

New research in compression therapy principles

For venous leg ulcer healing and prevention of recurrence, compression therapy is the most important treatment modality. Therapy is applied mainly by bandages or hosiery, with the highest pressures applied at the ankle and the pressure reducing towards the knee. The current thinking is that venous return is enhanced with a higher pressure at the ankle, and having a higher pressure at the calf than the ankle would impede venous return and increase venous hypertension. Recently, however, there have been some questions about the principle of graduated compression. The aim of this article is to look at recent research in this area of leg ulcer management.

Compression therapy is the most important treatment modality for venous leg ulcer healing and prevention of recurrence. Therapy is applied mainly by bandages or hosiery, with the highest pressure applied at the ankle and with the pressure gradually reduced towards the knee as the circumference of the limb increases towards the calf. The underlying principles of compression therapy are:

- ▶ A larger limb circumference results in lower sub-bandage pressures.
- ▶ Applying the highest pressure at the ankle encourages venous return and, therefore, decreases venous hypertension and reduces oedema.
- ▶ Compressing the calf enhances the action of the calf muscle pump.

Recently however there have been some questions about the principle of graduated compression. The aim of this article is to look at recent research in this area of leg ulcer management.

The International Compression Club (ICC) – comprising clinicians, academics and industry – is focused on compression therapy research. At a meeting in 2011, there was a debate about compression therapy and presentation of new evidence. The debate resulted in a list of 12 “dogmas” being compiled. One of these was: “Compression devices applied to the leg must provide a pressure gradient with decreasing pressures from distal to proximal” (Flour et al, 2012). The current consensus is that venous return is enhanced through higher pressure being applied at the ankle, and applying

a higher pressure at the calf than the ankle would impede venous return and increase venous hypertension.

RECENT RESEARCH

Mosti and Partsch (2011) tested a new concept in compression hosiery where the garment exerted more pressure at the calf than the ankle. The study involved 30 patients with chronic venous insufficiency (CVI) who were awaiting varicose vein surgery. The CVI was classed as severe on the basis of significant great saphenous vein reflux. Participants also had good joint mobility as they were required to perform exercises in the study.

Two stockings were compared: one with a conventional pressure profile and the other with an inverse gradient (higher pressure at the calf), which the researchers refer to as “progressive increase” (referred to in this article as “modified”). The ejection fraction was measured in order to assess the calf pumping function. Ejection fraction is a measure of the blood volume output when the calf muscle activates. The volume change was measured by strain-gauge plethysmography (Mosti et al, 2008). Interface pressures from the hosiery were measured 12 cm above the ankle (known as B1) and at the widest part of the calf (known as C) using a PicoPress® (Microlab) monitor. The ejection fraction was increased with the modified stocking compared with the conventional one ($P < 0.001$). The measurements were taken when supine, standing, and when exercising.

KEY WORDS

- ▶▶ Compression therapy
- ▶▶ Graduated compression
- ▶▶ Ulceration
- ▶▶ Venous insufficiency

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The stockings delivered 15 mmHg–25 mmHg of pressure at the ankle and were applied to the leg that was to undergo surgery. The standard stocking was expected to provide a 20% reduction in interface pressure at the calf, and the modified stocking was expected to give a 50% increase at the calf. However, the conventional stocking gave a median ankle pressure of 22 mmHg and decreased by 14% at the calf. The progressive stocking gave a median ankle pressure of 18.5 mmHg and increased at the calf by 57%. The interface pressures increased slightly on standing and exercise.

The authors stated that the ejection fraction without compression was 33.29% in their participants, who all had CVI. They reported that with the conventional stocking, the ejection fraction increased to 44.5%. With the modified stocking, the ejection fraction rose to 52.54%. These figures were reported in the paper as +32.7% and +75% respectively. However, following the calculations in the paper is problematic, and although the former figure appears largely correct, it may be subject to a rounding error. The latter figure, using the same method of calculation, appears to be nearer +57.8%, rather than the reported +75%.

The authors concluded that the rationale for graduated compression that reduces toward the calf is predicated on a resting position. The same may not apply when walking as the calf muscle will produce very high pressures at the calf – therefore, a naturally high calf:ankle pressure ratio. They reasoned that external pressure on the calf will result in more effective emptying of veins at the calf.

Mosti et al appeared to claim that 30 mmHg at the calf was a desirable pressure, based on a positive correlation between the ejection fraction and the peak pressure at the calf. Given current standards, this would mean that a conventional stocking would need to exert about 44 mmHg–60 mmHg pressure at the ankle to result in 30 mmHg at the calf. As the authors pointed out, this may mean discomfort for the patient and difficulty in applying the stocking over the foot and ankle.

They did concede that their study demonstrates improved calf muscle performance on venous return, but this did not indicate an effect on chronic oedema/lymphoedema and thromboprophylaxis.

Couzan et al (2012) conducted a randomised controlled trial (RCT) using conventional and

modified stockings, although their modified ones exerted a lower pressure (23 mmHg) at the calf – more in line with pressures in current conventional compression systems.

Mosti and Partsch (2012) conducted a study to investigate inelastic bandages giving high calf pressures compared to a conventionally applied inelastic bandage. Twenty patients awaiting varicose vein surgery were enrolled in the study. The bandage was applied in a conventional manner, and for the modified bandage extra layers were applied over the calf to increase the pressure relative to the ankle pressure. They applied the same measurement techniques (strain-gauge plethysmography) as above to determine the ejection fraction.

The conventional bandage demonstrated a decrease in pressure, from 53 mmHg to 37 mmHg at the calf. With the modified bandage, the pressure increased from 50 mmHg at the ankle to 62 mmHg at the calf. The pressures were higher when standing; 75 mmHg and 59 mmHg for the modified and conventional bandage respectively. These pressures are much higher than those exerted by the stockings in the previous study. The ejection fraction was 75.6% in the conventional bandage and 89.1% in the modified bandage compared to 32.9% without compression reported earlier.

Mosti and Partsch (2012) speculated that high pressure in the calf when walking is beneficial to counteract high hydrostatic pressures when reflux is present. They also pointed out that such high pressure peaks can only be achieved and tolerated by patients when a stiff material is used.

Earlier research conducted by Mosti et al (2008) found that when comparing elastic and inelastic bandages in the treatment of people with CVI, the inelastic system ($n=30$) raised the ejection fraction more than the elastic system. They also found that when similar pressures were obtained in the supine position the inelastic system exerted much higher pressures on exercise.

This is the basis of the static stiffness index and it has an impact on calf muscle pump performance as measured by the ejection fraction. The patients reported high pressures from the elastic system as painful and these could only be tolerated for the laboratory study. Mosti and Partsch (2012) recognised that their results could possibly have

been achieved with a conventionally applied inelastic bandage, but in order to get a gradient from ankle to calf and keep the high calf pressure, they would need approximately 80 mmHg–90 mmHg of pressure exerted at the ankle, which would be difficult for the patient and may put them at risk of pressure damage.

Mosti and Partsch (2013) conducted a study with 30 healthy volunteers who had jobs where they sat or stood for long periods (theatre nurses and office workers). They investigated changes in leg volume with two types of stocking: a conventional one and one modified to exert higher pressures at the calf than the ankle. They also measured interface pressure, comfort, and experience of applying the stockings, which were measured on a visual analogue scale.

The volunteers had measurements taken without compression and then again the following day where one leg was covered with a conventional stocking and the other leg with a modified stocking. Stockings were applied as soon as the volunteers got out of bed to prevent oedema before stocking application. Leg volume increase was similar without compression, at 4%–4.3% for all participants. The oedema reduction in both stocking groups was significant at $P < 0.001$. The leg volume reduction was statistically significant between the stockings, but at a level of $P < 0.05$: 2.7% in the conventional group and 3.4% in the modified group.

The ease of applying the stockings was statistically in favour of the modified stocking ($P < 0.001$), but the actual score difference was 6 versus 7. The average comfort score was 9 in both groups, but the range of scores (8–9 vs 9–10) resulted in a significance of $P < 0.05$. The researchers highlighted their statistical outcomes in this study, but the sample was small, as were the numerical differences. In addition, the stockings were worn for only one shift. The researchers conceded that the possible adverse effect on formation of oedema in the gaiter region would need to be thoroughly investigated.

CONCLUSION

It is important to recognise that Mosti and Partsch (2011; 2012) acknowledge that their studies have not investigated side-effects, clinical outcomes or tolerance of the compression, or the effect on oedema at the ankle and foot. Clinically, we can see that when pressure is lower at the ankle

than the calf, or inadequate at the foot, there is an increase in foot and toe oedema. Tolerance is especially important in the context of the pressures involved and the experience of pain with high pressures. There is already a significant issue with concordance in people with compression therapy, and high pressures may exacerbate this problem. None of the participants in the studies had ulceration. In addition, the patients in the studies are awaiting surgery, which implies a degree of good health that many patients in clinical practice do not have.

Inevitably, further research, especially in different patient groups and with larger sample sizes must be conducted. It is worth recognising that all of these studies have been performed in a laboratory with the compression worn for a very short time. We need to embrace new scientific thinking about compression therapy and engage in clinical research, debate, and evaluation of new techniques and data.

The researchers argue that the calf pressure rather than the gradient is the key principle in enhancing the action of the calf muscle pump, but this new work will necessitate careful translation to practice. The application of this theory to practice is in its early stages. There are already concerns about training, knowledge, and competence in this field, and it is important that new techniques are understood and taught carefully to ensure patient safety and effective therapy.

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