is safe to use. Ongoing research challenges the present recommendations, shifting some contraindications into a list of potential indications. Complications of compression can be prevented when adequate assessment is performed and clinicians are skilled in applying compression.

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## Conflicts of interest

None declared.

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## Background

Chronic venous insufficiency (CVI), a consequence of lower extremity valvular reflux and/ or venous obstruction, produces hypertension in the dermal microcirculation.<sup>1–5</sup> The result is inflammation, which may lead to ulceration.<sup>1–3</sup> Venous ulcers can vary in size and can be difficult to manage, particularly if they are painful, complicated with dermatitis, or if they drain profusely.<sup>4</sup>

Guidelines translated in a clinical pathway may be a useful instrument to support prevention and treatment of venous leg ulcer patients.<sup>6</sup> Clinical pathways for patients with venous leg ulcers should include accurate diagnosis and the use of appropriate diagnostic tools. It is important to understand the individual patient issues to achieve an optimal treatment outcome, thereby treating the whole patient (holistic approach) and not just the affected leg.<sup>6</sup> Treat the underlying disease with adequate

compression and apply a suitable dressing that does not adhere to the wound bed.<sup>6,7</sup> Finally, skin care is important to address the issues associated with dry and/or inflamed skin. When the ulcer has closed maintenance using compression stockings is mandatory to prevent recurrence.<sup>3,5,8</sup> The adequate use of compression in venous leg ulcer treatment is equally important to patients as well as clinicians<sup>7–14</sup> Currently there is a lack of clarity on contraindications, risk factors, adverse events and complications, when applying compression therapy for venous leg ulcer patients.<sup>15</sup>

The topic of this review addresses these issues. The current project was conceived as a mechanism to optimize prevention, treatment and maintenance approaches by recognizing contraindications, risk factors, adverse events and complications, when applying, prescribing, distributing and reimbursing compression therapy for venous leg ulcer patients. The project is an initiative of the patient outcome group (POG) of the European Wound Management Association (EWMA) in collaboration with the International Compression Club (ICC).

### Compression treatment

Compression is the standard treatment for venous ulcers and is directed at lowering venous hypertension, decreasing venous stasis and inflammation and further enhancing tissue vascularization.<sup>1–11</sup> Before applying compression, the Ankle Brachial Pressure Index (ABPI) is to be assessed to provide information if sufficient arterial circulation is present and compression can be safely used and left in place day and night.<sup>2,3,15,16</sup> Lower extremity Doppler examination is recommended as the standard for patients with suspected peripheral arterial disease.<sup>15,16</sup>

According to a consensus paper<sup>16</sup> published in 2016, there is sufficient data to support the use of compression with reduced pressure levels in patients with non-severe arterial impairment, provided it is applied by a trained healthcare professional and the patients are monitored. Previous studies on compression bandaging for venous leg ulcer patients have confirmed that the proportion of complete ulcer healing is improved with high compression as compared to no compression treatment.<sup>6–14,17,18</sup> Compression has been demonstrated to reduce oedema and improve superficial skin lymphatic function, as well as lymph transport within the subfascial system.<sup>14</sup> Depending on the parameters measured, higher pressures are suggested to be more effective than lower pressures.<sup>7</sup>

### Methods & definitions

The authors, all members of the ICC, acknowledged for their expertise in compression therapy for venous leg ulcer treatment, reviewed the manuscript. We conducted this project in

accordance with Appraisal of Guidelines for Research and Evaluation II (AAGREE II) instrument and the ADAPTE framework for guideline adaptation.<sup>19,20</sup>

A systematic literature review was conducted of current guidelines on venous leg ulcer prevention, management and maintenance, randomized controlled studies, systematic reviews, meta-analysis and well-designed cohort studies. The focus is on risk factors, adverse events, possible complications and on warning about contraindications, when applying compression therapy for venous leg ulcer (VLU) patients.

Evidence was obtained from searches, which took place 29th February 2016 to 30th April 2016 of PubMed, MEDLINE, Embase, CINAHL and the Cochrane Library databases. Searches were prospectively limited to publications in the English and German languages, and publication dates were between January 2009 and April 2016. Earlier publications were included if an update was published between January 2009 and April 2016.

Medical subject headings terms used in various combinations were as follows:

- Compression therapy for venous leg ulceration treatment, maintenance, absolute contraindications, relative contraindications, assessments, risks of compression, adverse events and serious adverse events during compression, use of compression, compression bandaging, compression hosiery.

AA, GC and AM independently selected the guidelines, clinical pathways and consensus documents and agreed on including these in the review.

### Stakeholder review

Before submitting for publication we sought input from stakeholders: the results were presented and discussed in a multidisciplinary setting during an International Compression Club meeting held during the European Wound Management Association Congress 2016, Bremen, Germany, Wednesday 11 May). The feedback was taken into account, and adaptations were made. The data were then presented 27th September 2016 at the World Union of Wound Healing Societies in Firenze, Italy, during a venous leg ulcer symposium to wound healing experts including specialized nurses, vascular surgeons, dermatologists and phlebologists and at WOUNDS UK, Harrogate, UK, 15th November 2016 and Société Française et Francophone des Plaies et Cicatrisation, Paris, France, 15–17 January 2017.

### Mitigation of competing interests

The International Compression Club and EWMA supported this project. Funding of the International Compression Club by the industry members played no role in the development, content or approval of this manuscript.

## Definitions used

**Contraindication** Specific situation in which a procedure should not be used because it may be harmful to the person.

**Relative contraindication** Caution should be used when procedures are used. Acceptable if benefits outweigh risk.<sup>21</sup>

**Absolute contraindication** Procedure could cause limb loss or a life-threatening situation and should be avoided.<sup>21</sup>

**Adverse events** Any undesirable experience associated with the use of a medical product in a patient.<sup>21</sup>

### Serious Adverse events

- Any undesirable experience associated with the use of a medical product in a patient that poses a substantial risk of dying at the time of the adverse event, or use or continued use of the device or other medical product might have resulted in the death of the patient.<sup>21</sup>
- Lead to admission to the hospital or prolongation of hospitalization was a result of the adverse event.<sup>21</sup>
- Lead to emergency room visits that do not result in admission to the hospital but should be evaluated for serious outcomes (e.g. limb or life-threatening; required intervention to prevent permanent impairment or damage; other serious medically important event).<sup>21</sup>
- Resulted in a substantial disruption of a person's ability to conduct normal life functions, i.e., the adverse event resulted in a significant, persistent or permanent change, impairment, damage or disruption in the patient's body function/structure, physical activities and/or quality of life.<sup>21</sup>

**Complications** Unwanted or dangerous reactions: – not treatment related or – related to treatment.<sup>21</sup>

## Review of venous leg ulcer guidelines

The focus is on compression therapy, contraindications, risk factors, adverse events and complications. Fourteen guidelines<sup>15,16,22–29,31,33,34,36</sup> on venous leg ulcer treatment with compression, published between 2008 and 2016, were included. Additionally three consensus<sup>30,37</sup> and position<sup>35</sup> papers and three algorithms<sup>38–40</sup> on compression therapy for venous leg ulcer treatment, published between 2010 and 2013, were also included (Table 1). The majority of guidelines, algorithms, consensus and position papers were published in English. The development of guidelines algorithms, consensus and position papers was carried out by various disciplines and organizations, including: Phlebology specialists, Dermatologists, Specialized nurses, Vascular surgeons, Multidisciplinary groups.

**Table 1** Search results: Guidelines, consensus papers, clinical pathways and algorithms

Guideline/consensus paper/algorithm and date	
Clinical practice guideline (2014) VLU <sup>15</sup>	Consensus (2013) recommendations for VLU <sup>30</sup>
Guideline EWMA 2016 <sup>16</sup>	Clinical practice guideline (2011) VLU <sup>31</sup>
Guideline (2014) VLU <sup>22</sup>	Guideline (2011) VLU <sup>33</sup>
Guideline (2010) VLU <sup>23</sup>	Clinical practice guideline (2011) VLU <sup>34</sup>
Clinical Practice Guideline (2015) VLU <sup>24</sup>	Position document (2009) compression <sup>35</sup>
National clinical guideline (2010) for VLU <sup>25</sup>	Practice guidelines (2010) VLU <sup>36</sup>
Guideline (2008) Clinical studies with compression devices in VLU <sup>26</sup>	Consensus recommendations 2013 VLU <sup>37</sup>
Guideline (2008) VLU <sup>27</sup>	Best practice algorithm (2010) VLU <sup>38</sup>
Guideline (2010) VLU <sup>28</sup>	Evidence-Based Algorithm (2013) VLU <sup>39</sup>
Guideline (2009) phlebologic compression <sup>29</sup>	Health service pathway 2013 VLU <sup>40</sup>

*N* = 20: Fourteen guidelines (2008–2016), three consensus and position papers (2013) and three algorithms and clinical pathways (2010–2013). VLU, Venous leg ulcer.

Guidelines, consensus papers and clinical pathways were developed by various disciplines and organisations, including: Phlebology specialists, Dermatologists, Specialized nurses, Vascular surgeons, Multidisciplinary groups.

Quality of the Selected Guidelines: Most guidelines were of acceptable quality.<sup>15,16,22–29,31,33,34,36</sup>

- Validated levels and grading of evidence
- Clinically relevant and applicable
- Validated classification systems for VLU
- Addressed multidisciplinary aspect of VLU management
- Regular updates no later than 5 years

Practice and healthcare systems in various countries may differ greatly from countries where guidelines were developed, posing challenges for implementation of recommendations given. It is not feasible to provide information on their implementation and/or clinical use.<sup>41–43</sup> Information on implementation of the guidelines was lacking as well as information on their impact on clinical practice. Even when the guidelines are well implemented there is a lack of homogeneous results and a good clinical response to compression therapy if the complete chain is not addressed.<sup>41,42</sup>

**Absolute and relative contraindications** Guidelines<sup>15,16,22–29,31,33,34,36</sup> algorithms<sup>38–40</sup> and consensus papers<sup>30,37</sup> agreed on the following absolute contraindications:

Arterial occlusive disease and pulmonary oedema from congestive heart failure (*n* = 20/20 (Table 2)). Four guidelines included suspected or proven peripheral arterial disease, including history of peripheral arterial bypass grafting.<sup>22,26–28</sup>

Ankle brachial pressure index (ABPI) was suggested (*N* = 20/20) as a standard assessment to determine sufficient arterial

**Table 2** Contraindications, Relative contraindications and Contraindications without classification

Absolute contraindications	No	Relative contraindications	No	Contraindications without classification	No
Arterial occlusive disease <sup>15,16,22-31,33-40</sup>	20	Diabetes mellitus/peripheral neuropathy <sup>15,16,22-31,33-40</sup>	20	Heart failure <sup>37-39</sup>	3
Heart failure <sup>15,16,22-31,33-40</sup>	20	Heart failure <sup>15,22,24,25,28-31</sup>	8	Neuropathy <sup>34,35,38</sup>	3
ABPI < 0.5 <sup>15,16,22-25,27-31,36</sup>	12	Compensated peripheral arterial occlusive disease <sup>15,22,24,28-31</sup>	7	Extensive thrombophlebitis, thrombosis or suspected thrombosis <sup>33,34</sup>	2
ABPI should be recorded but no values were given	5				
Extensive thrombophlebitis, thrombosis or suspected thrombosis <sup>23,24,26,31-34</sup>	7	Intolerance to dressing material/allergies <sup>16,22,23,26,31-34</sup>	8	Erysipelas <sup>33,34</sup>	2
Phlegmasia coerulea dolens <sup>15,22,24,25,28-31</sup>	8	Skin diseases <sup>22,23,31-34</sup>	6	Serious non-controlled hypertension <sup>15,23,30,32</sup>	4
Erysipelas <sup>15,22,24,28-31</sup>	7	Malignant diseases <sup>22,25,26,31,37</sup>	5		
Serious non-controlled hypertension <sup>15,22,24,26,28,36</sup>	6	ABPI < 0.8->1.2 <sup>37,38</sup>	2		
		ABPI < 0.9 <sup>33-35,38</sup>	4		
		ABPI < 0.5 <sup>15,16,22-25,27-31,36</sup>	12		

ABPI, Ankle brachial pressure index.

**Table 3** Arterial circulation and Ankle Brachial Pressure Index

Ankle brachial pressure index	Arterial circulation	Compression treatment
ABPI > 1.00-1.3 <sup>15,16</sup>	Normal	Apply compression
ABPI = 0.8-1.0 <sup>15,16</sup>	Mild peripheral Disease	Apply compression with caution <sup>15</sup>
ABPI ≤ 0.8-0.6 <sup>15,16</sup>	Significant arterial disease	Use modified compression with caution <sup>16</sup> – refer to specialist <sup>15</sup>
ABPI < 0.5 <sup>15,16</sup>	Critical ischaemia	Do not compress – refer urgently to vascular specialist
ABPI > 1.3	Refer to vascular/diabetic specialist	

ABPI, Ankle Brachial Pressure Index.

circulation before starting compression treatment.<sup>15,16,22-31,33,34,36-40</sup> Measurement of ABPI is performed in the supine position with a sphygmomanometer cuff placed just above the ankle and a Doppler probe used to measure the systolic pressure of the posterior tibial and dorsalis pedis arteries of each leg. ABPI is calculated by dividing the systolic ankle pressure by systolic arm pressure. The reproducibility of ABPI varies but is significant enough to be clinically relevant and can detect a change in clinical status.<sup>15</sup> The typical cut-off point for diagnosis of peripheral arterial disease is ABPI ≤ 0.90 at rest, with ABPI ≤ 0.50 indicating critical limb ischaemia (Table 3).<sup>15,16</sup> In patients with diseases that cause vascular calcification, such as diabetes and renal insufficiency, tibial vessels at the ankle may become non-compressible, leading to false ABPI readings.<sup>15</sup> For ABPI ≤ 0.90 at rest referral for to a vascular specialist should be considered for further arterial evaluation before starting compression therapy.<sup>15,16</sup>

Extensive thrombophlebitis, thrombosis or suspected thrombosis<sup>23,24,26,31-34</sup> were recognized as absolute contraindications in  $n = 7/20$  and were extensively critiqued by ICC members and peers. However, the majority of guidelines recommended for patients with proximal deep vein thrombosis to wear graduated compression stockings with an ankle pressure greater than 23 mmHg for at least two years beginning a week after diagnosis

or when swelling is reduced sufficiently, and if there is no contraindication.<sup>43,44</sup> Immediately after diagnosis stiff compression bandages are recommended as part of the total treatment approach.<sup>44</sup>

There are differences between Europe and the USA on absolute contraindications and relative contraindications; however, there is agreement on arterial occlusive disease and heart failure as absolute contraindications.

#### Reported complications of compression therapy regarding 'absolute contraindications'

Adverse events caused by compression therapy have been reported in patients with arterial occlusive disease, while the warnings concerning heart failure are obviously based more on theoretical concerns and even beneficial effects have been published under compression.<sup>45,46</sup>

The most common cause for adverse effects in patients with arterial occlusive disease is the fact that the arterial disease was not recognized by the bandager which underlines the importance to check every patient carefully before leg compression is applied by palpating foot pulses and measuring the ankle pressure.<sup>47</sup> The compression pressure should never exceed the arterial perfusion pressure. If the arterial brachial pressure index is

between 0.6 and 0.9 bandages with reduced compression (~20 mmHg) and close surveillance of the patients has been recommended.<sup>47</sup>

Inelastic short stretch bandages exert a massage effect during walking, which will reduce swelling and increase the blood flow. In a similar way, intermittent pneumatic pressure machines have been shown to increase arterial blood flow and to reveal beneficial clinical effects even in patients with symptomatic arterial occlusive disease.<sup>48</sup>

On the other hand, elastic material maintaining a constantly high resting pressure independent of body position has the lowest margin of safety because pressure remains high even when the patient is lying down and compression therapy is not needed. Skin damage has been reported even with light thromboprophylactic stockings. Incorrect fitting and lack of daily surveillance seem to be the most important flaws in patient care in these cases.<sup>49</sup>

**Risks and adverse events** Pressure marks, necrosis, friction damage and leg ulcer formation, as a result of poorly applied compression or the wrong type of compression, were identified as risk factors and adverse events in all of the selected guidelines.<sup>15,16,22–40</sup> Injury to the skin was defined in fourteen guidelines,<sup>15,16,22–33,36</sup> and pain was recognized as a risk factor in ten of the selected guidelines<sup>22–25,27,28,31–33,36</sup> (Table 4).

**Complications** Tissue damage is identified by  $n = 11/20$  of the guidelines as type of compression and application related. Allergic reactions and arterial complications may be prevented when assessment and patient history are done up to standard. Moreover compression is to be delivered by trained medical staff.

**Discussion**

The selected twenty guidelines, consensus papers and clinical pathways<sup>15,16,22–31,33–40</sup> were designed for venous leg ulcer

prevention and management. They did not specifically address contraindications, risk factors, adverse events and complications. Depending on the disciplines involved in the development of guidelines, there is a marked difference in quality of content. Many of the selected guidelines used literature that was more than 10 years old.<sup>42</sup> As this is a field that is evolving and new technologies are making their way to the market, this may pose issues.<sup>42–44</sup> The guidelines ( $N = 20$ ) agreed on absolute contraindications, but gave conflicting recommendations on relative contraindications, risks and adverse events. Moreover, definitions were unclear and not consistent. Based on the information in the guidelines patients may not receive the care that is appropriate.

The information in the guidelines on ABPI is conflicting. Guidelines that specified ABPI values reported the typical cut-off point for diagnosis of peripheral arterial disease is  $ABPI \leq 0.90$  at rest, with  $ABPI \leq 0.50$  indicating critical limb ischaemia.<sup>15,16</sup> Furthermore, differences between Europe and the USA may be related to longstanding experience in continental Europe with inelastic compression (high stiffness).<sup>43,44</sup> The reliance on a single value as a cut-off point for treatment has been debated as it neither defines the transition between venous and arterial ulceration nor takes into account differences in perfusion pressure between the three vessels at the ankle – a pressure difference of 15 mmHg or greater indicates a proximal stenosis or occlusion in the vessel with the lower pressure.<sup>55,56</sup> Such a pressure difference will increase the risk of pressure damage to the related zone of the calf irrespective of the calculated ABPI for the limb. Variations in systolic pressure impact on the calculated ABPI showing that patients with a low brachial systolic pressure have a higher mean ABPI and that reference to accepted criteria for high compression therapy in such a situation may lead to inappropriate compression and bandage damage.<sup>55</sup> Reliance on a single ratio also fails to take into consideration other factors that may be important when defining the level of compression to apply to any particular limb.<sup>50</sup> These factors include the following: the limb shape; the presence of bony prominences; skin condition; the variability within the pressure measurement between the three ankle pulses; the presence of other diseases such as diabetes or rheumatoid arthritis; and the patient’s tolerance of compression.<sup>50</sup>

Although unanswered questions about the use of compression remain, high-quality evidence supports their use by patients with chronic venous insufficiency, especially those with ulcers.<sup>39</sup> Although the use of compression is usually safe, several adverse effects and complications, including allergic reaction and skin necrosis, have been reported. Clinicians often underestimate the importance of patients’ compliance with compression therapy, which is known to be low.<sup>51</sup> Addressing patients’ concerns, providing adequate information and reassurance, changing the material or lowering the degree of compression usually helps improve

**Table 4** Risks and adverse events Product/treatment related or assessment related

Risk & adverse effects	No	Complications	No
*Pressure marks/*, †necrosis/*friction/leg ulcer	18	*tissue damage/*, †necrosis/*friction/leg ulcer/gangrene	11
*Injury to the skin	12	†allergy/*skin irritation	6
Pain	10	Pain	6
*Local damage on the peroneus nerve/peripheral nerves	6	*constrictions	2
*Wrong compression pressure	4	*, †arterial complication	2
†Allergic reaction/skin irritation	4		

$N = 20$ .

VLU, Venous leg ulcer; AEs, Adverse events.

\*Product and application related.

†Assessment related.



compliance.<sup>52</sup> These issues should be addressed in the guidelines and should be an integral part of the treatment.<sup>53</sup>

As practice and healthcare systems in various countries may differ greatly, implementation of recommendations given may be challenging. However, a rationale for contraindications supported with evidence should improve availability of compression for patients who may benefit from this treatment.

Often guidelines are text heavy and not designed for practical clinical use.<sup>6</sup> Patient-focussed clinical pathways may be a more practical way forward to optimize care for venous leg ulcer patient management.<sup>6,54</sup> When developing guidelines a strategy for implementation should be included. All the guidelines included in the review omitted this important task.

In conclusion, the only true contraindications to compression therapy are critical limb ischaemia defined by an ABPI lower than 0.5 and pulmonary oedema. There is increasing evidence, that some of the 'classical contraindications' like heart failure, erysipelas, postischaemic oedema after arterial reopening, may be in fact valuable indications for modified forms of compression. Future work will be needed to evaluate optimal compression strategies for these indications.

## Conclusion

- The management of venous leg ulcers is complex and apart from techniques and products other factors such as patient's quality of life, individual patient features and various treatment settings are involved.
- Quality control aspects such as skills and knowledge of the clinicians play an important role in compression treatment delivery.
- Evidence-based guidance is needed to inform clinicians on contraindications, risk factors and adverse events when providing compression therapy.
- Complications of compression therapy can almost always be prevented when adequate assessment is performed and clinicians are skilled in applying compression.
- Effective patient education improves patient outcomes.
- The best guideline or pathway for improving patient outcomes is patient focused, implemented, regularly updated and used in every day clinical practice.

## References

- Bergan JJ, Schmid-Schönbein GW, Smith PD, Nicolaides AN, Boisseau MR, Eklof B. Chronic venous disease. *N Engl J Med* 2006; **355**: 488–498.
- Körber A, Klode J, Al-Benna S *et al.* Etiology of chronic leg ulcers in 31,619 patients in Germany analysed by an expert survey. *J Dtsch Dermatol Ges* 2011; **9**: 116–121.
- Vicaretti M. Compression and venous disease. *Aust Prescr* 2010; **33**: 186–190.
- Moffatt CJ, Doherty DC, Franks DDC. Community based leg ulcer classification and its relationship to healing. *Int Angiol* 2001; **20**(Suppl 1): 291.
- Partsch H. Compression therapy in venous leg ulcers. In: Negus D, Coleridge S, Bergan JJ, eds. *Leg Ulcers Diagnosis and Management*. Hodder Education, London, 2005: 109–116.
- Andriessen A, Polignano R, Abel M. Development and implementation of a clinical pathway to improve venous leg ulcer treatment. *Wounds* 2009; **21**: 127–133 <http://www.woundsresearch.com/files/wounds/pdfs/Andriessenmay.pdf>.
- Wong IKY, Andriessen A, Charles HE *et al.* Randomized controlled trial comparing treatment outcome of two compression bandaging systems and standard care without compression in patients with venous leg ulcers. *JEADV* 2012; **26**: 102–110.
- Clarke-Moloney M, Keane N, O'Connor V *et al.* Randomisierte kontrollierte Studie mit Vergleich von Kompressionsstrümpfen der Europäischen Klasse 1 versus Klasse 2 bezüglich Ulkusrezidiv und Patienten-Compliance. *Vasomed* 2014; **26**: 270.
- Gupta AK, Koven JD, Lester R, Shear NH, Sauder DN. Open-label study to evaluate the healing rate and safety of the Profore extra four-layer bandage system in patients with venous leg ulceration. *J Cutan Med Surg* 2000; **4**: 8–11.
- Partsch H, Damstra RJ, Tazelaar DJ *et al.* Multicentre, randomized controlled trial of four-layer bandaging versus short-stretch bandaging in the treatment of venous leg ulcers. *Vasa* 2001; **30**: 108–113.
- Cullum N, Nelson EA, Fletcher AW, Sheldon TA. Compression for venous leg ulcers. *Cochrane Database Syst Rev* 2009. DOI: 10.1002/14651858.CD000265.pub2.
- Mosti G, Mattaliano V, Partsch H. Influence of different materials in multicomponent bandages on pressure and stiffness of the final bandage. *Dermatol Surg* 2008; **34**: 631–639.
- Mosti G, Mattaliano V, Partsch H. Inelastic compression increases venous ejection fraction more than elastic bandages in patients with superficial venous reflux. *Phlebology* 2008; **23**: 287–294.
- Partsch H. The static stiffness index (SSI): a simple method to assess the elastic property of compression material in vivo. *Dermatol Surg* 2005; **31**: 625–630.
- O'Donnell TF, Passman MA, Martston WA, Ennis WJ *et al.* Management of venous leg ulcers; Clinical practice guidelines of the society for vascular surgery and the American venous forum. *J Vasc Surg* 2014; **60**: 3S–59S.
- Franks P, Barker J, Collier M *et al.* Management of patients with venous leg ulcer: challenges and current best practice. *J Wound Care* 2016; **25**(6 Suppl): 1–67.
- Rabe E, Hertel S, Bock E *et al.* Therapy with compression stockings in Germany - results from the Bonn Vein Studies. *J Dtsch Dermatol Ges* 2013; **11**: 257–261.
- Schwahn-Schreiber C, Marshall M, Murena-Schmidt R, Doppel W, Hahn S. Long-term observational study on outpatient treatment of venous diseases with medical compression stockings in Germany. *Phlebology* 2016; **1**: 1–68.
- Brouwers M, Kho ME, Bouwman GP *et al.* AGREE Next steps Consortium AGREE II: advancing guideline development, reporting and evaluation in health care. *CMAJ* 2010; **182**: E839–E842.
- The ADAPTE process: resource tool kit for guideline adaption. ADAPTE Collaboration; 2009. Available [www.g-i-n.net](http://www.g-i-n.net). accessed March 20 2016.
- Page Last Updated: 02/01/2016. U.S. Food and Drug Administration 1-888-INFO-FDA (1-888-463-6332). <http://www.fda.gov/Safety/MedWatch/HowToReport/ucm053087.htm>
- Neumann HAM, Junger M, Munte K, Rabe E *et al.* European Dermatology Forum S3 guideline for diagnostics and treatment of venous leg ulcers. *J Eur Acad Dermatol Venereol* 2016; **30**: 1843–1875.
- Association for the Advancement of Wound Care (AAWC). Association for the Advancement of Wound Care (AAWC) Venous Ulcer Guideline. Malvern, Pennsylvania: Association for the Advancement of Wound Care (AAWC) December 2010 (Accessible at <http://aawconline.org/professiona1-resources/resources/>).
- Wittens C, Davies AH, Bækgaard N *et al.* Clinical practice guidelines of the European Society for Vascular Surgery (ESVS). *Eur J Vasc Endovasc Surg* 2015; **49**: 678e737.

- 25 Scottish Intercollegiate Guidelines Network (SIGN). Management of Chronic Venous Leg Ulcers: A National Clinical Guideline. Edinburgh: NHS Quality Improvement Scotland; 2010. Available at [www.sign.ac.uk/pdf/sign120.pdf](http://www.sign.ac.uk/pdf/sign120.pdf)
- 26 Rabe E, Partsch H, Junger M, Abel M *et al.* Guideline for clinical studies with compression devices in patients with venous disorders of the lower limb. *Eur J Vasc Endovasc Surg* 2008; **35**: 494–500.
- 27 Ehresmann U *et al.* Guideline Deutsche Gesellschaft Phlebologie 08, 2008: [www.phlebologie.de/deutsche-gesellschaft-fur-phlebologie/diagnostik-und-therapie-des-ulcus-cruis-venosum.html](http://www.phlebologie.de/deutsche-gesellschaft-fur-phlebologie/diagnostik-und-therapie-des-ulcus-cruis-venosum.html)
- 28 Wilm S, Wollny A, Rieger MA *et al.* Deutsche Gesellschaft für Phlebologie: DGP und DeGAM gemeinsam erstellte Kurzversion zum Ulcus cruris venosum. 2010. [www.degam-leitlinien.de](http://www.degam-leitlinien.de)
- 29 Leitlinien Deutsche Gesellschaft für Phlebologie: Phlebologischer Kompressionsverband (PKV) 2009; **38**: 168–171.
- 30 Kröger K, Assenheimer B. ICW. Consensus recommendation. Recommendations for compression therapy for patients with venous ulcers. *EWMA J* 2013; **13**: 41–47.
- 31 Australian and New Zealand Clinical Practice Guideline for Prevention and Management of Venous Leg Ulcers. The Australian Wound Management Association Inc. and the New Zealand Wound Care Society Inc., 2011. Osborne Park: Cambridge Publishing; 2011. [www.awma.com.au/publications/2011\\_awma\\_vlug.pdf](http://www.awma.com.au/publications/2011_awma_vlug.pdf)
- 32 Weller C, Evans S. Venous ulcer management in general practice – practice nurses and evidence based guidelines. *Aust Fam Physician* 2012; **41**: 331–337 [www.nzwcs.org.nz](http://www.nzwcs.org.nz).
- 33 Wound, and Continence Nurses Society (WOCN). Guideline for Management of Wounds in Patients with Lower-Extremity Venous Disease. O. Mount Laurel (NJ): Wound, and Continence Nurses Society (WOCN), Editor. 2011.
- 34 TVS clinical practice guideline: Wounds International 2011; **2**:18–21.
- 35 Understanding compression therapy: EWMA Position document. Wounds International 15 October 2009
- 36 Schweitzer BPM, Doornbosch J, Glotzbach R *et al.* Dutch college of GP (NHG) practice guidelines. *Huisarts Wet* 2014; **1**: 153–156.
- 37 Assenheimer B, Augustin M, Braunwarth H *et al.* Consensus recommendations for compression therapy for patients with venous ulcers. *EWMA J* 2013; **13**: 41.
- 38 Simms KW, Ennen K. Lower extremity ulcer management: best practice algorithm. *J Clin Nurs* 2010; **20**: 86–93.
- 39 Howard M, Kimmel DPM *et al.* An evidence-based algorithm for treating venous leg ulcers utilizing. *Cochrane Database Syst Rev Wounds* 2013; **25**: 242–250.
- 40 Edwards H, Finlayson K, Courtney M *et al.* Health service pathways for patients with chronic leg ulcers: Identifying effective pathways for facilitation of evidenced based wound care. *BMC Health Serv Res* 2013; **8**: 86.
- 41 Keiffer MR. Utilization of clinical practice guidelines: barriers and facilitators. *Nurs Clin North Am* 2015; **50**: 327–345.
- 42 Tang JC, Marston WA, Kirsner RS. Wound Healing Society (WHS) venous ulcer treatment guidelines: what’s new in five years? *Wound Repair Regen* 2012; **20**: 619–637.
- 43 Van Hecke A, Grypdonck M, Defloor T. Guidelines for the management of venous leg ulcers: a gap analysis. *J Eval Clin Pract* 2008; **14**: 812–822.
- 44 O’Donnell TF Jr, Balk EM. The need for an Intersociety Consensus Guideline for venous ulcer. *J Vasc Surg* 2011; **54**(6 suppl): 83S–90S.
- 45 Gorelik O, Almozino-Sarafian D, Litvinov V *et al.* Seating-induced postural hypotension is common in older patients with decompensated heart failure and may be prevented by lower limb compression bandaging. *Gerontology* 2009; **55**: 138–144.
- 46 Nose Y, Murata K, Wada Y *et al.* The impact of intermittent pneumatic compression devices on deep venous flow velocity in patients with congestive heart failure. *J Cardiol* 2010; **55**: 384–390.
- 47 Mosti G, Iabichella ML, Partsch H. Compression therapy in mixed ulcers increases venous output and arterial perfusion. *J Vasc Surg* 2012; **55**: 122–128.
- 48 Moran PS, Teljeur C, Harrington P, Ryan M. A systematic review of intermittent pneumatic compression for critical limb ischaemia. *Vasc Med* 2015; **20**: 41–50.
- 49 Chan CL, Meyer FJ, Hay RJ, Burnand KG. Toe ulceration associated with compression bandaging: observational study. *BMJ* 2001; **323**: 1099.
- 50 Nelson EA, Mani R, Thomas K *et al.* Intermittent pneumatic compression for treating venous leg ulcers. In: The Cochrane Library, Chichester, UK: John Wiley & Sons, Ltd., 2011.
- 51 Ziaja D, Kocelak P, Chudek J *et al.* Compliance with compression stockings in patients with chronic venous disorders. *Phlebology* 2011; **26**: 353–360.
- 52 Comerota AJ. Intermittent pneumatic compression physiologic and clinical basis to improve management of venous leg ulcers. *J Vasc Surg* 2011 Apr; **53**: 1121–1129.
- 53 Finlayson K, Edwards H, Courtney M. Factors associated with recurrence of venous leg ulcers: a survey and retrospective chart review. *Int J Nurs Stud* 2009; **46**: 1071–1078.
- 54 Dissemmond J, Protz K, Hug J, Reich-Schupke S, Kröger K. Compression therapy of chronic leg ulcers: Practical aspects. *Z Gerontol Geriatr* 2017. DOI: 10.1007/s00391-017-1191-9. [Epub ahead of print]
- 55 Carsar DG. Do we need to reappraise our method of interpreting the ankle brachial pressure index? *J Wound Care* 2001; **10**: 59–62.
- 56 Vowden P, Vowden K. Doppler assessment and ABPI: Interpretation in the management of leg ulceration. *World Wide Wounds* 2001. Last modified May 18, 2001 <http://www.worldwidewounds.com/2001/march/Vowden/Doppler-assessment-and-ABPI.html>