The basis for successful treatment of venous ulcers is an adequate compression therapy. The compression bandage compresses the limb, thus leading to the resorption of the fluid found in the tissue by the veins and lymphatic vessels through which the fluid is then drained away towards the heart. The application of a bandage requires some experience, however it has to be learned by doctors, qualified nursing personnel and the patients’ next of kin as a matter of principle. The aim should be to successfully come up with a bandage which does not slip and which attains an effective compression without causing pressure damage or deformations to the limb. As a rule, the indication for the application of a compression bandage should be determined by a doctor since he also takes responsibility for paying attention to the contraindication.

The following essential principles for applying a compression bandage on the leg should be taken into account irrespective of the material used and the preferred technique of tying.

Everybody who applies a compression bandage must know the potential side effects of compression. Every time the bandage is changed, the leg should be carefully inspected for possible pressure marks, skin changes and atypical swellings which have appeared as a result of lacings around the area.

The recommendations of ICW on compression therapy apply only to patients with a venous ulcer. Compression of the lymphoedema, for instance, is not taken into consideration. These recommendations are regarded as a supplement to the existing guidelines of other professional associations and should serve the wound specialist as a basis for discussion with relatives of the affected people and colleagues, and also with doctors and health insurance companies. The contents of these recommendations are approved by an external expert and would be defended by ICW as such in the event of a legal dispute.

Prof. K. Kröger and B. Assenheimer on behalf of the ICW
**Principles of compression therapy**

The compression bandage compresses the limb, thus leading to the resorption of the fluid found in the tissue by the veins and lymphatic vessels through which the fluid is then drained away towards the heart. To attain this effect, the compression must be sufficiently strong and should reduce in strength from the distal to the proximal end. On the other hand the compression should be used in a regulated manner and must not be so strong as to cause pressure damage.

The compression pressure created by the compression bandage is determined by the bandage material and the manner in which the bandage is tied. A compression bandage is not an immobilizing bandage. Patients with a compression bandage should and may move normally and they should make themselves active. This movement improves the effect of the compression bandage – especially by activating the ankle joint and calf-muscle pump, alleviates pain and reduces the risk of possible injury through compression.

**Compression and movement**

The pressure created by compression narrows the vessels in a physical manner and in that way increases the blood flow rate. This effect can only be effective with proper motion. Therefore the patient has to be encouraged to move with a compression bandage on and to carry out gymnastic exercises, such as rotating and wiggling the foot. Guidelines recommend controlled walking exercises under compression therapy for patients with venous ulcer in order to prevent the stiffening of the ankle joint and to activate the calf-muscle pump.

**Working pressure and resting pressure**

Distinguishing between working pressure and resting pressure is necessary for purposes of applying compression therapy:

The compression bandage exerts resting pressure on the resting limb. It corresponds to the force which the applied bandage exerts when trying to contract. Resting pressure can only be defined when the muscles are relaxed.

The working pressure is the pressure which arises during motion through the interaction between muscle tension and the compression bandage. It arises from the resistance which the bandage exerts on the muscle movement. The less the bandage gives way in that process, the higher the working pressure. The two pressures depend both on the material used, the number of bandage rounds applied and the force with which the compression bandage was applied. Since the working pressure is produced by active muscle tension, the working pressure is always higher than the resting pressure.

**BANDAGE MATERIALS**

Elastic bandages should be used as bandage materials, such as the so-called “ideal” bandage (a cotton elastic short-stretch-bandage according to DIN 61631) or the non-shrink bandage (made of natural and synthetic fibres), both of which can be cohesive (sticking on itself) or adhesive (sticky). Compression bandages have a material strength of 0.56 - 1.19 mm when in an unstretched condition and are made of polyamide, elastane, cotton, elastodiene and viscose in different compositions. The bandages normally come in widths of 6, 8, 10, 12 cm and in lengths of 5, 6, 7 m.

**Stiffness**

Stiffness refers to the ability of the bandage to remain rigid and to withstand the changes in the geometry of the calf musculature when under strain. A more stiff bandage leads to high pressure peaks of 60-80 mmHg within the bandage when the calf musculature is strained and hence makes efficient retrograde venous blood flow possible.

**Short-stretch**

Short-stretch-bandages are defined as bandages with only low elasticity (40-90 % short-stretch).

They are characterized by a high working pressure and a low resting pressure.

Resting pressure of 40-60 mmHg can be realized with short-stretch-bandages; however the pressure does not remain at that level after applying the bandage. When in motion and/or during oedema reduction, the pressure decreases over the first 24 hours. Due to loss of pressure it might often become necessary to apply a new bandage, especially during the early stages of treatment, to prevent the bandage from slipping. At the beginning dressings with short-stretch-bandages should therefore generally be controlled in short periods (2 to 3 times a week) and if necessary renewed, in case of an easy reduction of the edema at least once a day.

The manufacturer’s instructions should be followed when taking care of the bandages. The material loses strength not only when the bandage is being applied but also through washing. The following care instructions usually apply:

- Bandages can be boiled at temperatures of 95°C and can be re-used approx. 30 times; worn-out bandages are not useful any more and should be replaced
- Use mild detergent for washing
- Don’t wash with fabric softeners
- Lay the bandages flat over the laundry rack to dry; don’t dry them using the heater or the laundry dryer!
**Long-stretch**

Long-stretch-bandages are defined as bandages with high elasticity (150-200% long-stretch). They exert high resting and low working pressure. This means that the bandage would stretch during active movement and hence no resistance and reflux-inducing effect can occur during muscle contraction. Due to their ability to adapt to changes in the limb form and movement, they can sustain the pressure for several days. The use of a single long-stretch-bandage for purposes of applying a strong compression is not recommended due to the risk of damages caused by pressure. Long-stretch bandages entail additional risk particularly for immobile patients. Due to the high resting pressure, severe constrictions can occur in the case of longer resting phases.

**Bandaging systems**

The market offers ready-made bandaging systems consisting of several components. In the process short- and long-stretch-bandages are partly used in combination. The bandaging systems have the advantage that one does not have to master complex compression techniques. These systems consist of two, three or four components and usually contain padding, compression and fixation bandages. They can remain in place for up to seven days depending on the clinical presentation, they seldom slip and they continuously maintain the pressure exerted at the time of attachment up to the time of next bandage replacement, depending on the state of decongestion. During the maintenance phase these ready-made bandaging systems can stay in place for up to 7 days. This advantage cannot, however, be used in the case of pronounced oedemas during the decongestion phase and in the case of florid ulceration. Many bandaging systems are not re-usable.

There are no studies regarding the cutaneous compatibility of a compression bandage. Allergy against polyamide, elastane, cotton or viscose in the form of urticaria (immediate-type allergy) or in the form of contact eczema (delayed-type allergy) is rare. More often you get cases of allergy against latex or against substances containing rubber caused by compression bandages containing elastodiene or by cohesive bandages coated with latex. Coloured bandages should be avoided because of the increased risk of allergy. A hint at this point: If there is a case of known allergy against silicone one can resort to silicone-free compression bandages and compression bandaging sets.

**COMPRESSION BANDAGES**

It is misleading to talk about layers in connection with the application of a compression bandage. Since there is always overlapping of the individual bandage rounds applied, at least two layers of the bandage material lie on top of one another in a given spot of the bandaged leg such that there is nothing like a single-layer-bandage. In that regard every compression bandage is multilayered.

It is therefore better to talk of components. Components refer to the individual products like the padding and the elastic bands which are used for applying the compression bandage. Such a multi-component-system comprises for instance:

- a tubular bandage
- a padded bandage: made of orthopaedic cotton wool or washable/re-usable foam material
- an attachment bandage, in order to create a basis for the compression
- at least two elastic bandages with a mild to moderate compression

Since the number of components used can vary, the attained contact pressure of each individual compression bandage also varies considerably.

The contact pressure on the ankle for an ankle size of 18-25 cm should reach about 35-40 mmHg. Unfortunately there is no established method for measuring or checking the contact pressure of a compression bandage in everyday clinical situations. One should be rather cautious when applying the bandage on patients who are being dressed for the first time and only increase the contact pressure carefully during the second and third replacement of the bandage.

**APPLICATION OF A BANDAGE**

The application of a bandage requires some experience, however it has to be learned by doctors, qualified nursing personnel and the patients’ next of kin as a matter of principle. The aim should be to successfully come up with a non-slipping bandage with an effective compression without causing pressure damage or deformations to the limb. Only the least number of patients can practically carry out effective self-dressing since elderly people and those with reduced mobility in particular cannot reach their foot when the leg is stretched out straight.
The strength of the compression to be applied must correspond to the aim of the therapy and in that way be adapted to the stage of treatment. We therefore distinguish between the:

- **therapy phase** of the treatment (control of the chronically venous insufficiency, oedema reduction and the healing of the ulcer), and
- **maintenance phase** (prevention of an oedema and healing of the ulcer, avoidance of an ulcer relapse).

The compression must be a little stronger in the therapy phase than in the maintenance phase. The aim is to reduce the oedema and/or to heal the ulcer. The compression bandage must be applied more frequently in the therapy phase than in the maintenance phase. With pronounced oedema and prompt decongestion, the bandage slips and must be replaced even several times daily in individual cases. Replacement of the bandage for up to two times a day is necessary even in the case of a heavily exuding ulcer, despite the use of fluid-absorbing wound-dressing and absorbent dressing pad. By using a proper and professional compression the exudation will decrease, the lower leg is decongested and the changing intervals can be extended.

The maintenance phase is defined by the attainment of a stable condition. The oedema should have been removed and the ulcer should have healed or should at least have entered into a stable phase of healing. In the absence of an oedema the tissue can give in to the bandage sparingly and the pressure effect on the tissue and on the bone edges (tibia, ankle joint) is greater. It is for this reason that the compression in the maintenance phase should only be so strong as not to cause renewed oedema. An ulcer which has not yet healed completely can be treated further using damp surgical dressing. Since these bandages can be left on the wound for some days and the leg does not show any more oedema, one can leave a compression bandage in place for some days during the maintenance phase.

The length of time that the compression bandage can be left on also depends on the material used. Short-stretch-bandages generally give way within the first couple of hours and do not exert any consistent pressure. Moreover they slip easily. Therefore, in most cases they have to be applied afresh each day. Bandaging systems can be used for up to seven days. For some years now the market has also been offering ready-made stocking systems as an alternative for this medical condition, and they have to be worn over the wound dressing. Custom-made compression stockings are to be prescribed as a relapse prophylaxis only after the ulcer has healed.

The compression bandage can be taken off at night if the ulcer has healed and if the leg is well-decongested, since the legs lie at heart level in bed during the night and are refreshed next morning. For these patients, however, one should primarily strive for an adjustment from the compression bandage to a compression stocking.

**Ready-made stocking systems**

These consist mainly of two components, an understocking which protects the wound dressing and holds it in place, and a classic elastic stocking which exerts pressure. This type of stockings is a feasible alternative to the compression bandage, particularly among patients with venous ulcers in the stable healing phase. These ready-made stocking systems are therefore also referred to as bandage stockings. In the case of pronounced oedema in the decongestion phase such a stocking system is not recommendable since it has to be adjusted like a compression stocking, even if it is by just a few single measurements. The advantages of such a stocking made of two components consist in the fact that the under-stocking with its lower resting pressure can be left on even at night to safeguard the wound dressing, and during day the compression stocking then exerts the necessary pressure for healing the ulcer. In addition, the wearing comfort increased the quality of life, though with a few limitations in as far as shoe and clothing selection are concerned. Bandage stockings have an approval as technical aids and therefore do not fall under the medical budget. In a comparative study involving compression bandages and compression stockings the ulcerations healed faster under therapy with compression stockings.

Bandage stockings are not indicated for patients without ulcers in the stable maintenance phase. Such patients should be provided with classical medical compression stockings.

**BANDAGING TECHNIQUES**

There is a wide variety of individual bandaging techniques usually backed up by proper names which give clear instructions on how to go about them. The superiority of any one particular bandaging technique has not been proved, however, since comparative random studies on specific medical conditions have not been carried out with different bandaging techniques. Everybody should use the bandaging technique which he has learned best under specialized supervision in an appropriate training course with a fair share of practical work.
The minimum requirements for material used for a lower leg compression bandage on a normally formed lower leg are: Padding cotton wool or a foam material bandage and at least two short-stretch-bandages adjusted to the breadth corresponding to the limb size, e.g. 8 cm and 10 cm. Ideally a fixation bandage or a tubular bandage holds the padding in place. No adequate compression bandage can be applied using a single short-stretch-bandage.

- As to whether yet a third bandage is required depends on the size and length of the lower leg. Every additional bandage increases the stiffness of the compression bandage.
- The additional use of a long-stretch-bandage depends on the magnitude of the oedema and can be useful during the decongestion phase, while in the maintenance phase it is not necessary in most cases (exceptions can be lymphatic oedema in stage III and IV).
- The question of whether the bandages are tied in a synchronous or counter-rotational manner is a matter of individual choice.

The following essential principles for applying a compression bandage on the leg should be taken into account irrespective of the material used and the preferred tying technique:

- A compression bandage should always start as far as possible distally. The compression bandage therefore begins in the foot area right from the metatarso phalangeal joint, follows the course of the toes and encompasses the heel.
- When tying the bandage the foot should always be kept in a functional position (= at a right angle to the calf).
- Fix the starting end of the bandage with two circular routes.
- The breadth of the bandage should not be larger than the diameter of the body part to be wrapped, i.e. with shoe size 36, for example, one will need a bandage of 6 cm at the foot and then bandages of 8-10 cm width from the lower leg upwards depending on the circumference; at least two bandages are needed.
- The bandages should lie in the hand with the unrolled part facing up and pointing outwards so that it can be unrolled well (= when unrolling look at the bandage angle).
- When applying the bandage, one has to guide it directly along the leg while pulling lightly. In that way the material will lie evenly against the leg. If you pull the bandage too strongly the two bandage edges will be stretched disproportionately and there will be a danger of developing furrows, tension blisters, nerve injuries and decubital necrosis.

- The pressure which the bandage exerts must be stronger in the ankle area and decrease slowly towards the knee, that is to say the pressure decreases from the distal to proximal point. If the bandage is pulled evenly this decrease in pressure is attained automatically over the increasing circumference of the leg. One should avoid applying the bandage more tightly in particular sections of the leg either consciously or unconsciously. That increases the pressure in those areas and leads to fluid build-up in the distal area, thereby increasing the risk of thrombosis.
- The use of pressure pads and pellotes can further increase the effectiveness of the compression effect.
- The use of staples that accompany many bandages, also called mothers-in-law, poses a risk of injury. If the staples are bent open or if they are used in a place where the bandage is not thick enough, they can pierce through the bandage and injure the skin. Besides, they can come loose and injure the patient lying in bed!
- Adequate cushioning of protruding bones offers protection against pressure injuries. Therefore one has to think of under-padding for every compression (e.g. with padded cotton wool or re-usable bandages made of foam material). However, one can also do without the under-padding in the case of well-fitting bandages and compliant patients.

**Under-padding:**
When carrying out under-padding special attention has to be paid to the areas behind and beneath the ankles, the anterior edge of the tibia and the fibula head. Improper bandaging can lead to the development of furrows, blisters, pressure ulcers, skin necrosis and arterial pressure injuries.

- A tubular bandage of two and a half up to three times the length of the lower leg is worn up to the popliteal cavity.
- The projecting end at the foot is given to the patient to handle, if it is possible for him, or put between the toes or placed over the user’s shoulder.
- An under-padding wrapping consisting of cotton wool or re-usable foam material bandages is then placed over the tubular bandage and it ends at a distance of two fingers’ width below the popliteal cavity.
- The starting point of the compression bandage is at the metatarsal phalangeal joint for short-stretch-bandages.
- At the finishing point of the bandaging the tubular bandage is turned over the dressing in the knee area and the end facing the foot is then pulled up to the popliteal cavity and fastened using adhesive tape strips.
The padding used to attain optimized pressure distribution should be distinguished from the under-padding meant to prevent bruises.

Since the leg has an uneven form, pressure cannot be exerted evenly on it, for instance at the point where the ankle juts out. In order to level out such anatomical irregularities, special pressure pads, so-called pelottes, can be used.

During the therapy phase one should be mindful of how long the compression bandage has to be left on at night too. If the patient continues walking around at night after the removal of the compression bandage, or if he gets up frequently at night or if he moves for a long time in the morning without a compression bandage, then it may not often be possible to achieve consistent decongestion.

It is not necessary in most cases to leave the compression bandage on at night during the maintenance phase. If the compression bandage is taken off for the night, it should be replaced as much as possible just before getting up the following morning. Replacing the bandage later allows the formation of oedema to resume even in the maintenance phase and hence ruins the outcome.

Due to the anatomy of the ankle joint, uniform compression is difficult in this area. The compression bandage runs from the medial malleolus or lateral malleolus respectively to the Achilles tendon. In the process, the protruding ankles prevent an effective compression of the area behind the ankles. If the leg is swollen together with the ankle joint, this fact is not given any consideration during the initial decongestion. With increasing decongestion, and especially during the maintenance phase, care has to be taken, however, to make sure that even the area around the Achilles tendon becomes oedema free. For that purpose it is necessary to pad the concave areas behind the ankle joint. For strong and rather round legs, a folded pad or a kidney-shaped pad made of foam material, or a cushioning tampon is sufficient for padding the area behind the medial and lateral malleolus. In the case of profoundly projecting ankles it is necessary, however, to fill out the concave area behind the ankle joints with a fitting pelotte because oedema fluid will otherwise keep on accumulating there.

Attention should also be devoted to a florid ulcer when applying the compression bandage. If the ulcer lies in the concave area behind the ankle joints, additional padding of the area is by all means necessary. If the ulcer is located over a bone, e.g. the tibial crest, excessive pressure can easily be exerted, such that it becomes necessary to apply additional padding using cotton wool or foam material.

**COMPLICATIONS arising from the application of a compression bandage**

Everybody who applies a compression bandage should know the complications, potential side effects and dangers of compression. Every time the bandage is changed, the leg should be carefully inspected for possible pressure marks, skin changes and atypical swellings which have appeared as a result of lacings around the area. The reduction in oedema during the decongestion phase should be documented by measuring the size of the leg. This aspect of measuring is of little significance in the maintenance phase.

- Pain is always an alarm signal. A compression bandage which hurts must always be removed. A freshly applied bandage can by all means be perceived as being too tight by patients with fresh thrombosis or a florid ulcer within the first minutes of application, but it should not be painful. If the pain felt by the patient does not subside within a few minutes or if it does not improve after a few steps, then the bandage should be taken off. Unfortunately there is no objective sign which indicates that the compression bandage sits optimally.

- The assumption that one can check the right compression pressure by the fact that the toes will first turn slightly blue when the bandage is applied but then assume their natural colour again when one walks, has not been corroborated. It is true that this appearance of the natural skin colour when walking shows that there is sufficient blood circulation at this moment, however it does not reveal how the situation will unfold in the next 24 or 48 hours.

- Pressure marks and redness of the skin under a compression bandage appear mainly in the areas of the tibial edge, the ankle joint, the Achilles tendon and the back of the foot. Risk factors include reduced sensation/pain sensation, long-term use of steroids and the existence of a chronic illness (e.g. rheumatoid arthritis) in connection with reduced mobility, loss of calf muscles and foot-/ankle deformation. All pressure marks are a pointer to a too strong localized compression or insufficient padding.

- As in the case of a cast, a compression bandage can also cause local damage to the peroneus nerve at the level of the fibula head. One should be mindful of good padding in this area as well as a fresh occurrence of a weak foot dorsiflexion.
CONTRAINDICATIONS
for the application of a compression bandage

Advanced peripheral arterial occlusive disease, acute decompensated heart failure and phlebitis coerulea dolens (severe progression of venous thrombosis with total occlusion of all veins of a transverse section) are defined as absolute contraindication. Relative contraindications are: severe sensory disorders (paraesthesia) of the extremities, advanced peripheral neuropathy (e.g. in the case of diabetes mellitus), intolerance to dressing material and a yet compensated peripheral arterial occlusive disease. One would usually not apply a compression bandage to these patients. If there is a clinical indication for a compression bandage for such a patient, a critical risk-benefit analysis is required.

- If an arterial perfusion disorder is not ruled out, no compression bandage should be applied. Properly tactile foot pulses speak against arterial perfusion disorder, but they don’t provide conclusive proof. The ankle-brachial pressure-index must be determined in each individual case. A sufficiently compensated peripheral circulatory disorder does not represent any contraindication for the application of a compression bandage. However, such patients need special supervision. Loss of colour in the toes and reports of pain can be taken as a sign of a too tight bandage and the bandage has to be taken off. In borderline cases the compression bandage should be removed after two to four hours and the leg should be examined for pressure marks. Patients with arterial circulatory disorders often tolerate a compression bandage only during the day when the leg is suspended but not at night when the leg is lying in bed. In such cases the compression bandage has to be removed at night.

- Diabetic polyneuropathy makes the patient not to feel a bandage which is too tight or padding which is not sufficient. It is possible to have a properly applied compression bandage even in the case of diabetic polyneuropathy, but since there is no feedback from the patient regarding pain and pressure marks, there is a higher risk of inflicting injury to the tissue. In this situation too there is nothing else one can do other than to remove the compression bandage again after two to four hours and to examine the leg for pressure marks.

- A florid infection (phlegmon, abscess) represents a contraindication for a compression bandage.

Heart failure is always cited in medical literature as a systemic contraindication. However only the acute decompensated heart failure represents a contraindication since the body cannot cope with extra fluid in such a situation. The chronic heart failure often existent in elderly people does not represent a contraindication, but it requires increased supervision. If compression therapy is necessary in these cases, the quantity of fluid which can be realized has to be considered. The decongestion should be intensified gradually and the compression bandage should be applied in a well-regulated manner. One should start with only a distal compression in one extremity, for example. In many cases patients with heart insufficiency benefit from a compression bandage which when applied during day prevents the swelling up of the legs. The fact that there is no build-up of oedema reduces or removes nycturia as a sign of the nocturnal fluid redistribution.

Compression therapy has to be used only with caution in the case of bedridden patients. The cause of oedema build-up in bedridden patients is seldom the disturbed venous or lymphatic reflux. The legs lie at the level of the heart and the gravitational force does not become effective. Bedridden patients often suffer from muscle degradation and have a higher risk of developing pressure induced lesions irrespective of possible compression bandages. Even a well-applied compression bandage can increase this risk. The need for a compression bandage for bedridden patients therefore always requires special indication and supervision.

Moreover there is no muscular activity, and therefore compression alone would not work. The intermittent compression proves to be of good help in this case.

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