Comparison Between a New, Two-component Compression System With Zinc Paste Bandages for Leg Ulcer Healing: A Prospective, Multicenter, Randomized, Controlled Trial Monitoring Sub-bandage Pressures

Giovanni Mosti, MD;1 Aldo Crespi, MD;2 Vincenzo Mattaliano, MD1

Abstract: Compression therapy is standard treatment for venous leg ulcers. The authors prefer multi-layer, multi-component, stiff, high-pressure bandages to treat venous leg ulcers. The Unna boot (UB) is an example of this type of bandage. The aim of this study was to compare the effectiveness and tolerability of UB to a new, two-component bandage. Methods. One hundred (100) patients with venous ulcers were randomized into two groups: group A (n = 50) received UB and group B (n = 50) 3M™ Coban™ 2 Layer Compression System (C2L). All patients were followed weekly for 3 months and then monthly until complete healing was achieved. The primary outcomes were: ulcer healing or surface reduction; pain; and exudate control. The secondary outcomes were: ease of application and removal of the bandage, pressure exerted in the supine and standing position after application and before removal, and bandage comfort. Results. C2L was associated with 100% ulcer healing; 47 out of 50 cases healed within the first 3 months after application of the bandage. Compared with the UB, there was no statistically significant difference. In both groups the effect of compression on pain and overall well being was excellent; pain decreased by 50% within 1–2 weeks and remained low throughout the duration of treatment and overall well being improved significantly. There was no significant difference between the two systems concerning level of comfort. Conclusion. C2L proved to be effective in treating venous ulcers due to its stiffness and pressure. Its effectiveness was similar to UB, which is often considered the gold-standard compression device for venous ulcers. This fact, in combination with high tolerability and ease of application and removal, make this new bandage particularly suitable for the treatment of venous leg ulcers.

Compression therapy is the standard treatment for venous ulcers.1–3 Multi-layer, multi-component devices are preferable to single-layer, single component systems and should exert a strong pressure espe-
cally in the standing position to counteract the venous ambulatory hypertension that is a common trait in patients with a venous disease. The Unna boot (UB) bandage is made up of inelastic gauze bandages impregnated with zinc oxide. Cotton wool is used for padding the shin and tendon prominences and a short-stretch adhesive bandage is wrapped over the top. This is one of the most widely used bandages in the treatment of venous ulcers and is considered by many experts as one of the most effective.

Recently, a new bandage became available for ulcer treatment that consists of two-components; one inner comfort component comprised of foam and a cohesive layer and one outer compression component that is a cohesive bandage. Both components are short stretch and cohere to each other resulting in a bandaging with high stiffness.

The aim of the present study was to compare the new two-component bandage, 3M™ Coban™ 2 Layer Compression System (3M Health Care; Neuss, Germany) (C2L) with the UB, concerning effectiveness, pain control, tolerability, exerted pressure, and ease of application and removal in an outpatient setting.

Materials and Methods

Patients. One hundred (100) patients (76 women, 24 men aged 70.1 ± 10.3 years) with venous ulcers of the lower limbs were enrolled in three centers. Venous etiology was documented by Duplex scanner showing massive reflux in the superficial (74 cases) and/or deep veins (26 cases).

Inclusion criteria. Patients of both sex, aged 20–80 years with non-infected venous ulcers of the lower leg (including those with mild arterial disease, but ABPI > 0.8), ulcer area from 2 cm²–100 cm², ulcer duration no longer than 1 year.

Exclusion criteria. Patients younger than 20 or older than 80 years, ulcer size greater than 100 cm² and duration longer than 1 year, arterial disease with an ABPI < 0.8, insulin-dependent diabetes mellitus, ulcer infection, immunosuppressive or cytostatic drug intake, allergy to one of the materials used, bedridden/non-ambulatory, pregnancy, or breastfeeding.

Duplex examination. All patients were checked for superficial and/or deep venous insufficiency or obstruction by means of Duplex scanner (Esaote MyLab 75 with linear a probe 7.5 to 10 MHz; Esaote s.p.a. Genoa; Italy) in standing position. Venous reflux was elicited in longitudinal view by means of manual calf compression distally to the examined point and was considered pathologic when longer than 0.5 seconds. Compression maneuver (CUS) in cross-sectional view was performed along the deep vein system to elicit deep vein obstruction.

All patients were fully informed of the study details and provided their written consent to participate in the study. In Italy, studies comparing CE marked products are regarded as observational studies and do not require ethical committee approval.

Following enrollment, patients were randomized into two groups (50 each) and treated either with the new C2L or the UB. Randomization was done for the entire sample with an automated list randomizer (www.random.org/lists/).

**Key Points**

- The present study compared a new two-component bandage (C2L; 3M™ Coban™ 2 Layer Compression System) with a modified Unna Boot (UB) concerning effectiveness, pain control, tolerability, exerted pressure, and ease of application and removal (Editor’s Note: The Unna Boot described and used in this study is not the same type of Unna Boot most clinicians use in the United States. See the description of the Unna Boot used in this trial in the Bandages sub-section below.)

Bandages. The UB was applied with a zinc-oxide bandage (Zincobend Anelastic®, PMA; Lainate, Italy) applied without tension, a cotton bandage, another zinc-oxide bandage applied with moderate tension and finally an adhesive bandage (Fisiplast HM®, PMA, Lainate Italy) applied with an extension of 100% and a 50% overlap. C2L is made up of two components; the first, comfort component was wrapped around the leg with no/minimal tension and minimal overlap to provide sufficient comfort; the second component was wrapped over the first layer with a 50% overlap and at full stretch. The two layers cohere to each other producing a final bandage with high stiffness.

Both bandages were applied from the base of the toes up to 3 cm distal to the popliteal fossa with a pressure in the supine position of at least 40 mmHg–50 mmHg. All leg ulcers were dressed with the same polyurethane foam dressing (3M™ Tegaderm™ Foam Dressing [nonadhesive], 3M Health Care, St. Paul, MN) to prevent the introduction of any additional variable. When necessary, a skin barrier was used to prevent maceration of the surrounding skin (3M™ Cavilon™ No Sting Barrier

Vol. 23, No. 5  May 2011

127

Mosti et al
Film, 3M Health Care, St. Paul, MN). The dressing and bandage changes were performed weekly and the objective and subjective parameters were assessed.

Patients were followed weekly for 3 months. At the conclusion of the study period, they continued with the same treatment regimen and were monitored monthly until complete healing was achieved.

**Objective outcome parameters:**
- Ulcer size (using Visitrak® Wound Measuring System; Smith & Nephew; Hull, England),
- Ulcer bed appearance (presence of necrosis or fibrin, granulation tissue, epithelization),
- Ankle and calf circumference and bandage slippage (measured in cm).
- The pressure exerted by the bandage was measured in the supine and standing position and the difference between the standing and the supine pressure, called Static Stiffness Index (SSI), was calculated. A new device (PicoPress®, Microlab, Padova, Italy) was used to measure the interface pressure. This pneumatic system has a pressure probe measuring 5 cm in diameter and less than 1 mm thick. The probe is placed on the medial aspect of the calf at the point where the gastrocnemius tendon turns in the gastrocnemius muscle (point B1) and filled with 2 mL of air during measurement. At the end of the measurement the probe can be removed from the leg by means of a sliding sleeve or it can be disconnected by the measuring device, left in place under the compression system and reconnected when a new measurement has to be performed. In this study, the probe was left in place underneath each bandage for 7 days and the pressure was measured again before bandage removal whenever possible (when B1 point was not included in the ulcer area).
- A digital photograph was taken at every visit to document ulcer bed appearance, skin changes (scaling, blisters, redness), amount of exudate, surrounding skin condition, and ease of bandage application and removal.

**Subjective outcome parameters:**
- Pain level (by visual analogic scale) and overall well-being feeling (by means of a scoring system from 1 to 10, 1 being very poor, 10 excellent) time needed to reduce the pain by half.
- Discomfort such as constriction or tightness, loss of sensitivity or warmth, itching, and dryness (classified as “not present,” “mild,” “moderate,” or “severe”).
- Those who applied the bandages graded the ease of application and removal as “very easy,” “medium easy,” or “difficult.”

**Statistical Analysis**

Values were expressed as medians with interquartile range (IQR) and minimum and maximum values. Non-parametric tests were used to compare the two groups. The surface area of the ulcer, healing time, and time to reduce the pain by half were compared with the Mann-Whitney test. The Kaplan Meier log-rank test was used for comparison of survival curves. The interface pressure in supine and standing position after application and before removal, SSI, initial and final pain level, state of well-being, ankle and calf circumference at the beginning and end of treatment were compared using the Kruskal-Wallis test and the Dunn test (multiple comparisons between groups). P < 0.05 was considered statistically significant.

The software Prism 5 (GraphPad, San Diego, CA) was used for statistical analysis and to create the graphs.

**Results**

Thirty-seven (37) women and 13 men aged 69.6 ± 12 years with a median ulcer surface area of 7 cm² (IQR 4–10) were treated with C2L, while 40 women and 10 men aged 70.8 ± 8.4 years with a median ulcer surface area of 7.5 cm² (IQR 3.5–15.5) were treated with UB (Table 1). The two treatment groups were comparable concerning sex, age, ulcer size, ulcer duration, pain

**Table 1. Main characteristics of the patients.**

<table>
<thead>
<tr>
<th></th>
<th>Age (years)</th>
<th>Male</th>
<th>Female</th>
<th>Ulcer area</th>
<th>Ulcer duration</th>
<th>Pain (VAS)</th>
<th>WBF</th>
<th>Ankle circumference</th>
<th>Calf circumference</th>
</tr>
</thead>
<tbody>
<tr>
<td>C2L</td>
<td>74 (66–77.2)</td>
<td>13</td>
<td>37</td>
<td>7 (4–10)</td>
<td>5.8 (3–11)</td>
<td>4 (2–5)</td>
<td>8 (7–9)</td>
<td>25 (23–26)</td>
<td>39 (37–41)</td>
</tr>
<tr>
<td>UB</td>
<td>72.5 (65–72.5)</td>
<td>10</td>
<td>40</td>
<td>7.5 (3.5–15.5)</td>
<td>6.1 (3–12)</td>
<td>3.5 (2–4)</td>
<td>8 (7–8.7)</td>
<td>24 (24–26)</td>
<td>37 (35.2–40)</td>
</tr>
</tbody>
</table>

VAS: Visual Analogue Scale
WBF: Wellbeing Feeling
Data are given as median with the interquartile range in parenthesis.
level, and ankle and calf circumference (no statistically significant differences).

Ninety-nine (99) patients completed the study; one patient in the UB group did not complete the study due to maceration of the wound bed associated with pain refractory to analgesics, which required different management of the wound.

Forty-seven (47) out of 50 patients (94%) in the C2L group and 45/49 patients (91.8%) in the UB group were healed after 3 months (Figure 1).

The median healing time was 49.5 days (IQR 27.7–69.7) with C2L and 48 days (IQR 33–63.5) with UB (n.s.). Pain control was very effective with both bandage systems. Patients reported a 50% decrease in pain evaluated by means of Visual Analogue Scale within 1 week in both groups (IQR 1–2 in the C2L group and 1–1 in the UB group, n.s.) and did not report any pain after 2.8 weeks of treatment. This was associated with the perception of an improved overall wellbeing (Figure 2).

When present, leg edema rapidly disappeared and limb circumference decreased by 7.3% with UB and 8.5%

**KEYPOINTS**
- 47 out of 50 patients (94%) in the Coban group and 45/49 patients (91.8%) in the modified Unna Boot group were healed after 3 months.
- The median healing time was 49.5 days (IQR 27.7–69.7) with Coban and 48 days (IQR 33–63.5) with modified Unna Boot.

**Figure 1.** Kaplan Maier plot showing the ulcer healing rate in the two treatment groups. The log-rank comparison between the two curves showed no significant difference.

**Figure 2.** Pain measured with a Visual-Analogue Scale (VAS) at the beginning and end of treatment (left) and overall well-being (right); there is a significant difference between pre-treatment and post-treatment in both groups. There are no significant differences between the two groups. Data are given as median with interquartile ranges, and minimum and maximum values.

***P < 0.001
**Figure 3.** Ankle and calf circumference on application (left) and 7 days later (right). The differences between the start and end of compression treatment are significant. **P < 0.01; ***P < 0.001. Data are given as median with interquartile ranges, and minimum and maximum values.
with C2L at the ankle, and 7.3% with UB and 7.7% with C2L at the calf with no significant difference between groups (Figure 3). The bandaging did not cause any major skin lesions in either group. Four patients in the C2L group with a thin leg (initial ankle circumference less than 23 cm and a prominent tibia) reported mild pain and tenderness in the anterior aspect of the leg at the beginning of the treatment. Improvement of this symptom was best achieved by applying additional padding material using the leftover material from the first layer over the tibial prominence.

Slippage of the bandage and skin scaling occurred significantly more often with C2L than with UB (Table 2). There were no other reported symptoms related to poor tolerance to the bandage such as itching or sensation of excessive constriction or tightness. C2L was reported to be easier to apply and remove than the UB by those who applied the bandages. Interface pressure upon application was higher with the UB, both in the supine position (n.s.) and in standing position ($P < 0.001$). After 7 days, the pressures significantly dropped before removal in both groups, but to a significantly lesser extent with C2L. As a result, at bandage removal the supine pressure was higher with C2L, while standing pressure was still slightly higher with the UB (no significant difference in either case [Figure 4]). The SSI was higher with the UB both after bandage application and before removal; this difference was significant ($P < 0.001$). However, in both groups these observed values were largely in the range of bandages with high stiffness (Table 2, Figure 5).

**Figure 4.** Interface pressure upon application (left) and before removal (right) of bandages after 1 week. Pressure while supine did not show any significant differences; pressure while standing was significantly higher but not significantly different at time of removal. **$P < 0.01$.** Data are given as median with interquartile ranges, and minimum and maximum values.

**Figure 5.** Static Stiffness Index (SSI) was always significantly higher with the UB. SSI was within the normal range of inelastic bandages for both bandages. ***$P < 0.001$.** Data are given as median with interquartile ranges, and minimum and maximum values.
Discussion

Compression therapy is crucial in the treatment of leg venous stasis ulcers. A recent Cochrane review confirms what has been reported in previous research: compression (by any means) is better than no compression. This same review concluded that high-pressure compression is better than low-pressure compression and that multi-component systems (consisting of different materials) are preferable to single-component systems (consisting of one single material). However, pressure has been measured only in very few of these comparative studies and the definitions of high and low pressure are not clearly specified. As the effectiveness of the compression depends on its pressure—it will make a great difference if a compression device that should be applied with high pressure was actually applied with low pressure. In cases where the pressure exerted by a compression device is not measured, the authors were not able to determine if different outcomes were due to a the efficacy of the compression device or incorrect application of an effective product. This study is the first in which pressure was measured not only after application, but also before bandage removal 1 week later in order to measure the pressure loss of the 2 different materials we used.

Corresponding to a definition given in a consensus report, the initial pressure of both bandage systems was in the range of “strong compression” (40 mmHg–60 mmHg) falling into the “medium range” (20 mmHg–40 mmHg) before removal. This underlines the fact that the comparison of the two systems was fair and that there was no bias concerning different application techniques. Compared to the literature, we were able to achieve outstanding healing rates with the inelastic bandages applied with high pressure.

The high pressure that was applied to the compression devices with all of the bandages and effective pressure maintenance are the main reasons for the results seen in the present study. The absence of clinical infection, severe diabetes mellitus, severe arterial disease, complete venous obstruction, as well as the small ulcer size and the use of a high quality wound dressing, might also have played a role in achieving the reported outcomes.

Key points

- This study is the first in which pressure was measured not only after application, but also before bandage removal 1 week later in order to measure the pressure loss of the 2 different materials.

A new PicoPress device was used for pressure measurements, which is easy to handle, shows a high level of accuracy and reproducibility, and fulfills the prerequisites for a reliable measurement of compression bandages, as formulated in a consensus conference.

The recommendation of applying high pressures in the treatment of venous leg ulcers is justified by the fact that only pressures in this range can exert a hemodynamic effect by narrowing the venous lumen at rest and intermittently occluding veins during muscle activity (standing, during exercise). Intermittent venous occlusions during muscular systole imitate a sort of valve mechanism, which occurs when the pressure exerted by the bandage exceeds the intravenous pressure. The narrowing/occlusion of the venous lumen is important to correct the main pathophysiological parameters in venous insufficiency—i.e., venous reflux, reduced ejection fraction, and ambulatory venous hypertension.

Compared with elastic, inelastic material leads to a significantly greater reduction of venous reflux and a significantly greater increase of venous pumping function, as assessed by measuring ejection fraction. A high systolic pressure can be achieved using any compression system because the pressure provided by the bandage is directly proportional to the applied tension and to the degree of overlapping while wrapping the bandage.

Nevertheless, a bandage feature that must absolutely be taken into account is its tolerability, which is directly correlated with the association between a high pressure while sitting or standing (necessary to counteract venous hypertension) and a low, tolerable pressure in the supine position. The SSI is a meaningful index to characterize the relationship between efficacy and tolerability, which is calculated by subtracting the supine pressure from standing pressure.

Only inelastic bandages provide a high standing pressure starting from a relatively low resting pressure. In fact, they do not give way to the calf circumference increase that occurs when moving from the supine to standing position (due to muscle contraction), thus producing a significant increase in interface pressure usually more than 10 mmHg (the SSI will always be superior to 10 mmHg). The yielding elastic materials, by contrast, give way to the leg circumference increase in the transition from supine to standing, only producing a small pressure rise, usually less than 10 mmHg. In order to obtain a high standing pressure with these materials, one must therefore apply the bandage with a high resting pressure.
An increase in pain

C2L meets all the requirements necessary to exert a hemodynamic action in venous insufficiency: it is a multilayer, bi-component bandage, which provides high pressure in the upright position (median value 66.5 mmHg), starting from relatively low pressure in the supine position (50.5 mmHg); the high SSI (16 mmHg), within the range of inelastic bandages, makes this new bandage well tolerated.

Compared with the UB, which is considered the prototype of inelastic bandages and consists of totally inelastic and inextensible materials, C2L showed similar though quantitatively different characteristics. The supine pressure of the C2L was higher, while its standing pressure was lower than the UB—this produces a lower SSI.

The pressure loss of both bandages after 1 week may be explained by the edema reduction documented in Figure 3. In a separate study, the authors have shown that the hemodynamic efficacy of inelastic bandages is maintained in spite of pressure loss. However, C2L showed a better capacity to maintain pressure over time compared with the UB; after 7 days the supine pressure was even higher, while the standing pressure was roughly similar. This substantial equivalence in pressure produced by the two compression systems some time after the application could explain the similar results obtained in terms of healing.

Within 3 months of observation most ulcers (92 out of 100, 47 out of 50 patients in the C2L group, and 45 out of 50 in the UB group with no significant difference) were healed with an average healing time of less than 50 days in both groups (no significant difference). The ulcers that did not heal after 3 months eventually healed (range 7–110 days). One patient treated with the UB did not complete the study because of superimposed infection and pain.

Both bandages were well tolerated and none of the patients had to discontinue treatment. It was observed, however, that for patients with thin limbs in particular, the thickness of the first padding component above the dorsum of the foot and shin should be increased in order to prevent skin damage, especially when high pressure is indicated.

A very important finding in this study is the effectiveness of compression in reducing ulcer related pain. Compression therapy is often blamed for increasing ulcer pain; the present study shows that the contrary is true. Compression reduces the ulcer related pain, which often disappears completely after a few weeks. The present findings are consistent with reports of other authors. The effects of compression on microcirculation are most likely responsible for the pain reduction. Actually, compression releases anti-inflammatory, anti-coagulatory, fibrinolytic, and vasodilating mediators from the endothelial cells. Furthermore, compression removes edema and dramatically reduces the high levels of proteases and inflammatory cytokines irritating the nerves that are contained in the edema fluid, thus favoring the reduction of pain and inflammation that are quite frequent in venous insufficiency. An increase in pain under compression can be a result of technical mistakes during bandage application or use of improper material (eg, elastic material applied with high stretch).

Comparing the tested compression systems, the conclusion was made that both were well tolerated by the periwound skin and the overall limb, causing just some mild skin scaling in a minority of cases. C2L showed minimal slippage in a small number of patients. Alternately, the C2L has definite advantages regarding ease of application and removal compared to the UB. The latter consists of 4 bandages and its application requires some practice. Even its removal, while not difficult, is not as simple as removing the C2L: the greater thickness and rigidity of the bandage makes it more difficult to cut.

Conclusion

Measuring the interface pressure when comparing different devices is of utmost importance to be sure that the correct pressure was applied and a fair comparison is possible.

In the present study both inelastic compression systems applied with high pressure were extremely effective for ulcer healing. The rate of complete healing achieved within 12 weeks was 94% in the C2L group and 92% in the UB group (no significant difference). Both devices were equally comfortable, skin friendly, and effective in reducing ulcer pain. These data indicate that the C2L is easier to apply and to remove, and can be considered at least as effective as the UB, which is often considered the standard compression treatment for venous ulcers.

**Key Points**

- Compression therapy is often blamed for increasing ulcer pain; the present study shows that the contrary is true.
- Both inelastic compression systems applied with strong pressure were effective for venous ulcer healing.
Acknowledgements
The authors gratefully thank Prof. Hugo Partsch for all of his suggestions and his help in editing the text. The authors acknowledge the help of 3M™ (Nuess, Germany) in providing all the dressing and compression materials.

References